Educational transformation: 21st century skills and challenges for higher education

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Published in
Frontiers in Education

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Educational transformation: 21st century skills and challenges for higher education

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Editorial: Educational transformation: 21st century skills and challenges for higher education

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Editorial on the Research Topic
Educational transformation: 21st century skills and challenges for higher education

We live in an era of rapid transformation, driven by technology, globalization, and constant changes in labor and social dynamics. In this context, higher education is faced with a crucial challenge: preparing students with not only technical knowledge but also the skills necessary to adapt and thrive in an ever-evolving world.

Twenty-first-century skills—such as critical thinking, problem solving, effective communication (Halpern, 1998; Sternberg, 1985; Perkins and Salomon, 1989), digital literacy, and teamwork—have become essential components in the comprehensive training of future professionals. However, effectively integrating these skills into curricula requires rethinking traditional teaching approaches (Dwyer et al., 2014). Education must go beyond the mere transmission of information and embrace active, interdisciplinary, and innovative methodologies that foster meaningful learning and the development of transversal competencies.

Higher education institutions must take a leading role in educational transformation by updating their academic programs, incorporating technological tools, and strengthening formative experiences that equip students with the confidence and creativity needed to face labor market challenges.

In this regard, higher education must evolve to meet the new needs of students and society. In addition to imparting knowledge, institutions should focus on cultivating key competencies that help future professionals adapt to dynamic environments, enhance critical thinking, and promote autonomous learning.

This Research Topic of our journal brings together a collection of articles that address various challenges and opportunities in higher education and explore key topics that impact university education today. These topics include how community service learning can enhance literacy, the effects of flipped classrooms on teaching, and the relationship between academic performance and skill development for the digital age. Additionally, this Research Topic examines how the combination of in-person and online learning influences student autonomy and the effects of active learning methods on academic outcomes.

Furthermore, this Research Topic includes research on the cognitive and motivational factors that influence intentions to drop out of university, emergency remote teaching for English as a Foreign Language (EFL) students, and the connection between critical thinking, psychological wellbeing, and academic performance. These studies provide a comprehensive perspective on how higher education can adapt to the challenges of the 21st century by integrating innovative strategies that enhance student learning and engagement.

In line with these themes, the collection contains a wide array of articles that address educational transformation from multiple perspectives. It features studies on flipped classrooms in physiology, student wellbeing based on perceptions of the learning climate, and multimodal literacy through service-learning. Other articles explore dropout risk factors, digital and complexity-related skills, and university teacher identity. Additional contributions examine active learning methods across modalities, and the importance of self-regulated learning in blended contexts. Several studies expand our understanding of computing identity and 21st-century skill development across cultures. The volume also discusses the differences between emergency remote teaching and structured online learning, the implementation of STEAM pedagogies, and the implications of artificial intelligence in education—both as an institutional force and a classroom tool. Finally, the Research Topic explores gaps in skill assessment and presents models for curricular integration based on global experiences. Collectively, these 22 articles offer a comprehensive and multifaceted view of how higher education can—and must—evolve to meet present and future demands.

There is no doubt that higher education must act urgently to address the challenges of the 21st century by transforming its pedagogical approaches to effectively prepare students for a rapidly changing world. Seizing the opportunity to integrate key skills such as critical thinking, effective communication, and adaptability into curricula will not only enhance graduates' employability but also contribute to building a more dynamic and innovative society. The educational community must collaborate to develop programs that foster active and collaborative learning. In doing so, we not only ensure that our students are equipped to face future professional challenges, but we also strengthen the role of education as a driver of social and economic progress.

In conclusion, this *Frontiers* Research Topic, titled *"Higher Education and 21st Century Skills: Challenges and Opportunities,"* presents 22 articles that offer valuable insights into the discussed topics. It highlights the importance of examining the strengths and challenges identified in various studies related to the development of transversal skills in higher education. This volume aims to contribute to the academic debate and reinforce the role of research in shaping solutions to the current challenges of university education (Saiz and Rivas, 2023).

Author contributions

SR: Conceptualization, Writing – original draft, Writing – review & editing. AB: Writing – review & editing. JC: Writing – review & editing. CS: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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'Love, Love not'—a discovery of study engagement at higher education and the factors involved

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Taking that higher education is career-oriented, this study examines how Vietnamese undergraduate students engage with their study and how the factors related to the training program and occupation's prospects contribute to students' engagement with their study. The study applies a mixed-method approach. Self-administered questionnaire survey is used to collect data from 973 Vietnamese undergraduate students, of which 48.2% are social work students and 51.8% are non-social work students. In addition, the study conducts 27 semi-structured interviews with students and lecturers to explore their perspective and experiences with regard to students' study engagement and the factors involved. The results show that social work students are more engaged with their study than non-social work students, even though they feel more worried about job opportunity and income. Approximately one-third of social work students consider not to pursue social work profession when they graduate mostly because they believe that working in social work cannot provide them the income they need for their living. However, the results also show that students' satisfaction/dissatisfaction with income in their field was not statistically related to their study engagement. Instead, feeling of personal growth, opportunity to perform personal ability, sense of significance, convenient access to study materials and activities, and feeling proud of their school and lecturers' prestige are found positively associated with students' level of study engagement. The study hence provides some recommendations for educators to strengthen students' study engagement at higher education level.

1 Introduction

Student's study engagement is one of the key factors affecting the outcome quality in higher education (Hart et al., 2011; Boulton et al., 2019; Kim et al., 2019). Studies explain that when students are engaged with their study, they invest more time and energy in academic effort and professional and extracurricular activities in school, tend to develop coping mechanisms to help them maintain and self-regulate their own learning process, and thus

increase the quality of their education outcomes. Research also shows that study engagement results in increasing satisfaction and self-confidence and reduces the risk of failures and dropouts. Importantly, study engagement is a multidimensional ability that can be trained, developed, and improved over time (Assunção et al., 2020). Therefore, creating a learning environment that promotes study engagement has been a concern in the higher education sector (Bowden et al., 2021).

However, studies also point out that promoting study engagement is increasingly a challenge for higher education sector. Nowadays, students tend to be less committed to their studies in all cognitive, emotional, and behavioral dimensions (Collaco, 2017). In this context, understanding students' study engagement and identifying the factors related to study engagement is of great importance. Therefore, not only university lecturers and researchers but also policymakers are paying more and more attention to students' study engagement as a key to solving problems, such as student's poor academic performance, classroom boredom, and dropping out of school (Fredricks and McColskey, 2012). What is study engagement? Unfortunately, there is no consensus in conceptualizing study engagement. Along with the increasing interest of stakeholders (educators, researchers, and policymakers) in the issue of study engagement, study engagement has been explored under various conceptualizations and many different names, such as academic engagement, class engagement, or school engagement (Fredricks and McColskey, 2012). Even the concept of 'engagement' remains instinctive (Schaufeli, 2013).

The concept of 'engagement' originally, however, does not only come from educational studies but also from studies of occupation and employment. This concept has recently been adapted to the field of education (Assunção et al., 2020). Assunção et al. (2020) detect conceptualization and measures of "engagement" and find that it originates from the concept of "burnout," which is introduced by Maslach and Leiter (1997). According to these two authors, whereas burnout is a concept that refers to the erosion of cohesion, engagement is observed as the opposite state of exhaustion and is defined with dimensions of (1) the feeling of energy, (2) commitment, and (3) fulfillment. When engagement wears off, energy drains, commitment turns to skepticism, and productivity becomes ineffective, burnout comes in. According to this perspective, employees are assessed on the burnout-engagement axis in relation to work. However, according to Assunção et al. (2020), this way of conceptualization has a shortcoming that some people are neither exhausted nor necessarily engaged in their work.

In educational research, the concept of study engagement is first built on two components: behavior (e.g., participation, effort, and positive behaviors) and emotion (such as interest, feelings of belonging, value, and positive emotions). Cognitive factor (e.g., self-discipline, investment in learning, and learning strategies) is later supplemented as the third component of study engagement (Fredricks and McColskey, 2012). Currently, the Glossary of Education Reform defines study engagement as "the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education"[1]. In the same line with these conceptualizations, Schaufeli et al. develop the Utrecht Work

Engagement Scale for Students (UWES-S) to measure students' engagement with their learning. The scale was first developed to measure work engagement and then quickly became the most popular instrument applied in various populations. As its original construct, this UWES-S is also composed of three factors: vigor, dedication, and absorption. Since it was introduced, the UWES-S scale has been popularly used to measure tertiary students' study engagement in various contexts (Carmona-Halty et al., 2019).

Study engagement of social work students in Vietnam is an interesting case for understanding study engagement at higher education level and its relations with factors at micro level (e.g., personal factors), mezzo level (higher education programs), and macro level (job market). In Vietnam, social work remains a new profession. Even though the literature shows that professional social work was introduced to Vietnam during French colonization period (Tran, 2015), social work was absent during war times, the first period of building the united socialist Vietnam. Social work has just become prominent in modern Vietnam recently due to efforts of the Vietnam Government to boost the role of social work profession to meet the growing demands from society. Within just a decade after Vietnam Prime Minister issued the Decision to boost social work profession in Vietnam in 2010 (often known as 'Project 32'), BSW program has been rapidly initiated in many higher education institutes in Vietnam. Up to now, approximately 50 universities in Vietnam provide bachelor's degree in social work (BSW) program. However, little is known about how these programs are operated in meeting students' demand for their occupation training, in particular, and preparing for social work profession, in general.

We started our study from a perspective that higher education is essentially occupational education. When a student applies for a program at university, she/he is aiming at and investing in a certain profession for her/his future. Therefore, program-related and job-related factors may be significant factors that affect students' study engagement. In the field of occupation studies, work engagement is often investigated under job demand-resource (JD-R) framework. JD-R theory emphasizes the impact of organizational environment on employees' wellbeing and performance and focuses on two categories of organizational factors: efforts that the job demand the employees to make to accomplish their roles and the resources that the job and working environment provide for employees to achieve their goals (Tummers and Bakker, 2021). In this study, since our study objects are tertiary students who are investing in their future career, we approach study engagement from Kahn (1990) theory because this theory helps explore how personal expectations interact with *de facto* conditions, and these interactions contribute to students' engagement with their study.

According to Kahn (1990), engagement is internally constructed. Kahn (1990), p.700 proposed that 'people have dimensions of themselves that, given appropriate conditions, they prefer to use and express in the course of role performances… Engaging behaviors simultaneously convey and bring alive self and obligatory role. People become physically involved in tasks, whether alone or with others, cognitively vigilant, and empathically connected to others in the service of the work they are doing in ways that display what they think and feel, their creativity, their beliefs and values, and their personal connections to others'. With this conceptual approach, Kahn (1990) asserts that engagement is a state where a person's personal and social dimensions are activated to complete their jobs, and this completion

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1   https://www.edglossary.org/student-engagement/

is, in return, to perform their own self and social connections. Furthermore, Kahn claims that engagement is constructed upon the meeting of three psychological needs, including meaningfulness, psychological safety, and availability. To be more specific, how engaged a person is when carrying out a task depends on the answers of three questions: (1) How meaningful it is for me to bring myself into this performance, (2) how safe it is to do so, and (3) how available I am to do so (p. 703).

Meaningfulness refers to how individuals perceive their investment of their physical, cognitive, and emotional energy into tasks as worth, valuable, and useful (i.e., whether what they receive deserves what they give) so that they can feel the meaning of their work and life. It is worth noting that Kahn, though likely referring to the 'cost and benefit' model, stresses not only on the rational calculation of cost and benefit but also on individuals' perception of meaningfulness. *Safety* refers to students' perception of their ability to show and employ themselves into doing tasks without the fear of any harm to their self-image, or status means that individual is able to show himself without fear of negative consequences. Kahn (1990) proposes that the sense of safety is created in an environment/situation which is predictable, secure, and trustworthy. Meanwhile, *availability* refers to students' belief if they possess required physical, emotional, and psychological capacity to invest into role performance.

Based on Kahn (1990)'s proposition, when examining the training program, we focus on the way the training program can bring to students what Kahn called 'meaningfulness', 'safety', and 'availability' so that students can feel their 'self-in-role' and examine how this contributes to students' engagement.

To deepen the understanding of study engagement at higher education, this study focuses on social work major and makes comparisons between social work and some other majors provided in the same universities. The study aims at answering two core questions: (1) how social work students are engaged with their study and (2) how some training factors (such as course designs, course assessment, and lecturers) and job market factors (such as income and job opportunity) relate to students' study engagement.

2 Research methods

2.1 Methodological approach and research procedure

Because little research on study engagement has been conducted in Vietnam, this research applied an exploratory sequential mixed-method approach, aiming at capturing the strengths of both qualitative and quantitative approaches (Creswell and Creswell, 2018), to explore tertiary students' study engagement and how study engagement is related to their training program at university and job issues. The research was deployed in three phases. In the first phase, we conducted 22 semi-structured interviews with students and university lecturers. We used thematic analysis to identify common factors related to students' study engagement. In phase two, we developed an online self-administered questionnaire to measure study engagement and the factors involved, based on the qualitative findings and Kahn (1990) theory. We then delivered the questionnaires to undergraduate students of 13 universities in Vietnam. In the last phase, we conducted five more semi-structured

interviews with undergraduate students and lecturers to cross-check the quantitative data.

All participants participated in this study on a voluntary basis. An invitation letter together with a leaflet introducing the study was sent to participants first, and then, researchers approached them to check if they agreed to participate in the study.

The research design, ethical proposal, and research tools were reviewed and approved by IRB at VNU-Hanoi University of Social Sciences and Humanities.

The two research methods (semi-structured interviews and questionnaire survey) are described in detail in the following sections.

2.2 Semi-structured interviews

The study conducted 27 semi-structured interviews with tertiary students and lecturers. We followed five steps to develop interviewed guide suggested by Kallio et al. (2016). After identifying the prerequisites for using semi-structured interviews in this current study, a literature review of study engagement in higher education was conducted to formulate the preliminary interview guide. We piloted this interview guide with five undergraduate students before finalizing the interview guide.

In each interview session, participants were reminded about confidentiality and participants' rights (e.g., the right to withdraw from the interview at any time) before the interview was conducted. Each interview often lasted from 60 to 75 min. Most of the interviews were conducted at a quiet café which was selected by the participants. All of the interviews were recorded with the permission of the participants.

2.3 Questionnaire survey

2.3.1 Questionnaire survey sample

There were 973 students from 13 universities who participated in the survey. In total, 469 students (48.2% of the total) are social work students, the remaining are from other majors, such as law, business, philosophy, and psychology. Of all undergraduate students who participated in the survey, 29.8% were first year students, 34.6% were on their second year, 16.8% on third year, and 18.8% on fourth year. All BA programs examined in this study lasted for 4 years.

Among 469 social work students who participate in the study, 80% are women, 19% are men, and 1% are LGBTQ+. Regarding living areas, 42.6% of participants came from rural areas, and the remaining 57.4% of participants came from urban areas.

2.3.2 Instruments

2.3.2.1 Study engagement scale

Upon the permission of Prof. Schaufeli, we use the version UWES-9S developed by Schaufeli and Bakker (2004). Research documents that this short form of study engagement scale has equivalent psychometric properties with the 17-item version (Carmona-Halty et al., 2019). The scale consists of three factors. The first factor is named 'vigor', refers to students' concentration in study, being ready to invest their effort in the study and being resilient when facing difficulty in studying. Vigor is measured in UWES-S via three items: 'When I'm doing my work as a student, I feel bursting with

energy'; 'I feel energetic and capable when I'm studying or going to class'; 'When I get up in the morning, I feel like going to class'. The second factor is called 'dedication', refers to students' feeling of meaningfulness, enthusiastic, pride, and inspiration in their study. In the 9-item version of UWES-S, dedication is measured via three items: 'I am enthusiastic about my studies'; 'My studies inspire me'; and 'I am proud of my study'. The last factor is named 'absorption' which means being fully and happily sunk in their study so that they may find it difficult to separate themselves from studying. This factor is measured via three items: 'I feel happy when I am studying intensely', 'I am immersed in my studies'; and 'I get carried away when I am studying'. Each item was measured on a five-point Likert scale with 0 = never and 4 = always. The higher score represents the higher level of study engagement. Cronbach's alpha value is 0.83 for vigor, 0.86 for dedication, 0.87 for absorption, and 0.93 for the total scale, showing a good internal consistency of the scale.

2.3.2.2 Factors related to study engagement

Based on semi-structured interviews with social work students, this study assesses four sets of factors identified by thematic analysis of qualitative data as factors contributive to students' study engagement: sociodemographic characteristics, students' major; training program organization; and job market issues. Except for sociodemographic factors, students are asked to assess how they agree with the statements describing the aspects of the factors on a five-point Likert scale from 0 = 'I totally disagree' to 4 = 'I totally agree'.

(1) Sociodemographic factors of students: sex, living area (rural vs. urban), and students' academic performance (assessed by their GPA).
(2) Factors related to the training program: *meaningfulness* ('my major has a high social recognition', 'my major is contributive to social development', 'Course assessment helps me to understand my ability', 'Course design allows me to show my ability', 'Studying my major contributes to my personal growth), *safety* ('Course materials are accessible'; 'Many of the lecturers in my major program are well-known experts'; 'When I meet difficulty in my study, lecturers are quite supportive'; 'The assessment is fair'); *availability* ('the training program help connect me with job opportunity'; 'the training program prepares me well to do my job in the future'; (4) 'what I have learnt from this program is practical and applicable to my daily life'). All factors are assessed on a five-point Likert scale with 0 = 'I totally disagree' and 4 = 'I totally agree'
(3) Factors related to job-market: income (jobs in my field are low paid) and job opportunity ('it is not easy to find a job in my field'). All factors are assessed on a five-point Likert scale with 0 = 'I totally disagree' and 4 = 'I totally agree'.

2.3.3 Data analysis

Data were analyzed using SPSS 23.0. We resorted to descriptive statistics (frequency, mean-value, and standard deviation) to describe the central tendency of study engagement and inferential statistics (independent sample *t*-test, paired sample t-test, one-way ANOVA, chi-square test, and Pearson's test) to compare between social work (SW) and non-social work (NSW) majors and test the relationship between variables.

3 Results

3.1 How Vietnamese social work students engage with their study

In a [0:36] scale, it appears that Vietnamese social work students are quite engaged with their social work education (mean = 20.3; SD = 7.7). The following (Figure 1) shows the specific mean scores of each dimension of study engagement, as reported by social work students.

On UWES-9S, each dimension of study engagement has a range of 0–12, and the results show that Vietnamese social work students score highest on dedication dimension ($M = 7.65$, SD = 2.72) followed by Vigor ($M = 7.03$, SD = 2.78). They score lowest in absorption dimension ($M = 5.65$, SD = 3.09). Paired sample t-test shows that the differences between these dimension scores are statistically significant: Vigor–Dedication has $t_{(468)}$ value = 7.27 ($p < 0.001$); Vigor–Absorption has $t_{(468)}$ value = 12.33 ($p < 0.001$); and Dedication–Absorption has $t_{(468)}$ value = 18.36 ($p < 0.001$).

Comparing between social work and non-social work students about their study engagement, one-way ANOVA analysis showed that the difference in the level of study engagement between social work students and non-social work students is significant ($F_{(1,973)} = 9.051$; $p < 0.01$). It is interesting that whereas the mean score of social work students' study engagement is a little bit higher than that of students from other majors (20.3 and 18.8, respectively), standard deviation is also higher (7.7 and 7.4, respectively).

> Result shows that Vietnamese social work students are more engaged with their study than their non-social work counterparts.

To further understand students' study engagement, we also compare between social work students and non-social work students in the way they perceive their major and assess job prospects in their field. The score for each item ranges from 0 to 4, with 0 = 'totally disagree' and 4 = 'totally agree'. The higher the score the more the students agree with the statement (Table 1).

One-way ANOVA test results show that except for 'My discipline has a high social recognition', the differences between social work students and other majors are statistically significant. Students from social work major and the other majors assessed social recognition of their major at the same level (mean scores are approximately 2.6 point on a five-point Likert scale). Compared with students from other

FIGURE 1
The mean scores of each dimension of study engagement.
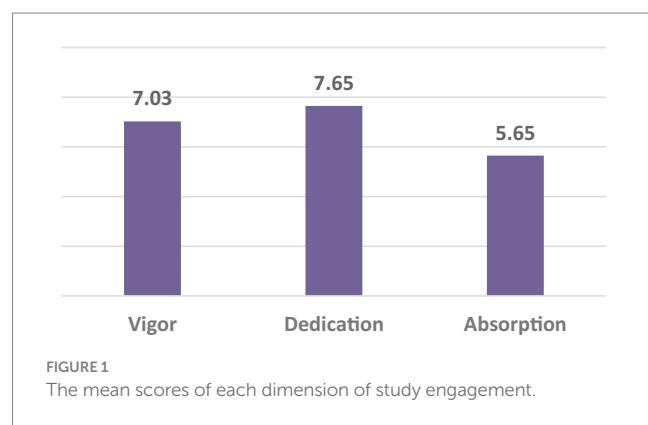
TABLE 1 Students' perception of their majors: comparison between social work students and students from other majors.

		Major	N	Mean	Std. deviation	$F(1, 973)$ p-value
1.	I am satisfied with what I am studying	Social work	469	2.979	0.8768	$F = 22.741$
		Other	504	2.696	0.9631	$p = 0.000$
2.	I often feel bored in classroom	Social work	469	1.478	1.1046	$F = 12.089$
		Other	504	1.716	1.0365	$p = 0.001$
3.	My major is contributive to social development	Social work	469	3.420	0.8089	$F = 65.306$
		Other	504	2.970	0.9187	$p = 0.000$
4.	My discipline has a high social recognition	Social work	469	2.610	1.0060	$F = 0.302$
		Other	504	2.645	0.9824	$p = 0.583$
5.	Jobs related to my major are often low paid	Social work	469	2.849	1.1039	$F = 53.298$
		Other	504	2.300	1.2322	$p = 0.000$
6.	It is not easy to find a job in my field	Social work	469	2.787	1.1664	$F = 16.437$
		Other	504	2.476	1.2192	$p = 0.000$
7.	My major contributes to my personal growth	Social work	469	3.143	0.8210	$F = 16.039$
		Other	504	2.925	0.8750	$p = 0.000$

majors, social work students are more satisfied with their major (higher mean score, lower SD, $F_{(1,973)} = 22.741$, $p < 0.001$). Social work students feel less bored in classroom than their counterparts (lower mean score, however a little bit higher SD, $F_{(1,973)} = 12.089$). Social work students also perceive that their discipline is significant for society (their major is significantly contributive to social development), and that studying in their major help contribute to their personal growth at a higher level than students from other majors (higher mean score, lower SD, $F_{(1,973)} = 65.306$ and 16.039, respectively, $p < 0.001$). However, social work students also highly agree that it is difficult to find a job in their discipline and jobs in social work area are low paid than students from other disciplines (higher mean scores, lower SDs, $F_{(1,973)} = 16.432$ and 53.298, respectively, $p < 0.001$).

> *The study finds that Vietnamese social work students are more satisfied with their major than non-social work students; however, they assess job prospects (income and job opportunity) in their field more negatively than their non-social work counterparts.*

When being asked if they would pursue jobs related to their current major, the proportion of social work students who intended to pursue social work job after graduation is lower than that of students from other majors, as presented in Figure 2.

Results show that whereas 41.7% students of other majors determined to pursue major-related job when they graduate, this rate among social work students is only 37%, as presented in Figure 2. This result is consistent with the above result that according to social work students, compared with non-social work students, social work jobs are normally lower paid, and it is not easy to find a job in social work field. In addition, Vietnamese social work students are, in general, from families with more disadvantaged economic conditions. They received less financial support from their family than their counterparts. In total, 26.2% of social work students reported that they had to pay for the expenses for their tertiary education by themselves, whereas the rate among students of other majors is 19.1%. The differences

between social work students and other-major students in financial burden is statistically significant ($X^2 = 11.820$; df = 4; $p < 0.05$).

> On one hand, I want to do social work when I graduate. I long to apply what I have learnt from my program in work. On the other hand, I need to earn money. My parents and my little siblings rely on me [financially]. I have to take care of them. I need to find a job that helps me to feed my family. But I also don't want to give up social work. I feel really stressed about that. (Student, 4th year, Social Work major)

Our study document that, unfortunately, the more Vietnamese social work students are close to graduate, the more uncertain they are in pursuing social work jobs in their discipline (Pearson R = −0.125; $p < 0.05$, $n = 468$).

As presented in Table 2, more than 40% of Year 1 and Year 2 social work students reported that they were determined to do social work after graduation, and this proportion of Year 3 students decreased to 37.9%. Remarkably, only 29.4% of Year 4 students wanted to pursue the job they were being trained in.

> *It seems that Vietnamese social work students are engaged with their study but less engaged with social work profession.*

3.2 Factors associated with social work students' study engagement

This part focuses on the factors contributive to study engagement as reported by the students during semi-structured interviews and clarifies how they are related to students' engagement with their study (Table 3).

Different from our expectation that the more the students are engaged with their study, the higher GPA they may achieve; our results show that GPA is not statistically related to study engagement.

FIGURE 2
Students' intention to pursue a job related to their current major when they graduate.
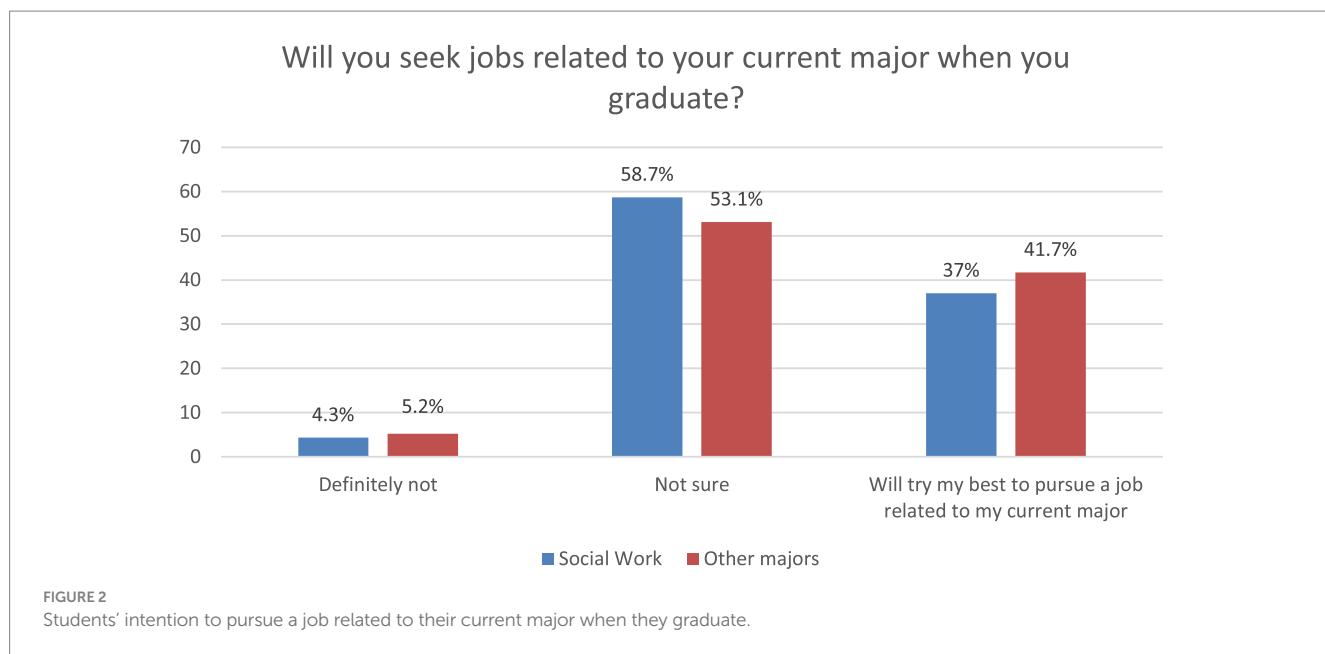
TABLE 2 Students' intention to pursue their major-related jobs and their school year by their school year.

			Social work students' intention to pursue social work job when graduated			Total
			Definitely not	Not sure	Will try my best to find a social work job	
School year	Year 1	Count	4	56	47	107
			3.7%	52.3%	43.9%	100.0%
	Year 2	Count	2	60	43	105
			1.9%	57.1%	41.0%	100.0%
	Year 3	Count	4	55	36	95
			4.2%	57.9%	37.9%	100.0%
	Year 4	Count	10	103	47	160
			6.3%	64.4%	29.4%	100.0%
Total		Count	20	274	173	467
			4.3%	58.7%	37.0%	100.0%

TABLE 3 Correlations between study engagement (SE) and some demographic factors.

			1	2	3	4
1.	Study engagement	Pearson Correlation	1			
		Sig. (2-tailed)				
2.	Sex	Pearson Correlation	−0.094*	1		
		Sig. (2-tailed)	0.041			
3.	Living area	Pearson Correlation	0.096*	−0.038	1	
		Sig. (2-tailed)	0.038	0.408		
4.	GPA	Pearson Correlation	0.017	−0.161**	0.027	1
		Sig. (2-tailed)	0.708	0.000	0.559	
5.	Type of school	Pearson Correlation	−0.007	−0.033	0.316**	−0.027
		Sig. (2-tailed)	0.873	0.475	0.000	0.564

*Correlation is significant at the 0.05 level (two-tailed).
**Correlation is significant at the 0.01 level (two-tailed).

TABLE 4 Correlations between study engagement and major-related factors.

			1	2	3	4	5
1.	Study engagement	Pearson's r	–				
		Sig. (2-tailed)					
2.	Socially significant	Pearson's r	0.286**	–			
		Sig. (2-tailed)	0.000				
3.	Social recognition	Pearson's r	0.336**	0.420**	–		
		Sig. (2-tailed)	0.000	0.000			
4.	Low income	Pearson's r	−0.041	0.179**	−0.030	–	
		Sig. (2-tailed)	0.207	0.000	0.351		
5.	Job opportunity	Pearson's r	−0.017	0.155**	−0.041	0.695**	–
		Sig. (2-tailed)	0.604	0.000	0.203	0.000	
6.	Personal growth	Pearson's r	0.437**	0.481**	0.296**	0.075*	0.049
		Sig. (2-tailed)	0.000	0.000	0.000	0.020	0.128

*Correlation is significant at the 0.05 level (two-tailed).
**Correlation is significant at the 0.01 level (two-tailed).

However, it means that the students are engaged with their study, and engagement has no effect on their academic results.

However, the lecturers we interviewed in phase 3 seem not to be surprised with this result.

> I think the result [no relationship between study engagement and GPA] is understandable. You know, GPA is of great significance to us Vietnamese, so that since early education [primary and secondary education] the kids are well trained to be able to achieve good scores in exams. Sometimes they may be technically good at getting good scores rather than being good at studying. I mean, they don't need to love study to be good at studying (Lecturer, public university)

Another surprising finding is that type of school (whether the school is public or private) also does not relate with students' study engagement. The social work curriculum in public universities in Vietnam tend to be more academic, knowledge-based training, whereas private universities offer a more practice-based training with more opportunities for students to connect with social work agencies and projects. In addition, the properties and facilities of the private universities sampled in this study are much more modern, large, comfortable, and convenient for students and their study than their public counterparts. Hence, we proposed that students at private school would be more engaged with their study. Actually, semi-structured interviews show that students at private schools do highly appreciate the modern and convenient properties and facilities of the school. Otherwise, students at public universities report that they are proud of their school's history, reputation, and well-known faculties.

> Yes, my university is too crumped. But I am proud of being enrolled in this university. It is one of the oldest and the best universities in my field. Best faculty, too. (Student, 2nd year, public university).

However, there is a statistically significant association between students' study engagement and their sex and living area. Our study finds that female social work students are slightly more engaged with their study than their male counterparts, and rural students are more engaged with their study than urban students.

To better understand what underlies social work students' engagement with their study, we test the correlation between social work students' study engagement and some job-related and program-related factors. The results are as follows:

Contrary to our expectation, low income and difficulty in finding job in social work have no effect on students' study engagement. However, the study finds a strong and positive association between study engagement and students' perception of how social work education contributive to their personal growth (Pearson's $r = 0.437$, $p < 0.001$), showing that the more students perceive that their education program helps them improve themselves, the more they are engaged with their study. Similarly, students are feeling proud that their major has high social recognition, and students' perception that their major is socially significant (contributive to social development) is found positively associated with students' study engagement (Table 4).

The following table presents the results of the correlations between social work students' study engagement and factors related to program organization.

Among the factors related to the way social work program is organized in university (faculty, course materials, assessment, and relationships between lecturers and students), bivariate correlation results show that course designed in a way that allows students to show their ability which is the factor and has strongest and positive relationship with students' study engagement ($r = 0.537$, $p < 0.01$), followed by students' perception that their study prepares them well for doing social work jobs ($r = 519$; $p < 0.01$). If the program connects students with job opportunities, assessment helps them understand their ability, the knowledge, and skills they learn are practical and applicable in their daily life, course materials are accessible, and placement helps students to be aware of how social workers do their job; the students' level of study engagement is positively and strongly strengthened. In addition, lecturers' good reputation and being supportive to students and fair assessment also positively contribute to students' study engagement with a moderate strength (Table 5).

TABLE 5 Bivariate correlation coefficients between study engagement and factors related to program organization.

Course design allows me to show my ability	0.537**
I believe that my study helps me to do my job well in the future	0.519**
The program connects me with job opportunities	0.452**
Assessment helps me better understand my ability	0.452**
What I have learnt in my courses are practical and applicable in daily life	0.446**
Course materials are easily accessible	0.444**
Practice and placement are helpful in showing me how I will do my job in the future	0.428**
I proud that my lecturers are well-known professionals	0.395**
Lecturers are supportive	0.383**
Assessment is fair	0.372**

**Correlation is significant at the 0.01 level (two-tailed).

4 Discussion

In general, the results show that Vietnamese social work students are quite engaged with their study. Specifically, their dedication score is highest among the three dimensions of study engagement, followed by vigor, whereas their absorption score is remarkably lower than the above dimensions. The differential magnitude of each dimension is also documented in a research on Chilean undergraduate students, according to Carmona-Halty et al. (2019). These results are reasonable because dedication and vigor reflect students' affection and passion for the profession that they have chosen, while absorption dimension requires intensive efforts and concentration which young persons as undergraduate students may lack. According to Erikson (1950), young adulthood is a developmental stage when individuals focus on establishing and building upon relationships. Career is of great importance; however, building up intimacy is also at the center of concern for individuals of this age, which may reduce their concentration for study. However, more study on different populations is needed to observe how different sociodemographic groups may differ in each dimension of engagement.

Our results further acknowledge that Vietnamese social work students are more engaged with their study than their non-social work counterparts. Social work students report a higher level of satisfaction with what they have learnt from their major, they feel less bored in classroom, and they find that their major is significant. However, higher value of standard deviant suggests that the level of study engagement is quite varied among Vietnamese social work students.

Our findings strongly support Kahn (1990) theory. When the training programs can bring about the sense of *meaningfulness, safety,* and *availability,* it is more likely that students may develop higher level of study engagement. How social work students perceive the social significance and social recognition of their major represents what Kahn calls 'meaningfulness'. The reasons for why these factors significantly explain social work students' engagement with their study are that social work has been demonstrated as a profession attached with positive values as "empowerment and respect," "social justice," and "compassionate vocation" (Levesque et al., 2019) or "work for the good of other" (Millington, 1981). Our results documented a statistically significant and positive association between students' study engagement and their perception of major as being socially significant and having positive social recognition.

In addition, as a helping profession, social work education provides students with knowledge, skills, and values necessary to support their clients. While doing so, social work education also helps students better understand themselves and work better with their personal and social life. It is demonstrated that experiences during studying social work help increase students' self-awareness (Bartkeviciene, 2014) and hence increase their sense of personal growth. Therefore, studying social work can boost students' sense of meaningfulness, which, in turn, strengthens students' engagement with their study. This study found that correlations between factors such as 'courses contribute to my personal growth', 'courses allows me to show my ability', 'assessment helps me better understand my ability'; and 'what I have learnt in my [social work] courses are practical and applicable in daily life' and students' level of study engagement are positive and strong.

Unanimously, our findings show that students' perceptions of 'course materials are easily accessible', 'lecturers are well-known professionals in the field', 'lecturers are supportive', and 'assessment is fair' positively contribute to students' study engagement. These are factors that create a learning environment which is trust-worthy, secure, supportive, and predictable. As claimed by Kahn (1990), such an environment boosts the sense of safety and hence strengthens personal engagement with their tasks.

In the same line with this proposition, our findings document that students' belief that 'study helps me to do job well in the future', 'the program connects me with job opportunities', and 'course design allows me to show my ability' are positively associated with students' study engagement, and these associations are at moderate level. It appears that students' sense of *availability*—whether the training program can help them find themselves able to do their trained profession in the future—is also significantly contributing to their study engagement at a lower level of magnitude if compared with *meaningfulness.*

Contrary to our expectation, job prospects such as income and job opportunity are not related to students' engagement with their study. Vietnamese social work students perceive that social work profession is low paid job. They also report a stronger belief that it is uneasy to find a job in their field than their non-social work counterparts. Accordingly, a remarkably smaller proportion of social work students confirm that they will pursue social work profession after graduation, whereas non-social work students report a much stronger commitment with the profession in which they are being trained. In

addition, the more social work students are close to graduation, the more they are uncertain about pursuing social work job. These results suggest that social work program is attractive to Vietnamese students, however social work jobs are however unattractive. In fact, this finding is understandable because social work remains a new profession in Vietnam. Recently, Vietnam Government has paid many efforts to boost social work education and social work profession via national projects such as the commonly known 'Project 32′ signed by Prime Minister in 2010, and then, Prime Minister's Decision No.112 was signed in 2021 to develop social work profession in 2010–2020 and 2021–2030, respectively. These efforts help make social work more well-known to the public, resulting in an increase in students' applications to BSW programs. However, work positions for social workers in Vietnam have still been limited and low paid.

In summary, we started our study with a premise that higher education was career-oriented training, and since we human beings were rational, the students' study engagement would be associated with occupation-related calculation (whether I can get job in this field, whether salary in this field is adequate) and learning benefits provided by the program. However, our results show that study engagement is not related much to rational calculation. Instead, students' study engagement is more associated with emotional and social experiences and students' motivation to improve themselves and perform their strengths. Therefore, the results suggest that in order to boost students' engagement with their higher education, the training program should pay attention to create more opportunities to help students perform their personal strength, let the students perceive the social significance of their major, and increase students' sense of safety and availability.

As mentioned above, another remarkable finding of this study is that 'low income' (students perceive that social work jobs are low paid) and 'job opportunity' (students perceive that it is difficult to get a job in their field) are not significantly associated with students' study engagement. In occupation studies, low income has been demonstrated to be a condition reducing employees' work engagement (Siegrist, 1996). However, our findings show that financial rewards and accessibility to labor market have no relationship with students' engagement with their major. We believe that the reason for this result is although higher education is occupational training and career-oriented, students mostly interact with learning process and conditions rather than occupation-related factors. Therefore, their study engagement depends on mostly training factors rather than occupational factors. However, in this study, it is worth noting that social work students reported a higher level of hesitation to pursue social work job when they come closer to graduation. This means though social work students are more engaged with their study than students from other majors, social work profession remains unattractive for them. In the long run, this situation may negatively affect social work education at tertiary level because education at tertiary level is basically occupation-oriented. Hence, the study suggests that policymakers should pay more attention to reduce the gap between study engagement and profession commitment in the field of social work in Vietnam.

To better understand this finding, it should be noted again that social work is still a new profession in Vietnam. Therefore, the findings that students love studying social work but do not want to do social work may be also a result of situation. Due to the national projects promoting social work profession in Vietnam, social work becomes more well known to the public, so it attracts high number of students enrolling in social work program in universities. However, the more they know about social work career, the less they are committed to social work profession because of the limitedness of job opportunity and low income.

5 Practical implication

The findings of this study suggest that, in order to boost students' study engagement, universitiesand educators should develop strategies to boost the students' perception of *meaningfulness, safety,* and *availability*. Students will find meaningfulness if they perceived that their major program has high social recognition and is contributive to social development. In addition, the more the courses provided in the program can help students understand and show their ability and help them to improve themselves, the more the students will be engaged with their study. Meanwhile, students' perception of *safety* can be reached if course materials are made accessible; lecturers show their supportive attitude to students' learning if the faculty staff is well-known experts in the field. Finally, the training program can increase their students' study engagement by ensuring their perception of *availability*. Strategies to increase students' perception of availability is creating more chances to connect students with job opportunity, ensuring that knowledge, skills, and professional attitudes provided in each courses are practically related to occupation so that students can feel that they are well prepared to do their job in the future. Moreover, if the training program can provide knowledge and skills which students can applied in their daily life, they will be more interested in and engaged with study.

6 Limitations of the study and recommendations for future research

As an exploratory study, the current study has some limitations. The study is limited in providing a more rigorous and comprehensive understanding of how program-related and job-related factors contribute to students' study engagement, especially when conceptualizing program-related factors into three aspects as meaningfulness, safety, and availability, as suggested by Kahn (1990). We developed the items for examining program-related and job-related factors based on qualitative interviews with undergraduate students in combination with Kahn (1990)'s suggestions in an exploratory approach. Our results suggest that it is worth for future research to develop a more reliable and rigorous measure of program effect in accordance with Kahn's theory. Moreover, we used convenient sampling strategy for questionnaire survey; even though the sample size is quite high, the findings are not generalizable. However, the findings of this study provide some considerable suggestions for future research in establishing an explanatory framework for study engagement at higher education level.

7 Conclusion

In comparison to students from some other majors, Vietnamese social work students are more engaged with their study and show a more positive perception of their major. However, they perceive that

social work profession brings lower income, and it is more difficult to find a job in social work than in other fields. However, the study documents that job prospects such as income and job opportunity have no association with Vietnamese tertiary students. The study strongly supports Kahn (1990) proposition that if the training program can provide students' sense of meaningfulness, safety, and availability, it can increase students' engagement with their study. However, further analysis acknowledges that this engagement seems not strong enough to motivate students' commitment to the profession which the students are being trained at universities. The exploration of social work education in Vietnam suggests that low income and limited job opportunities may neutralize the effect of study engagement on profession commitment. This might heighten the risk that students give up the profession in which they are trained at university to seek different occupations, despite how engaged they feel to their study at university.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Author contributions

TN: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. TB: Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – review & editing. LN: Investigation, Methodology, Project administration, Resources, Validation, Writing – review & editing. HD: Conceptualization, Investigation, Project administration, Resources, Writing – review & editing. NN: Investigation, Methodology, Project administration, Resources, Writing – review & editing. HM: Investigation, Project administration, Supervision, Writing – review & editing. HN: Data curation, Methodology, Validation, Writing – review & editing.

Ethics statement

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Check for updates

Student perception of sustainability in industry: a case study in an undergraduate petroleum processing course

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Research demonstrates a predominantly negative public perception of the oil and gas (O&G) industry, regardless of initiatives created to minimize the environmental impact. This might be attributed to a lack of open communication and debate spaces where these initiatives are learned and discussed. To test our hypotheses within a university setting, a major revamp of the course "Petroleum Processing" in our university was implemented, where sustainability concepts and open discussion were assimilated into the lecture content. Pre- and post-surveys were conducted to assess students' perceptions regarding sustainability in the O&G industry before and after the course. Perceptions remained unchanged following course delivery. However, students believe they are more informed about the sustainability approaches implemented.

KEYWORDS

SDG 9: industry, innovation and infrastructure, course revamp, oil and gas (O&G)
industry, students' perceptions

1 Introduction

The oil and gas (O&G) industry has been traditionally perceived as incompatible with transparently addressing and successfully incorporating green technology and sustainability initiatives into their supply chain operations (United Nations, 2017, 2023; Dadd et al., 2023), with significant discrepancies observed even today among companies and geographies (Okeke, 2021; CAPP, 2023). An analysis of 150 annual reports of 15 O&G firms based in Europe, America, and Asia led Okeke (2021) allows us to conclude that European companies have typically put more emphasis on environmental, social, and economic components of environmental sustainability than their American and Asian counterparts. This trend may be attributed to the regulatory pressure on implementing sustainability measures and initiatives to enhance societal awareness toward fulfilling such core sustainability practices (Okeke, 2021). Nevertheless, public perception of the O&G industry continues to reflect distrust and dislike, which may potentially arise from

its repeated non-compliance regarding environmental and social issues (Theodori and Jackson-Smith, 2010). A survey conducted by the consulting firm Ernst & Young found that over half of the 1,200 surveyed teenagers responded that the O&G produced presently is "not worth the environmental impact" (Rassenfoss, 2019). When compared to the public perception of various other industries, the survey revealed that the respondents distrusted industrial giants almost at the same level as healthcare; this distrust is only surpassed by the banking and pharmaceutical sectors.

Despite significant contribution toward climate change, the O&G industry continues to, and likely will for the foreseeable future, remain a key player in the global energy pool (Dewar et al., 2022). As such, several major O&G players worldwide are mandated to develop and implement integrated sustainability initiatives and strategies to maintain their operating licenses while global energy trends shift toward greener measures. Such strategies primarily focus on (i) reducing operations-based emissions by piloting and deploying commensurate technologies that monitor waste/exit streams, (ii) research initiatives to develop novel mitigation technologies, and (iii) diversifying toward the low carbon energy sector (Dewar et al., 2022). However, commensurate quantification of these measures' impact(s) remains challenging, as several more longitudinal indicators are required. Moreover, the public may also be unaware of novel transformative measures undertaken by the O&G sector. We hypothesize this occurrence because of: (i) a lack of open communication, and failure to adequately highlight the spectrum of "green" initiatives undertaken by the O&G sector, and (ii) a lack of spaces where people may debate about the perceived/actual benefits/drawbacks of these measures.

To test our hypotheses within a university setting, a major revamp of the elective course "Petroleum Processing" in the Department of Chemical Engineering and Applied Chemistry at the University of Toronto was implemented, and key sustainability concepts, such as integration between biorefineries and petrochemical plants and hydrogen production, were assimilated into the lecture content. A succinct simplified Life Cycle Assessment (LCA) comparison between different processes/industries was also performed. Students were provided with a space to discuss these impactful environmental/sustainability initiatives and offer opinions. Students' perceptions were recorded using a pre-survey at the beginning of the semester and a post-survey at the end of the course. This curriculum transformation exercise supports preparing our engineering students and future leaders to tackle the challenges in the sustainable development goals (SDG), particularly SDG 9 (industry, innovation, and infrastructure), as the revamping of our course aligns with encouraging students to actively upgrade industries by promoting innovative sustainable technologies and ensuring their access to information.

This article is structured as follows: section "2 Materials and methods" details the methodology used to record and assess students' perceptions regarding sustainability in the O&G industry before and after course delivery. Section "3 Results" presents and discusses the results we obtained from the conducted surveys. Section "4 Conclusion" discusses key conclusion that can be drawn from the survey results as well as future directions for this research.

2 Materials and methods

This section describes our sustainability integration strategy, and the framework used to assess students' perceptions.

2.1 Original course description and structure

CHE 451 – Petroleum Processing is a fourth-year elective course offered to chemical engineering undergraduates. Typically, the course is delivered in-person during the fall semester and has 15–25 students enrolled annually. The course aims to examine the operations of the oil refining industry from a primarily macroscopic standpoint via block flow diagrams (BFDs), while its main learning outcome is for students to obtain a generic overview of key petroleum processing operations, products, their economic importance, as well as major safety and environmental aspects employed in oil refining. Prior to implementing the revamp described in this work, the course traditionally included 16 lectures (designated as L), as summarized in **Table 1**. The grading scheme included a midterm (worth 25%), two assignments (A1 and A2), each worth 10%, a final project worth 20% (an essay on refineries for the future), and a final assessment worth 35%. The lectures had only one module discussing the environment and safety aspects and the course content was predominantly industry focused, rather than environment/climate-change focused.

2.2 Sustainability integration strategy

The imminent need to incorporate sustainability initiatives into traditional engineering curricula has been an issue addressed by several prior researchers. Some novel practices reported in the literature are (i) the embedding of sustainability-based perspectives into courses, (ii) careful design of new courses, and (iii) providing pathways for students to specialize and gain expertise in sustainable development (Ashraf and Alanezi, 2020). Out of these, the design and introduction of new courses, which aim to educate and empower students toward the ever-changing global perceptions and needs, remains the most popular pedagogical pathway of choice. Implementation of these strategies has recently revealed that (i) most such studies neglect the learning process in favor of assessing learning outcomes at a specific timeframe (a form of testing bias); (ii) and students' perceptions of sustainability may often approach those of their instructors throughout the learning experience, which may be viewed as a sign of conformance (van Mierlo and Beers, 2020). We believe that this convergence of ideological stance is to be avoided, and suitable learning environments should be devised, where students may develop their individual, different stances on the subject matter, which may be different from their fellow students and instructors. Thus, we aimed to develop and execute a course revamp in an unbiased, minimally disruptive fashion, to assess any tangible shift in student perception accurately. Therefore, this led to the design of a sustainability integration strategy to address the following research questions: (i) what are the current problems students perceive with the O&G industry? and (ii) how can a teaching team facilitate spaces for

TABLE 1 Original and revamped CHE 451 lectures (L) and assignments (A).

Code	Original CHE 451	Revamped CHE 451
	Description	
L1	Introduction to petroleum processing	Introduction to petroleum processing
L2	Refinery feedstocks and products	Petroleum products and test methods
L3	Refining processes	Processing operations in a petroleum refinery
L4	Crude distillation	Lubricating oils
L5	Coking and thermal processes	Petrochemicals
L6	Catalytic cracking	Product blending
L7	Hydroprocessing and hydrotreatment	Supporting processes
L8	Catalytic reforming and isomerization	Alberta crude oil
L9	Alkylation	Safety and environmental issues
L10	Product blending	Biofuels in a petroleum refinery
L11	Supporting processes	Hydrogen production
L12	Alberta crude/heavy crude oil	The refinery of the future
L13	Lubricating oils and blending stocks	–
L14	Petrochemical feedstocks	–
L15	Environmental and safety aspects in refining	–
L16	Refinery of the future	–
A1	Mass/volumetric balance in a refinery	Mass/volumetric balance in a refinery
A2	Safety aspects in a refinery	Safety aspects in a refinery

open discussion regarding industry practices and future directions for the energy transition? As a first solution, we executed a paradigm shift on the learning process by (i) aiming to deliver more comprehensive lectures that describe the environmental impact of oil production, refining/petrochemical supply chain operations, and actions implemented toward remediating it; (ii) facilitating in-class discussions comparing the LCAs between oil and biorefineries, as well as blue/green hydrogen production; and (iii) facilitating open discussions for students to debate the pros and cons of specific sustainability-related issues.

2.2.1 Lectures and assignments

The modified lectures for CHE 451 are summarized in Table 1.

While lectures L1–L3 maintained a similar structure as those being offered previously (ensuring minimal disruption and some conformity with previous content), the environmental impact of oil refining and petrochemical plants operations were incorporated in L4–L8, accounting for 15% of the course content. L7 was restructured to have 60% of the content discuss carbon capture initiatives and hydrogen sulfide management in refineries. L9 was dedicated to describing in detail potential safety issues and risks related to oil refineries, potential environmental issues, mitigation paths, and a summary of incidents experienced, and lessons learnt by the global O&G industry. L10 was a completely new lecture which introduced biorefineries, highlighting feed characteristics, operation and maintenance, and integration with existing oil refineries and/or petrochemical plants. Likewise, another novel lecture, L11, introduced hydrogen production in its entire color spectrum (blue and green primarily, but also turquoise, pink, yellow, gray, etc.). Moreover, a new assignment A2 was formulated

including safety aspects in oil refineries. Students were asked to complete a fault tree analysis on the side stripper of a distillation column, perform a simplified Hazardous Operation Procedure (HAZOP) analysis on a gasoline storage tank, and size a pressure relief valve on a pressure vessel containing an ideal hydrocarbon vapor.

2.2.2 Life cycle analyses discussions in-class

Life cycle analysis (LCA) is a reputed methodological framework often employed to perform a detailed environmental impact and feasibility assessment of a process/product through its five life cycle stages: raw material extraction, manufacturing and processing, transportation, usage and retail, and waste disposal. An LCA analysis typically estimates resource consumption, including energy or carbon emissions. However, despite several efforts toward standardization and universalization, LCAs tend to be specific, as inventory data may often be limited, and they may not necessarily estimate which product/process proves to be most cost-effective or best-performing. Nevertheless, we considered that by resorting to a structured process that analyzed the life cycles of biorefineries, oil refineries, and hydrogen production, LCAs permit for a fair comparative assessment of their individual environmental impact(s) and by extension, their sustainability. For the purposes of course discussion, three existing LCAs from the literature are selected: for oil refining (Liu et al., 2020), biodiesel (Sajid et al., 2016), and hydrogen production (Wilkinson et al., 2023). The instructor provided a summary of these papers during lecture L11, and a comparison table was provided to the students for analysis. Student discussions were to be based around comparing the assumptions and total

emissions generated by each of these processes. Current LCAs favor biorefineries/hydrogen-based processes over O&G processes in terms of sustainability, and this is in line with current global energy market trends. However, the road toward a sustainable alternative is not straightforward (expectedly), as standardization efforts are required to accurately evaluate/quantify sustainability through the LCA framework between these options. This exercise aimed to elucidate the inconsistencies between the assumptions employed in the LCAs, and the subsequent challenges in making a fair comparison between different processes.

2.2.3 General discussions

A set of discussion questions was provided to students during the lectures, including: (i) "Can biorefineries be integrated into refineries?", (ii) "How have oil refineries changed over the last 100 years?", (iii) "Are petrochemicals the future of the O&G industry?", (iv) "Do we "need" oilsands?", and (v) "Is hydrogen the fuel of the future?". For each of these prompts, students discussed in depth the advantages and disadvantages of these processes and their corresponding technologies, as well as any foreseeable challenges. These questions were intentionally designed to engage students in current "hot" topics, such as biorefineries and hydrogen production, and topics of controversy, such as petrochemicals/oilsands. We hypothesized that these discussions would promote changes in the students' perception of the O&G industry, which may be inferred from the post-survey results (see section "2.2.4 Assessment of integration effectiveness").

In our general discussions we explored the integration of biorefineries into refineries as an effective path to shift the knowhow from O&G toward clean energy, while simultaneously revamping existent oil refineries. We reviewed the environmental regulations required for upcoming years, and discussed contradictory reports pointing out that these efforts might or not be sufficient to tackle and/or eradicate the concern of the emissions. Other "non-conventional" oil extraction/production processes, such as oil-sands, were also discussed, specifically the potential of oil-sands to produce more pollution than its conventional counterpart, its contribution to Canada's economy, and current innovation efforts to reduce environmental impact.

The discussion about petrochemicals and their role as important raw materials for several processes and final products, was also incorporated in CHE 451. Recycling was the highlight of the discussion, with particular emphasis on the challenges facing current recycling practices worldwide.

Finally, a discussion surrounding blue hydrogen as a feasible alternative to other energy sources, such as coal, petroleum, and natural gas was incorporated. The benefits of blue hydrogen technology, such as the maturity of the production process, as well as the technical challenges around hydrogen storage and transportation were discussed.

2.2.4 Assessment of integration effectiveness

To effectively identify and measure the extent of the impact of the implementation of our sustainability integration strategy in CHE 451, students were asked to anonymously fill out a pre-survey at the beginning and a post-survey at the end of the fall semester. The pre-survey (Rassenfoss, 2019), run through Quercus (the online platform of our university), included three sections. The

first section featured two rating-based questions (Q1 and Q2) and was intended to assess the extent of student knowledge on process sustainability in the O&G sector. The second section was related to the perception of the O&G industry and included 15 rating-based questions (Q3 to Q14) and was intended to assess the student's perception of the O&G industry with respect to topics such as innovation, level of pollution, technology, leadership, economic importance, among others. The third section of the pre-survey referred to student's general industry perception, where seven rating-based questions were intended to rank the perception of the following industries: technology, automotive, retail, healthcare, energy, investment banking, and pharmaceutical. The post-survey was designed to assess changes in the students' perception of the course. This was done through three rating-based questions (Q1, Q2, and Q14 from the pre-survey). The rating scale for both surveys was defined from 1 to 5, as shown in **Supplementary Appendices A, B**.

3 Results

Figure 1 shows the results of the pre-survey. In **Figure 1A**, it can be observed that students believe that they are fairly informed about the sustainability approach adopted by the O&G (2.6/5.0). At the same time, students have slightly positive perceptions on how the industry efficiently tackles sustainability issues (3.0/5.0). In **Figure 1B**, we can cluster the responses based on rankings, observing that questions Q3 to Q7 provide the highest-ranking values (greater than 4.0), followed by Q8/Q9/Q11/Q14 (greater than 3.0), and Q10/Q12/Q13 (less than 3.0). The first cluster includes economic variables (e.g., importance to the national economy, it is a major employer, and provides a valuable service) and ranking the industry based on pollution. The second cluster encompasses items regarding how innovative and technologically advanced the industry is and the overall perception of the O&G industry. Finally, the third cluster includes the students' perception of the O&G industry's long-term importance, and the level of trust students have in O&G companies. Based on the results of the pre-survey, we can infer that the students believe the O&G industry plays an important role in the economy (4.6/5.0) and fairly rank its contributions to technological advances and innovations (3.7/5.0); there is an interesting finding that students neither agreed or disagreed that the O&G industry is "not worth the impact to the environment" (2.5/5.0). Finally, the level of trust "to do the right thing" reveals inconclusive results (2.8/5.0).

Figure 1C shows the students' general industry perception (technology, automotive, retail, healthcare, energy, investment banking, and pharmaceutical). Students cautiously rank their positive perception of all industries, with all rankings less than 3.1/5.0. The responses can be clustered into Technology and Energy ("high" positive perception, with 3.1/5.0 average), Pharmaceutical, Healthcare, and Automotive ("medium" positive perception, with 2.3/5.0 average), Retail and Investment Banking ("low" positive perception, with 1.6/5.0 average).

Finally, when comparing the results from the pre- and post-surveys (Q1, Q2, and Q14), **Figure 2** reveals that students perceive that they are better informed about the sustainability approach adopted by the O&G industry at the end of the semester (+54.8%

FIGURE 1
Pre-survey results: (A) questions 1 and 2, (B) questions 3 to 14, and (C) general industry perception.

FIGURE 2
Comparison of University of Toronto students' perception before and after the course.

FIGURE 3
Distribution of responses in the pre- and post-surveys, (A) Q1, (B) Q2, and (C) Q14.
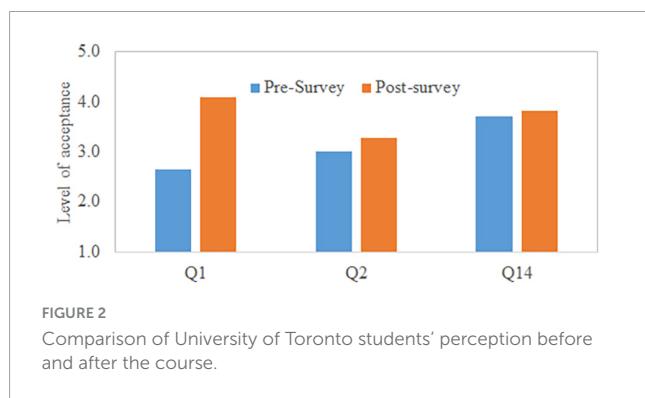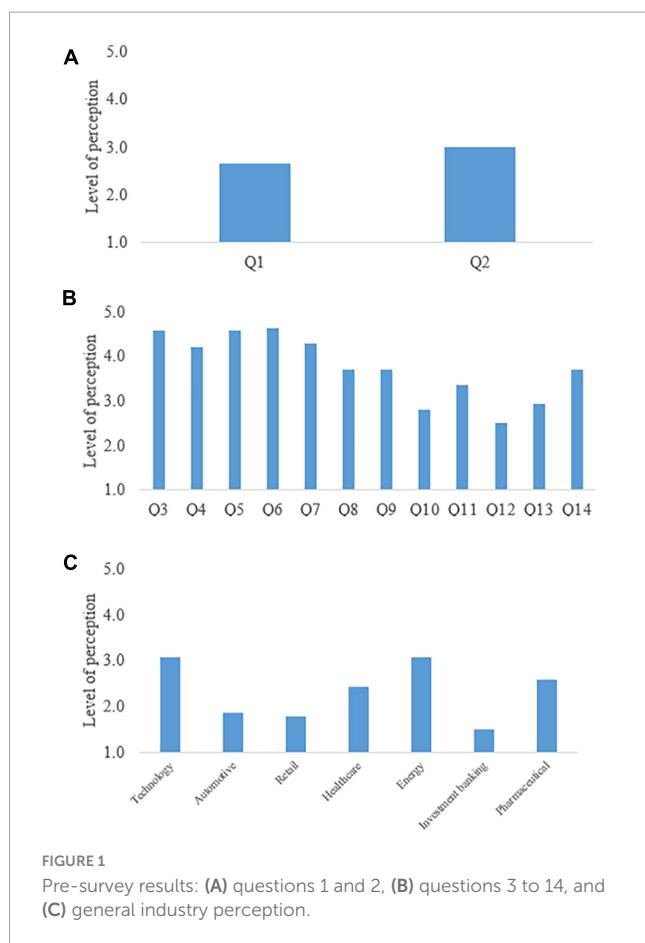
compared to the pre-survey). A +9.1% for Q2 reveals that students have a "more positive" perception of the O&G industry efficiently tackling sustainability issues; nevertheless, there is no substantial increase in terms of their "positive" overall perception of the industry (+2.8% for Q14). We believe that by revamping the course Petroleum Processing, students became more informed about the current trends and challenges related to the O&G industry and the energy transition, as was reflected in the post-survey results.

Figure 3A shows the distribution of responses in the pre- and post- surveys for the students. For Q1, a larger variation in student responses can be seen in the pre-survey in comparison to the post-survey. In the pre-survey, student responses for all five level of perception ratings were reported, with 50.0% of the students submitting a response of 2 ("disagree"). In comparison,
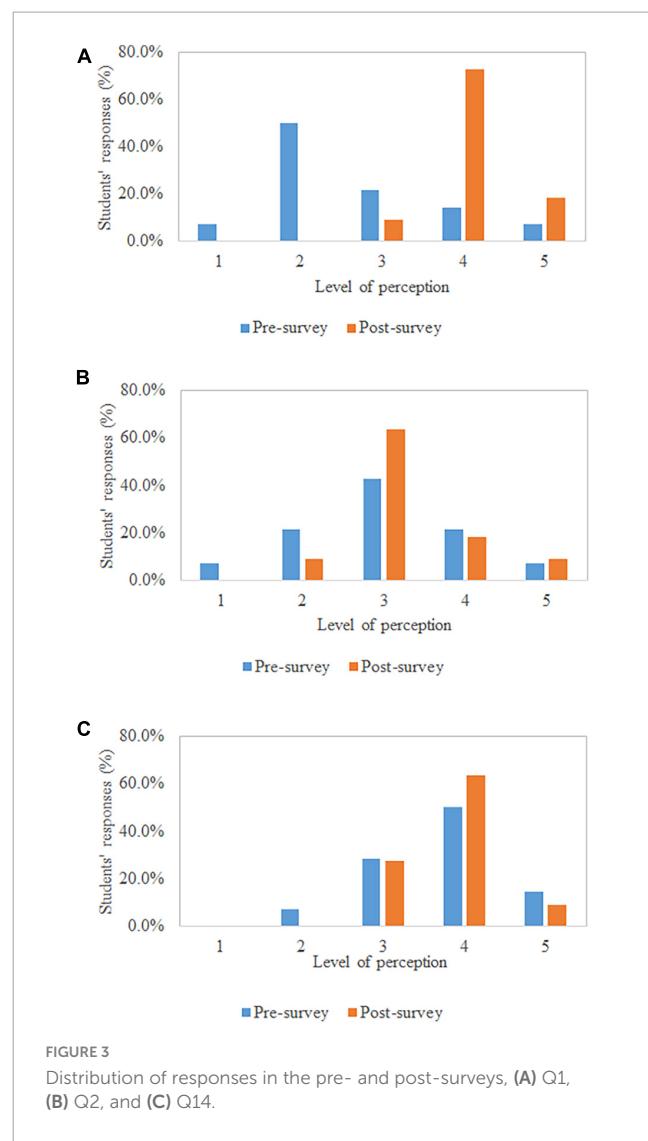
in the post-survey, only three different levels of perception ratings were reported, with 72.7% of the students submitting a response of 4 ("agree"). From this result we can infer that students entered the class with different levels of perceived knowledge surrounding sustainability approaches in O&G and that by the conclusion of the course, the majority of students reported.

Figure 3B shows that prior to the course delivery, the students' rankings for Q2 followed a "normal-like" distribution. Following course delivery, there is a shift in this distribution, with 63.6% of students reporting a ranking of 3 ("neither agree or disagree") and no students reporting a ranking of 1 ("strongly disagree").

Figure 3C shows minimal change in the distribution pattern of survey responses for Q14, however there was an increase of 13.6% in the number of students that reported a ranking of 4 ("agree").

In order to investigate the generalizability of the pre-survey findings, future work will include conducting similar surveys across different higher education institutions in different locations. For example, within Canada, students' responses in provinces such as Alberta may differ, as in this province, O&G is a larger contributor to its GDP, compared to the province of Ontario. Post-surveys can also be conducted in different institutions (including different

countries), considering different levels of sustainability content, to understand the impact that it has on students' perceptions. For instance, it would be quite interesting to compare students' perceptions in countries where the O&G industry makes a large contribution to the country's GDP in comparison to Canada (The World Bank, 2021). Most notably, our approach paves the pathway for a more rigorous curriculum design/development. The role of sustainability to create more inclusive, well-aware students has been documented in the construction sector (Hayles and Holdsworth, 2008), and that the predominant aim of environmental education is to change perceptions, bias, attitudes, to impact collective behavior change (Cotgrave and Kokkarinen, 2010). The biggest barriers to the incorporation of sustainability in an existent curriculum are, perhaps, academic indifference and approach toward teaching and assessment, student backgrounds, and lack of effective communication between the industry and academia (Cotgrave and Kokkarinen, 2010). This work provides a "middle-path" that does not shame the existent O&G sector, but instead, consciously presents sustainability in this sector in an unbiased fashion to university students, empowering them to critically assess and take their unique stance and perceptions on this industry.

Our results might have significant implications in the context of curriculum design and sustainability issues, which becomes even more relevant for future "environmentally conscious" generations. It is worthwhile to comprehensively understand the drivers and barriers for/toward curriculum change, to identify and develop a compatible framework to realize these goals. The instructor's ability, as well as the techniques/modes of delivery of the lecture content is also known to influence student perceptions (Stubbs and Schapper, 2011). What is also most reassuring is the fact that our approach has been shown to work in other scenarios, such as the comparative study between the UK and Australia, to develop appropriate curriculum design and promote sustainable literacy in construction education (Cotgrave and Kokkarinen, 2010). Likewise, attempts in the USA (Vincent and Focht, 2011) to obtain an ideal view of student curriculum reveal three curricular models (Systems Science, Policy and Governance, and Adaptive Management) as being most favored. A review on the characteristics of a sustainable curriculum (Woo et al., 2012) reveal that the key characteristics of curriculum structure should be based on complexity of knowledge (being flexible and permeate at a given discipline level), contextualization, prospective orientation, as well having consistency between theoretical concepts and practical cases. Simultaneously, teaching methods for instructors are more valued if they incorporate authentic learning experiences, reflection/introspection space, mutual learning, and research. Our approach to revamp a university elective curriculum builds on these "best practices" and is likely to pave the way for more pedagogical revamps across several universities in the future. As learning competencies become more technology-based (Chakraborty et al., 2023), it becomes progressively critical to integrate sustainability initiatives toward a more Artificial Intelligence (AI) predominated world; both contributing extensively toward the E.D. 4.0 goal and the I.D. 4.0 competencies. There is a growing revolution of Higher Education Institutions (HEI) to integrate curricula with the UN's Sustainable Development Goals (Cuevas-Cancino et al., 2024), and our work serves to clearly demonstrate how such pedagogical initiatives may be integrated/revamped into existing university curricula.

4 Conclusion

In this work, an undergraduate course in Petroleum Processing was revamped to include sustainability-related content, as well as the facilitation of open discussions to debate the pros and cons of sustainability approaches adopted by O&G industry. A pre-survey gathered information regarding the students' perception of the O&G industry, O&G industry with respect to other industries, as well as how well-informed students believe they are on the sustainability measures currently employed by the O&G industry. A post-survey was administered following completion of the course to assess changes in students' perceptions related to the pre-survey. We believe that the changes implemented in the course Petroleum Processing make students more informed about the current challenges facing the O&G industry regarding sustainability and trends in approaches taken to contribute to the energy transition by consciously presenting sustainability in this sector in an unbiased fashion to university students, to ultimately empowering them to critically assess and take their unique stance and perceptions on this industry. Moreover, our results might have significant implications in the context of curriculum design integrating sustainability issues for future "environmentally conscious" generations.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the University of Toronto, Ethics Protocol 44048. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SC: Formal analysis, Investigation, Validation, Writing – original draft. SK: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft. YG: Conceptualization, Formal analysis, Investigation, Resources, Writing – review & editing. JM: Formal analysis, Investigation, Resources, Visualization, Writing – review & editing. DG: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – review & editing.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024. 1396377/full#supplementary-material

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Check for updates

Students are using large language models and AI detectors can often detect their use

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Large language model (LLM) artificial intelligence (AI) has been in development for many years. Open AI thrust them into the spotlight in late 2022 when it released ChatGPT to the public. The wide availability of LLMs resulted in various reactions, from jubilance to fear. In academia, the potential for LLM abuse in written assignments was immediately recognized, with some instructors fearing they would have to eliminate this mode of evaluation. In this study, we seek to answer two questions. First, how are students using LLM in their college work? Second, how well do AI detectors function in the detection of AI-generated text? We organized 153 students from an introductory microbiology course to write essays on the regulation of the tryptophan operon. We then asked AI the same question and had the students try to disguise the answer. We also surveyed students about their use of LLMs. The survey found that 46.9% of students use LLM in their college work, but only 11.6% use it more than once a week. Students are unclear about what constitutes unethical use of LLMs. Unethical use of LLMs is a problem, with 39% of students admitting to using LLMs to answer assessments and 7% using them to write entire papers. We also tested their prose against five AI detectors. Overall, AI detectors could differentiate between human and AI-written text, identifying 88% correctly. Given the stakes, having a 12% error rate indicates we cannot rely on AI detectors alone to check LLM use, but they may still have value.

1 Introduction

Students have long used digital writing tools (spelling, style, and simple grammar checkers) to write assessments since their emergence in word processing programs in the late 1980s. These tools save the students time, help them learn writing skills, and result in a better final product. For years, autocorrect on phones has helped many a wayward finger but is sometimes the bane of anyone texting on their phone. More recently, writing assistants such as Grammarly, WordTune, and Perusall have helped students improve their writing, especially those where English is a second language. In most cases, these tools have been seen as helpful assistants to students, pointing out errors and allowing students to focus on core learning objectives (Perkins, 2023). All of these tools rely on some sort of artificial intelligence (AI).

In late 2022, the emergence of powerful large language model (LLM) artificial intelligence has scrambled the world of written communication. Some examples of large language models are BERT, GPT, Falcon, Ernie, and Palm, with more coming every month. Most LLMs are neural networks trained on large sets of textual data. A large proportion of the data used to

train LLMs is freely available on the Internet. LLMs then use their giant neural network to predict the next word of a sentence, which is repeated over and over to generate a complete response (Radford et al., 2019). The ability of these models to create human-like text and engage in conversations has generated significant interest in their abilities.

Educators are excited to explore these tools and determine how they could foster learning. LLMs can potentially change the focus in written tasks from mundane grammar to higher-level functions that engage the student with the material under study (Hess, 2023). Users can further enhance their prompts to the LLM to improve the response through conversation with the AI. Answers from the LLM can be phrased in plain language, making information easier to learn and helping people with communication disabilities (Hemsley et al., 2023). These models can serve as a tool for providing preliminary feedback to students and allow the instructor to focus on the content of their ideas, leaving the LLM to help the students with grammar and phrasing (Zawacki-Richter et al., 2019). Other forms of artificial intelligence (AI) can also identify at-risk students for intervention (Ouyang et al., 2022). The utilities of AI in higher education will expand as educators' experience increases.

Some educators also fear that these tools will short-circuit the learning process. Having students explain their understanding through written communication is one of the most effective forms of formative and summative assessment (Graham et al., 2015). We are all concerned our students will use LLM tools to create written assessments on their behalf, as nearly one-third of students report using Chat GPT (Intelligent, 2023). How can an instructor be sure that the ideas in a paper are those of the student and not AI?

The rapid emergence of LLMs, the apparent rapid adoption by some students, and the fevered discussion in society in general have universities playing catch up. Some universities have prohibited it outright, others have allowed it with restrictions, but most universities are hesitant to set policy without a larger time frame to assess its costs and benefits (Sullivan et al., 2023). Many of these policy decisions are difficult to make due to the newness of LLMs. Much of the opinions so far reported in the media and journals focus on the reactions of university staff and not student behavior. News media coverage of AI use in schools focuses on concerns about academic integrity and ways to discourage students from using LLMs in their academic work (Sullivan et al., 2023).

However, an important distinction here is how the students use LLMs. Most would define misconduct by a student as using an LLM, without attribution, to create the majority of the content of an assessment. When asked in the Intelligent survey (Intelligent, 2023), nearly 80% of students felt using an LLM was somewhat or definitely cheating, but the survey gave no details on how the students were using LLMs. While a few groups have surveyed students, it is still unclear how many students use LLMs and how exactly they use them. We need to know how students are using LLMs. They could be using it as a sophisticated form of information look-up to generate ideas for a writing assignment, to outline a paper to be written, to write the actual paper, to answer questions on a homework assignment, or to answer questions on an online exam. Most would agree the latter three uses would be academic misconduct. However, opinions vary on the first three uses of LLMs in assignments. The undetected use of AI can also have significant societal impacts, including mass propaganda through social media, news invented by LLMs, toxic spam to drive engagement, dishonest writing,

fake product reviews, fake job applications, fake university application essays, or fake journal articles (Gillham, 2023). In addition, LLMs are known to hallucinate, making up facts or citations (Ye et al., 2023). Universities and other institutions must enact policies and procedures that ensure the transparent use of LLMs.

Nearly simultaneously with the rise of LLMs, detectors claiming to be able to detect content written by LLMs have emerged, including Open AI[1], Turniitin[2], GPTZero[3], ZeroGPT[4], Content at Scale[5], Winston[6], Originality.ai[7], and Packback[8]. These have met with mixed success; some assert their effectiveness, while others doubt their accuracy, but few independent studies of AI detectors have been undertaken. Liang et al. discovered that AI detectors would mistakenly flag non-native English speakers' writing as AI-generated (Liang et al., 2023). In some instances, faculty have unfairly accused students of cheating with AI based solely on the results of these detectors, resulting in significant controversies (Klee, 2023). Open AI eventually closed its detection tool due to its inability to differentiate between human and LLM-generated text. Other universities have decided to turn off the detection capabilities of some packages due to concerns about false positives (Coley, 2023).

Some studies have examined the ability of humans or AI-detection software to differentiate between human and AI-generated content. Small studies attempting to assess and train human graders to detect AI content have had limited success, with the graders identifying a significant amount of content incorrectly as human or AI-generated when the opposite was true (Clark et al., 2021; Gunser et al., 2021; Köbis and Mossink, 2021; Abd-Elaal et al., 2022). AI content detection tools have shown a better success rate. However, the occurrence of false positives and false negatives at too high a rate calls into question their usefulness (Elkhatat et al., 2023). A limitation of many of these studies is the small number of samples, especially human samples, tested. In addition, newer detectors are constantly appearing, as are tools that promise to avoid detection. An analysis using a larger group of students, focusing on a realistic assignment, would be useful. We also thought it would be interesting for students to work with a LLM and try to disguise the answer. Then, test AI detectors to see if they could correctly differentiate the writing samples.

In this study, we present an experiment carried out with the Fall 2023 cohort of introductory microbiology students at the University of Wisconsin-Madison. We asked students to write an essay of approximately 500 words explaining a topic in microbiology. They then created a prompt and submitted it to ChatGPT 3.5 or Google Bard to complete the same assignment. Finally, they attempted to disguise their answer to avoid AI detection. This process created a large dataset of 459 unique responses generated by individual students. We submitted all three essays from each student to five AI detectors: GPTZero, Wintson, Content at Scale, ZeroGPT, and Originality.ai. We chose these detectors because of their popularity, ability to

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1 The Open AI detector was discontinued due to inaccuracy.
2 https://www.turnitin.com/
3 https://gptzero.me/
4 https://www.zerogpt.com/
5 https://contentatscale.ai/ai-content-detector/
6 https://app.gowinston.ai
7 https://app.originality.ai
8 https://www.packback.co/

be automated, and price. Students were also surveyed about their use of LLM in their academic studies.

The work found that 46.9% of students had at least explored LLMs. However, only 11.6% were using LLM on at least a weekly basis. The survey also showed that 7.2% had used LLMs to write an entire essay, and 39.2% had used it to answer questions on an exam or homework. We also found that the AI detectors GPTZero, ZeroGPT, and Orginatily.ai were successful at differentiating writing by students from that written by LLMs. Most students were unable to disguise their text and fool the detectors, but there were rare exceptions where the students were successful at disguising the text.

2 Materials and methods

2.1 Recruitment and class characteristics

Students enrolled in Microbiology 303 (The Biology of Prokaryotes) in the Fall of 2023 at UW-Madison were invited to participate in the study. Microbiology 303 is the introductory lecture for microbiology majors, and various majors in STEM fields also enroll in the course. Students were awarded 5 extra credit points to participate in the experiment but were given the option to leave at any time and still earn the extra credit. All students who attended the experiment decided to participate. Out of the class population of 224, 153 took part in the study. The racial breakdown of students was 74% white, 17.5% Asian/Pacific Islander, 4.5% Hispanic, 1.3% Black/African American, and 1.9% prefer not to say. Their year in school was 1.3% freshman, 13.6% sophomore, 47.4% junior, and 35.1% senior, with the rest being graduate students, a special student, and a non-degree-seeking student. The experimental design was submitted to the Madison Institutional Review Board (IRB), which determined that since the survey was anonymous and the focus of the research was the efficacy of the AI detectors, it did not constitute human subjects research (Submission ID No. 2023–1,548).

2.2 Administration of the survey

The survey (Supplementary material S1) consisted of students answering a question involving the tryptophan operon with or without the help of AI (as described above), and also completing several follow-up questions regarding their personal use of AI. The students signed up to participate in one of nine one-hour time slots from 29 November 2023 to 14 December 2023. Students took the survey in the presence of the experimenter to ensure a clear understanding of the survey and to prevent them from using LLMs in inappropriate places or plagiarizing answers from other sources. In the survey, they answered the following question:

> Explain the three levels of regulation of the tryptophan operon in *E. coli*. Make sure to include the proteins involved in each level and how they modulate the expression of the genes. Your answer should be about 500 words.

This topic was chosen because TP recently lectured on the regulation of the tryptophan operon of *Escherichia coli* and assessed them on the same material in an exam. Understanding bacterial

regulation is a learning outcome in many microbiology courses, and the tryptophan operon is a common regulation paradigm. Students were allowed to use their notes to answer the question. Students then asked the same question of a LLM—either Google Bard (v. 2023.11.21 or 2023.12.06 versions)[9] or OpenAI's ChatGPT (v. 3.5)[10]. They could modify the prompt until they were satisfied with the answer. The students then added the unaltered AI answer to another part of the form. Next, the students attempted to modify the AI answer and disguise it in hopes of fooling an AI detector. The altered answer was put into a third part of the form. Finally, the students answered several questions about their use of AI. All responses were anonymous.

2.3 Testing of responses using AI detectors

All 153 survey responses were downloaded and saved as a CSV text file. We removed quotation marks (") in answers using Libre Office. This step prevents the quotation marks from confusing downstream scripts during processing. We developed a Python script to automate the process of submitting the students' answers to five AI detectors: GPTZero, Wintson, Content at Scale, ZeroGPT, and Originality.ai. The script took each answer and sent it to the detector website using an application programming interface or controlled the form interface at the website. The results of the AI check were then retrieved and recorded in a spreadsheet. The Python script is available in the Supplementary material S2. We recorded metrics for GPTZero, ZeroGPT, and Qriginality.ai as %AI (0–100) and for Winton as %Human. Content at Scale replied in one of three ways: *Passes as Human!*, *Hard to Tell!*, or *Reads like AI!*. In analyses, We converted the %Human value returned by Winston into %AI by subtracting %Human from 100.

2.4 Determining the accuracy of AI detectors

We determined the success of AI detectors as outlined by Gillham (2023). For comparisons, true positives (TP), false positives (FP), true negatives (TN), and false negatives (FN) were calculated. A TP was a human-written text that the AI detectors classified as ≤50% AI. A FP was a human-written text that was identified as >50%AI. A TN was an AI-written text that the AI detectors classified at >50% AI. Finally, a FN was an AI-written text that the AI detectors classified as ≤50% AI. We calculated the accuracy (a) of the detectors as follows:

$$a = \frac{TP + TN}{TP + FP + TN + FN}$$

Precision (p) as:

$$p = \frac{TP}{TP + FP}$$

Recall (r), the true positive rate, as:

$$r = \frac{TP}{TP + FN}$$

Finally, we determined the overall performance of each detector by calculating an F1 score. This score takes into account both FP and FN.

$$F1 = \frac{p * r}{p + r}$$

The values for a, p, r, and F1 can range from 0 to 1.

2.5 Calculation of similarities

We calculated similarity measurements between the text written by students using the Python natural language toolkit (Bird et al., 2009). We used three methods: the cosine similarity, the Jaccard Similarity Index, and the Levenshtein distance. The cosine similarity measures the closeness of two sets of text that have been vectorized into multidimensional space. The Jaccard Similarity Index is the measurement of the similarity of two datasets. The texts to compare are transformed into sets, and the size of the intersection of the two sets is divided by their union. The Levenshtein distance indicates the number of changes required to transform one text into another. We measured similarities between human vs. AI, human vs. disguised, and AI vs. disguised.

2.6 Statistical analysis

We performed statistical analysis in R (R Development Core Team, 2022). We plotted histograms of each set of essays (human, AI, and disguised) for each detector. These plots suggested non-normalcy, and a Shapiro–Wilk normality test confirmed it. To test for statistical significance between the means, we performed a two-sample Wilcoxon's signed rank test between human vs. AI, human vs. disguised, and AI vs. disguised for each detector. We also used R to generate box plots of the detector results. In addition, we used R to create scatter plots comparing the Jaccard Similarity Index vs. AI-detection rates. The R commands to generate the plots are included in the Supplementary material S3.

2.7 Coding of student answers to survey questions with "other" as a choice

Three questions need to be coded for analysis. These were: Q11, "How have you used AI in your college work?," Q12, "Which of the following would you consider ethical uses of AI in your college work?," and Q13, "If you used AI in a way that you or your instructor might consider unethical, why did you do it?" We read and coded students' other responses, organizing them into categories. For Q11, we created 14 categories: Increase Understanding, Answer Questions on Homework, Answer Questions on Exam, Focus on Premise, Outline an Essay, Write an Essay, Editor/Grammar, Summarize Text,

Study Guide Prompts, Writing outside of school (resumes, cover letters), Format/Find citations, and Find errors in code. For Q12, we created eight categories: Understanding Concepts, Premise/Title/Citations, Grammar, Outline Essay, Answer Homework Questions, Create Questions for Studying/Summarizing, None/Inaccurate, Write an Essay, and Answer questions on quiz or exam. For Q13, we created five categories: Lack of Time, After Large Effort, As Confirmation, Confusion with Writing/Reading, and Others are Using it.

2.8 Assessment of student, AI, and disguised answers

All 459 responses created by the students were graded using a rubric (Supplementary material S4). Before grading, the text was placed into a new spreadsheet, with each of the responses assigned a random code that hid the origin of the text (human, AI, and disguised) to prevent grading bias. A code sheet was also created that mapped each text response to its student ID and sample identity. After all samples were graded, the results were decoded using the code sheet, and the sample scores were compared.

3 Results

In total, 153 students explained the regulation of the tryptophan operon in about 500 words under direct supervision instead of having an online survey. These sessions allowed TP to clarify the directions and verify that students appropriately composed the three different pieces of writing. The goal of the writing exercise was to create authentic human writing, so students were allowed to use their notes, ask questions, or look up things online. The key was that they were to write their human response in their own words. Since the size of the groups was 30 students or less, we were able to verify that they wrote the human sections themselves. Students were allowed to work on the survey as long as they wanted, with most students finishing it in 30–60 min.

3.1 Students are using AI, but only occasionally

Students were surveyed about their LLM use. Over half (53.1%) have never used LLMs or experimented with them out of curiosity but decided they were not valuable to them. Approximately one-third (35.4%) use it a few times a month, 8.5% use it weekly, and 3.1% use it daily. The LLM used most often by students is ChatGPT (84.7%), with others mentioned being Chegg (6.1%), Bard (4.1%), Bing (3.1%), Snapchat AI (1%), and Quillbot (1%).

3.2 How are students using LLMs?

Students reported using AI in many ways, Figure 1. Many students (43 out of 153) are not using AI at all. In reading responses that students put in the other section of the question, these students gave two main reasons for not using AI: they "did not think it was helpful
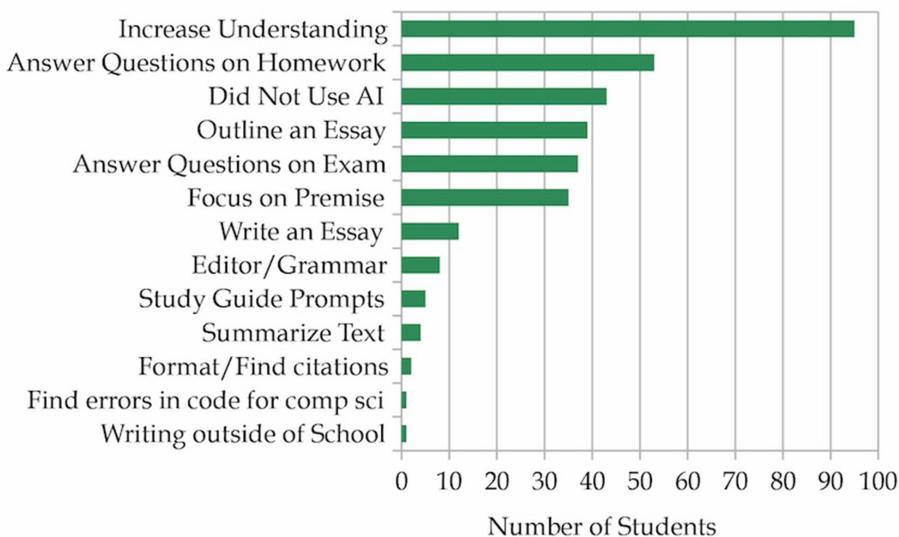
FIGURE 1
LLMs are used for many different tasks.

FIGURE 2
What students think are ethical uses of LLMs.

due to inaccuracies" or "they feared being accused of academic misconduct by their instructors." Students often used LLMs as a digital tutor, having the LLMs explain concepts they were trying to learn or summarize a text they were reading. They also reported using LLMs to offload some writing tasks, such as checking grammar and spelling, working on a premise, outlining a writing assignment, or even writing an entire article. Finally, students also used LLMs to answer questions on homework assignments or exams.

The survey also asked students what they would consider to be the ethical uses of LLM. Figure 2 shows the responses of 153 students. Most students (141) thought using LLM to understand concepts was ethical, and some more sophisticated users (5) used LLM to create questions or write summaries of topics under study. In writing, 101 thought finding premises for essays, improving grammar, or correctly formatting citations was ethical. While 64 felt more extensive uses, such as writing the outline, were appropriate, 5 even argued that having AI

write the first draft of the essay was acceptable. Some students (29) thought it was ethical to have LLM help them answer homework questions, and 5 thought having LLM answer exam and quiz questions was ethical. Finally, 5 students thought LLM had no ethical uses and were skeptical of its accuracy, especially in advanced classes.

For those students who did use the LLM in ways they thought others might consider unethical (54 students), the survey asked them why. Most often, students ran out of time or were stressed out (47.4%), or after trying to find an answer on their own and failing (19.3%), they would turn to the LLM for help. Others used AI as confirmation (15.8%) after they had answered a question. Some used AI when they felt their instructor did a poor job teaching concepts and they were confused about how to answer a question (8.8%). Finally, others justified using the LLM because they thought everyone else was using it (5.3%).

3.3 Students with a better understanding of the AI or the topic were no better at disguising their answers

Are students who have used AI better at disguising their answers than those who are naïve to AI? Students were divided into two groups: those who had used AI in the last 6 months (96 students) and those who had not (57 students). A comparison of their %AI scores of their human writing was identical, with both being marked with an average score of 16.1% AI with standard deviations of 31.3 for no AI use and 30.2 for the use of AI. The AI responses they submitted also had no difference, with AI scores of 98%. Finally, the deception text did show a small difference, with naïve students having an AI score of 81% while experienced students earning 74.3%. However, Wilcoxon's signed rank test showed a p-value of 0.31, indicating no significant difference between the means.

We also wondered if students who understood the topic would be able to better identify errors made by the AI and fix them and, in the process, also disguise the text from AI detectors. All 459 attempts to explain the regulation of the tryptophan operon were assessed using a rubric (Supplementary material S4). Before the assessment, the origin of the prose (human, AI, and disguised) was hidden to prevent grader bias. After grading, the scores were reassociated with each student for comparison. The scores were separated into two groups: students' human responses earning 100% of the points or higher (39 responses) and those earning <65% of the points (41 responses). Thus, we were comparing the students who answered the question well to those who scored the lowest on the question. The expectation was that students with better understanding might be able to better fool the detector. A comparison of disguised AI% scores for Originality.ai and ZeroGPT showed less than a 3.3% point difference between the higher scoring vs. lower scoring groups (Originality.ai: 73.3.0% vs. 72.1%) and (ZeroGPT: 52.4% vs. 55.7%).

A comparison of all the responses by students vs. AI showed that students were significantly better at answering the question overall, with human responses scoring 80% vs. 55% for the AI. Interestingly, when students tried to disguise their answers, they did not correct the mistakes the AI made, and there was very little improvement in the disguised score (57%). Many more students earned perfect scores (39) vs. the AI (6) or the disguised text (7).

3.4 Can AI detectors differentiate between human and AI-generated text?

We passed the text created by students through five AI detectors: Content at Scale, GPTZero, ZeroGPT, Winston, and Originality.ai. The AI detectors from GPTZero, ZeroGPT, and Orginality.ai reported values as %AI content. Winston's AI detector returned a %Human score. For comparisons, we converted Winston values to percent AI by subtracting the Winston %Human score from 100. Content at Scale returned three responses (Passes as Human!, Hard to Tell!, and Reads like AI!). While the AI-detector from Content at Scale had a recall rate of 0.89, its accuracy of (0.45) and precision of (0.47) indicate an anemic ability to identify AI-generated text. Due to the poor performance of Content at Scale, it will not be further analyzed in this study.

The other AI detectors had better success in correctly identifying human vs. AI-written text. Figure 3 shows a box plot of detector accuracy. In general, all four detectors could identify most of the generated content correctly. There was a clear distinction between human-generated text and AI-generated text. The students were somewhat successful in disguising their text, with the percentage AI value dropping 21% after being altered. However, the AI scores of the disguised text averaged 50 points higher than human samples. A two-sample Wilcoxon's signed rank test comparing human-vs-AI and human-vs-disguised for all detectors showed significant differences in means (Table 1). In the human and disguised samples, there were long tails on the box plots for some categories. The Winston detector failed badly when examining human text, flagging nearly half as false positives. GPTZero (24/152), Originality.ai (27/153), and ZeroGPT (15/153) had lower false positive rates. Thus, on average, for GPTZero, Originality, and ZeroGPT detectors, 14% of students would be detected using AI when they did not, and 5% of students who used AI would escape detection.
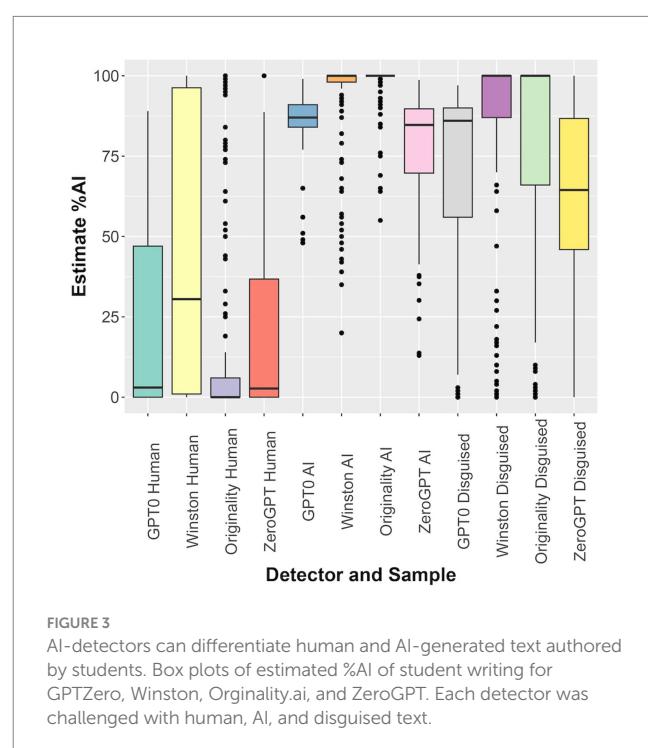
FIGURE 3
AI-detectors can differentiate human and AI-generated text authored by students. Box plots of estimated %AI of student writing for GPTZero, Winston, Orginality.ai, and ZeroGPT. Each detector was challenged with human, AI, and disguised text.

TABLE 1 AI benchmarks for detectors.

Detector	Wilcoxson (p)	Accuracy	Precision	Recall	F1
GPTZero (Human vs. AI)	< 2.2e-16	0.87	0.82	0.95	0.88
GPTZero (Human vs. Disguised)	< 2.2e-16	0.82	0.80	0.81	0.81
Winston (Human vs. AI)	< 2.2e-16	0.80	0.74	0.93	0.83
Winston (Human vs. Disguised)	5.053e-13	0.74	0.7	0.78	0.74
Originality.ai (Human vs. AI)	< 2.2e-16	0.91	0.85	1.0	0.92
Originality.ai (Human vs. Disguised)	< 2.2e-16	0.82	0.82	0.78	0.80
ZeroGPT (Human vs. AI)	< 2.2e-16	0.91	0.90	0.91	0.91
ZeroGPT (Human vs. Disguised)	< 2.2e-16	0.79	0.87	0.64	0.74

Several metrics are commonly used to assess the quality of AI detectors: accuracy (a), precision (p), recall (r), and F1 (see methods for details). Table 1 shows the results for each of the detectors when examining Human and AI-generated text. GPTZero, Originality.ai, ZeroGPT, and Winston did a comparable job, with Winston being a bit less precise (able to identify AI-generated text less accurately) than the others. If we exclude Winston's results, the F1 values of detectors were above 0.88.

Students' attempts to disguise the use of AI were somewhat successful (Table 1). All of the metrics dropped: recall (−20.6%), accuracy (−9.1%), precision (−3.7%), and F1 (−12.6%). Again, GPTZero, Orginality.ai, and ZeroGPT faired a little better than Winston, but the majority of the disguised text was still flagged as written by AI for all detectors.

An examination of the most successfully disguised text showed almost complete modification of the raw AI output (Figure 4). In panel A, the student reduced a response with an 89% AI score to 0 by substantial editing. (The non-highlighted text is the text the two responses have in common.) For those successful at disguising their AI answer, similarity metrics showed a large difference between the AI and disguised responses. In successfully disguised samples (<33% AI), the cosine similarity was 0.771 and the Jaccard Similarity Index was 0.501. In contrast, for those still detected as AI, the cosine similarity was 0.904 and the Jaccard Similarity Index was 0.69 between the AI-generated and disguised text. This lower similarity of the successfully disguised text shows that those who beat the detector successfully had done substantial editing. Panel B shows a disguised response that did not fool the detector. This failure to beat the detector is unsurprising since the student changed very little of the text. Examination of the several dozen or so responses that beat the detector showed a similar pattern. For students to beat the detectors, they had to rewrite the text substantially. It is possible that the students passed the initial AI response through AI summarizers such as AI Summarizer[11] or Quillbot[12] and did not edit the text themselves.

We plotted all four AI detector scores against the Jaccard Similarity Index between the AI-generated text and the disguised text, as shown in Figure 5. One would expect that as the students increased their modification of the text, the Jaccard Similarity Index would decrease, and the %AI score would also drop. The correlation roughly holds for GPTZero, ZeroGPT, and Originality.ai, with R values of 0.34, 0.36, and 0.38, respectively. The p-value for the Pearson correlation fit was significant for all three.

4 Discussion

This study organized a large group of microbiology students to answer a question about the regulation of the tryptophan operon. The same question was also posed to a LLM. Students were then tasked with trying to disguise the LLM answer to fool AI detectors. Students' creation of AI prompts and their attempts to fool the detector are the unique aspects of this study. We then assessed the ability of five AI detectors with the prose created by the students. Students also answered survey questions about their use of LLM.

There is a possibility that students were not truthful in the survey. However, we find it unlikely. The survey was anonymous, students were explicitly encouraged to be truthful at the beginning of each session, and there was no incentive for them to lie.

4.1 Half of the students had at least explored LLMs and some are using them in inappropriate ways

Of great interest to educators is how their students are using LLMs. This study found that about half of students are not using AI in their academic work. Another third used it only occasionally. We found that 11.6% of students routinely use AI in their college work. Other recent surveys found that approximately one-third of college students were using AI on written assignments (Intelligent, 2023). The use frequency of LLMs is lower than we expected (11.6% more than once a week). It appears right now that a majority of students are not

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11   https://www.summarizer.org/

12   https://quillbot.com/

FIGURE 4
Successfully disguised text has significant changes from the AI response. The AI response is on the left and the disguised text is on the right. **(A)** A successfully disguised answer that dropped the AI score from 89 to 0%. **(B)** A failed attempt to disguise an answer that did not change in AI score. The non-highlighted text is the text the two responses have in common.

using LLMs in their studies. However, we anticipate that the proportion of students using AI in academic work will increase.

A major benefit of the current study was asking specific questions about students' behavior and thoughts on the use of LLMs. The survey by Intelligent (2023) asked one-third of students using LLM if they thought they were cheating, and over 75% thought they were but did it anyway. In this study, we asked students about their behaviors in more detail. Much of the use of LLMs (66%) was to understand

concepts, double-check answers, help focus on a premise, summarize text, or perform grammar/editor functions. These uses would be acceptable to many instructors. It was concerning how many students (39%) were using LLMs to answer questions on homework or out-of-class exams. While other questions in the survey indicated that some of this work was double-checking answers, too many students are using it to cheat. The poor performance of LLMs in answering a basic question in bacterial regulation should serve as a
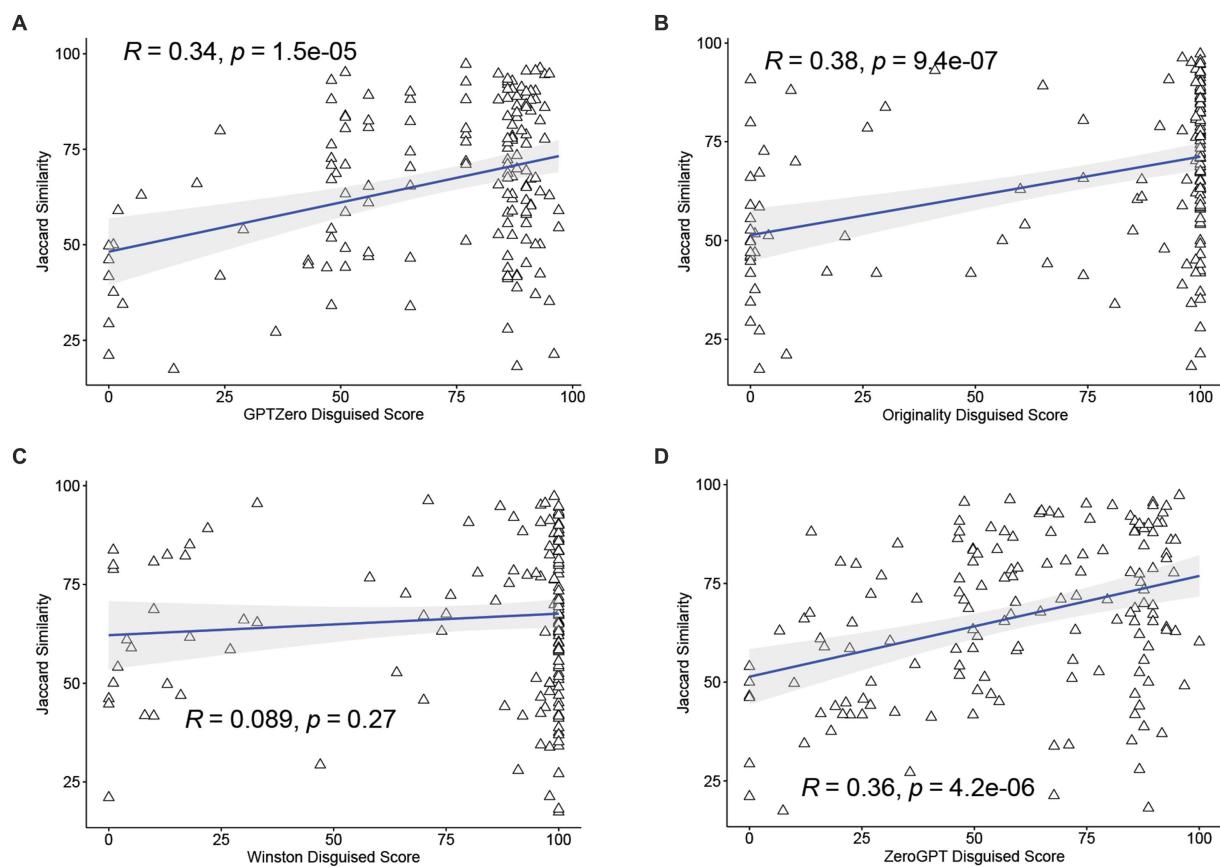
FIGURE 5
The more human editing that is done to disguise a text, the lower the AI score. A comparison of AI score vs. Jaccard Similarity Index between AI-generated text and disguised text. GPTZero **(A)**, Originality **(B)**, Winton **(C)**, ZeroGPT **(D)**. For three of the four detectors **(A,B,D)**, as the Jaccard Similarity Index decreases, so does the AI score.

cautionary tale to students. Instructors may have to redesign written, out-of-class quizzes and exams because, clearly, many students will use LLMs to complete them. A small minority (7%) of students reported using AI to write entire papers.

Students are just beginning to explore the uses of LLMs for their studies, and they have some sense of ethical uses of the technology. However, there is confusion about the boundaries, with some students believing that using AI to create outlines or even write first drafts of their academic work is acceptable. Many instructors would probably disagree. Students need to know the acceptable uses of AI in their classroom. It is imperative that instructors, administrators, and colleges set clear guidelines for students *and* instructors. Due to the rapid development and deployment of LLMs, this is an urgent priority, and higher education can no longer take a wait-and-see attitude.

When asked why students used LLMs in ways they would consider unethical, the number one answer was a lack of time. Students also listed a failure to find the answer on their own, confusion about what the question was asking, and because they thought others were using LLMs to cheat. These responses are in line with recent work that explains cheating by situational motivations (Waltzer and Dahl, 2023). The perception that using AI in these ways is not cheating, along with factors such as the need for a good grade, may override students' motivation to be honest.

The survey population was restricted to 153 students taking a microbiology course. Larger surveys, with greater diversity in race, class, and type of college, would be valuable.

4.2 Familiarity with using an AI does not correlate with avoiding detection

Understanding of the topic or familiarity with AI tools did not impact the ability of the students to evade detection by the AI detectors. It seems as if knowing how to use an AI or being skillful at writing effective prompts did not correlate with an ability to avoid detection. Avoiding detection seems to be a separate skill set, one that is not honed by using AI. Avoiding detection requires significant rewriting by the student, to the point that just writing the assignment themselves would probably be less effort.

The grading of the answer to tryptophan regulation indicated that many students on their own understood the regulation of the operon and could explain it well. However, the AI responses earned close to a failing grade. General LLMs can create responses that, on the surface, seem accurate. However, when the LLM was asked to explain what we would consider basic regulation in bacteria, it was not up to the task.

In reading through all the AI responses, there were wildly inaccurate explanations stated in confident language. One common error was the inclusion of the *trp* RNA-binding attenuation protein in discussing the regulation of tryptophan in *Escherichia coli*. This protein is not found in *E. coli* but instead is present in *Bacillus subtilis* tryptophan regulation. A second common error was the insertion of catabolite repression, a system that regulates the expression of carbohydrate degradation genes in *E. coli* but is not involved in tryptophan biosynthesis. It appears that AI struggles significantly when it is asked to produce text in an area of specialized knowledge. The limited ability of AI to answer more specific questions is unsurprising since LLMs are trained on publicly available text. There is too large of a probability that training text will contain inaccurate information, thus confusing the LLM. A common misconception for students is to mix up the behavior of the secondary structure in attenuation and describe the opposite result. In other words, they will think low concentrations of tryptophan lead to the formation of the rho-independent terminator that stops transcription. We often found this error in LLM explanations, suggesting it may have picked up this misconception from errant pages describing the process. LLM explanations also frequently skipped the post-translation mechanism of feedback inhibition. This reflects a common misunderstanding of bacterial regulation, where the focus is solely on gene expression and later regulation points are ignored. The LLM did get right the simpler facets of tryptophan regulation, namely the behavior of the *trp* repressor.

4.3 AI detectors work, but not well enough to stand alone

Four of the five AI detectors tested were able to identify AI-generated text. The Content at Scale detector failed to identify over half of the AI-written text as AI. However, the four other detectors could differentiate human vs. AI-generated text. A comparison of AI-score distributions between human vs. AI and human vs. disguised text showed that GPTZero, Winston, ZeroGPT, and Originality.ai all showed highly significant differences between the means. All four detectors had false negative rates below 9%, with Originality.ai having no false negatives. The accuracy, precision, recall, and F1 were all above 0.7 in all cases.

Nevertheless, AI detectors need to be nearly perfect for them to be trusted to take on the role of policing student writing. The sticking point is false positives. Instructors do not want to accuse students of academic dishonesty unless they are certain it exists and any error, where the detectors flag human writing as AI, is problematic. Unfortunately, GPTZero, Winston, ZeroGPT, and Originality.ai too often identified human writing as written by AI, with rates of 15.6, 45.8, 9.8, and 17.6%, respectively. The high rate of false positives from the Winston detector makes it unusable to monitor students. One method of reducing false positives is to use two detectors in combination. When a piece of human writing was passed through both GPTZero and Originality.ai and only counted as suspicious if both detectors flagged it, the false positive rate dropped to 5.2%. Still, this is too high to be relied on alone and creates more false negatives.

It is clear from this study that AI detectors cannot be relied upon as the only metric to determine the use of AI by students. However, it is also true that AI detectors are generally able to flag the use of AI. Instructors may be able to use AI detectors as one tool to incentivize students to do their own work.

This study provides a snapshot of students' current use of LLMs and the capability of AI detectors. While students are beginning to use LLMs, their use is not universal. Of those who do use LLMs, many are using them ethically, but too many use them in ways their instructors would probably consider inappropriate. It is possible to use AI detectors as one component of a comprehensive policy to encourage ethical uses of LLMs. As these technologies develop, the landscape is sure to shift. Instructors and institutions must stay current on the latest technologies and create supportive environments where students understand the responsible use of LLMs.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The experimental design was submitted to the Madison IRB which determined that since the survey was anonymous and the focus of the research was the efficacy of the AI detectors, it did not constitute human subjects research. (Submission ID No. 2023-1548). Written informed consent for participation in the study was not required from the participants in accordance with the local legislation and institutional requirements.

Author contributions

Funding

Acknowledgments

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1374889/full#supplementary-material

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Global competence in higher education: a ten-year systematic literature review

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In the current epoch of economic globalization, the globalization of higher education has spurred an increasing interest in comprehending global competence. A systematic literature review was conducted, analyzing a wide range of studies from 2013 to 2023 using the Web of Science and Scopus databases. The review aimed to present an updated overview of research on global competence, covering various aspects such as its definition, assessment dimensions, research objectives, methodologies, results, and limitations. Most publications define global competence using knowledge, attitudes, and skills as crucial dimensions, drawing from international organizational documents and research findings. However, the review also emphasizes the need for future research to adopt a longitudinal approach and develop global competence verification tools to measure global competence among university students and faculty. By providing a comprehensive analysis of current research, this review highlights the importance of understanding global competence in higher education and its potential impact on students and faculty in an increasingly interconnected world.

KEYWORDS

global competence, higher education, internationalization, PRISMA protocol, systematic literature review

1 Introduction

The interconnected, multicultural world has experienced significant changes due to the opportunities and challenges brought about by globalization (Shliakhovchuk, 2019). Similarly, the Fourth Industrial Revolution has brought about significant transformations in different sectors, like artificial intelligence, robotics, and data analytics, altering our everyday lives and work environments (Fuchs, 2018; Fukuyama, 2018). There has been a significant shift in preparing future generations with the necessary expertise and skills to meet the changing industry demands, aligning educational programs with what is required to prepare students for the dynamic environment (Schroeder, 2016). Hence, adopting global competence-based higher education is crucial for succeeding in the current fast-paced global professional environment (Robertson, 2021a; Robertson, 2021b). This approach equips students to grasp global events, work well with people from various cultures, and promote peaceful, inclusive, and sustainable communities. Mastering intercultural communication, cross-border collaboration, and leveraging technology effectively are essential skills in today's globalized world (Oliver, 2022). This underscores the significance of higher education focusing on global competence, as it directly prepares students for the challenges and opportunities of the international professional environment.

Higher education institutions are vital in preparing students with the essential global skills needed to thrive in the fast-changing global landscape (Saito, 2019). Many universities have acknowledged the growing emphasis on improving students' global competence (Deardorff and Arasaratnam-Smith, 2017). Universities around the globe have adopted different approaches to enhance students' global skills, including providing international courses, promoting cross-border mobility, and employing professors with international experiences (Li et al., 2021; Guo-Brennan, 2022). There has been a shift in higher education toward emphasizing values over knowledge and skills, transitioning from 'aptitude to attitude'. However, some argue that the shift lacks a suitable epistemic framework and instructional system (Zha and Wu, 2021). Global competence has garnered significant attention in research, not only within academic domains but also notably in the aftermath of the OECD's Global Competence Assessment conducted in 2018. Delving into conceptual understanding and definition, some studies focus on the nature of global competence and its components (Sälzer and Roczen, 2018). The focus of research centers on the advancement and assessment of global competence and the analysis of methods to enhance students' global competence in higher education settings (Majewska, 2023). Despite the different perspectives and in-depth analyses provided by these studies, there is still a need for a comprehensive understanding of global competence in higher education. The full synthesis of its domains and dimensions remains incomplete. With this gap in mind, the study aims to comprehensively synthesize global competence, evaluate the standards for assessing global competence in university faculty and students, identify the latest developments in global competence assessment in higher education, summarize the progress in global competence research over the last decade, and highlight the limitations of this research. This study offers an overview of the status and development of global competence among students and teachers in higher education. To achieve this goal, the review will investigate the following research questions:

1. What is the definition of global competence within the context of higher education?
2. What are the typical dimensions employed to evaluate the global competence of university teachers and students?
3. What are the major research purposes, methodologies, and outcomes of research on global competence in higher education over the last decade?
4. What are the limitations of the research on global competence within higher education?

The subsequent sections of this paper are organized as follows: Firstly, the methodology employed for this review and the selection criteria utilized to identify pertinent studies are delineated. Subsequently, the findings are presented, and the research questions are addressed based on the selected literature. Furthermore, the potential limitations of the study are highlighted. Finally, the conclusions are presented along with suggestions for future research on the development of global competence in higher education.

2 Materials and methods

This review is based on the guidelines for systematic literature reviews provided by Kitchenham and Charters (2007). The research

questions were explicitly stated as the primary objectives at the beginning of the review. The databases used for the search, as well as the search strings and criteria used to assess and select relevant studies, were described. Then, the publications included in this review were introduced. Finally, this study followed Gough et al.'s (2017) three main phases of systematic review: selecting, identifying, and synthesizing.

2.1 Search strategy

The present literature review opted for using two electronic databases: Web of Science (WOS) and SCOPUS. These databases were selected as the primary sources of international, multidisciplinary academic literature (Chadegani et al., 2013).

A search was conducted for the selected terms within the papers' titles, keywords, and abstracts. The search strings per chosen electronic database were as follows:

WOS: TS = (("global competence*" OR "global abilit*" OR "global skill*") AND ("higher education" OR "universit*"OR "college*")).

Scopus: TITLE-ABS-KEY (("global competence*" OR "global abilit*" OR "global skill*") AND ("higher education" OR "universit*"OR "college*")).

2.2 Study selection

A comprehensive and meticulous study selection process encompassed multiple stages and activities. The search design was specifically tailored to encompass the most recent trends and research findings on global competence, ensuring alignment with the rapid evolution of global technology. Initially, 271 articles were retrieved through the search process, reflecting the thoroughness of the selection process.

2.2.1 Inclusion and exclusion criteria

To ensure that the studies selected were appropriate for addressing our research questions, established inclusion (Table 1), and exclusion criteria (Table 2) were utilized. Each study was evaluated based on these criteria. To validate these criteria, a group of experts consisting of three university professionals and one education expert was consulted.

2.2.2 Quality criteria

The chosen papers' evaluation relied on various evaluation criteria, considering the diverse methodologies used in this review. The critical appraisal skill program (CASP, 2018) checklists were used

TABLE 1 Inclusion criteria.

Inclusion criteria
• The research is related to the global competence of teachers or students in higher education.
• The publication includes state-of-the-art information on global competence.
• Research papers are published between 2013 and 2023.
• The research papers are written in English.
• Peer-reviewed articles.

TABLE 2 Exclusion criteria.

Exclusion criteria
• The research work is not related to the global competence of teachers or students in higher education.
• The publication does not include the state of the art on global competence.
• Research papers are not published between 2013 and 2023.
• Research papers are not written in English.
• Research papers have been published without a peer review process.

to assess the rigor, credibility, and relevance of the qualitative investigations. The CASP consists of ten questions ranging from 1 to 9, with response options of "Yes," "No," or "Cannot tell" (Table 3). For item 10, the authors discussed and jointly determined the appropriate response.

The Critical Appraisal Checklist (CEBM, 2014) was utilized to evaluate the cross-sectional quantitative study. This checklist comprises 12 queries, offering response options of "Yes," "No," or "Cannot tell." The checklist encompasses questions that assess various aspects, such as the study's design, subject selection, sample representativeness, measurement reliability, and conducted statistical analysis (Table 4).

Consistent procedures were followed for all evaluations to assess the overall score and quality of the articles included in this systematic review. Tables 3–4 present the processes and calculations. Initially, the cumulative score for each column was calculated and subsequently divided by the overall score. Then, these scores were converted into percentages to categorize the articles' quality. The articles were then classified into three categories based on the percentage distribution and range. Finally, studies with percentages ranging from 80 to 100% ranked as high quality, from 60 to 79% as good quality, and with percentages below 60% as low quality.

2.2.3 Data extraction

The study employed the guidelines proposed by Ma et al. (2017) to extract and organize the investigations' key characteristics and significant results. Several important attributes, such as the author(s), publication year, country of research, investigation objectives, study design, sampling method, individuals involved, focus and relevance of findings, and quality level were included. During the initial phase, the studies were classified and condensed the studies according to their qualitative or quantitative methodology. Table 5 provides a comprehensive summary and categorization of the features and significant conclusions drawn from these investigations.

The review process began with examining 271 papers obtained from the search (60 from WoS and 211 from Scopus) against the predetermined inclusion and exclusion criteria. During the initial screening, 43 duplicate articles were identified, and 185 articles were excluded due to their failure to meet the inclusion criteria. Subsequently, the remaining 43 articles underwent a thorough evaluation based on quality criteria to ensure that they aligned with the inclusion and exclusion criteria, thereby guaranteeing the selected works' quality for addressing the research questions. By applying a set of quality questions as criteria, 19 articles were eliminated, resulting in a final selection of 24 articles for analysis and addressing the research questions.

Figure 1 visually represents the data extraction procedure using the PRISMA flow (Moher et al., 2009).

3 Findings and discussion

This section presents the results of the systematic literature review (SLR) structured according to the research questions posed, providing answers through the analysis of the selected articles.

3.1 Definitions of global competence within the context of higher education

A total of 24 selected articles in this review were examined to provide clarification on the definition of global competence. Among these articles, 10 cited both previous research and international organization documents to define global competence. Three articles relied solely on documents from international organizations, while nine publications based their definitions solely on research. Two publications did not mention a specific source for their definition.

In the selected literature, it was common for researchers to refer to the definition of global competence as proposed by the Organization for Economic Cooperation and Development (OECD) or other organizations. The OECD defined global competence as "the ability to look at local, global, and intercultural issues, to understand and value other people's points of view and worldviews, to interact with people from different cultures in an open, appropriate, and effective way, and to work for collective well-being and sustainable development" (OECD, 2018). Nine of the chosen publications used this definition.

Additionally, three publications referenced the definition of global competence provided in the book "*Educating for Global Competence: Preparing Our Youth to Engage the World*" by Mansilla and Jackson (2011). This book emphasized the importance of integrating global competence into education and defines it as "the capacity and disposition to understand and act on issues of global significance" (Mansilla and Jackson, 2011).

Scholarly research also contributed to the definition of global competence. Among the selected literature, 19 publications referred to previous research, with many citing the work of Hunter and Reimers. Hunter et al. (2006) used Delphi techniques to define global competence as "having an open mind while actively seeking to understand cultural norms and expectations of others, leveraging this gained knowledge to interact, communicate, and work effectively outside one's environment." Reimers (2009) defined global competence as having three interdependent dimensions: a positive disposition toward cultural difference and a framework of global values; language proficiency beyond one's dominant language; and deep knowledge and understanding of global topics and the process of globalization, along with critical and creative thinking skills to address global challenges.

Furthermore, five publications in the review discussed the similarities or overlaps in meaning between global competence and other terms such as "intercultural competence," "global perspective," "global awareness," and "global citizenship." This indicates that a unified definition of global competence is still under development.

Some scholars argued that the OECD-PISA definition possesses the most authority and should serve as the unified definition of global competence in academia, based on a combination of organizational

TABLE 3 Quality appraisal of the qualitative studies.

Author(s), year, country	1. Was there a clear statement of the aims of the research?	2. Is a qualitative methodology appropriate?	3. Was the research design appropriate to address the aims of the research?	4. Was the recruitment strategy appropriate to the aims of the research?	5. Was the data collected in a way that addressed the research issue?	6. Has the relationship between researcher and participants been adequately considered?	7. Have ethical issues been taken into consideration?	8. Was the data analysis sufficiently rigorous?	9. Is there a clear statement of findings?	10. How valuable is the research?	Total score (%) and quality
Crawford et al. (2020), America	Y	Y	Y	Y	Y	Y	N	Y	Y	The research is valuable as it shows a developmental approach to global teacher education	8/9 (88.9%) High
Genau (2013), German	Y	Y	Y	Y	Y	Y	N	Y	Y	The research is valuable as it shows a new study abroad program to increase global competency	8/9 (88.9%) High
Kim (2019), Korean	Y	Y	Y	Y	Y	Y	N	Y	Y	The research is valuable as it applies a theory of cosmopolitanism to understand the relationship between global competence and student identity	8/9 (88.9%) High
Kjellgren and Keller (2018), Sweden	Y	Y	Y	Y	Y	Y	N	Y	Y	The research is valuable as it shows an extra-curricular Certificate of Global Competence as a nonintrusive way	8/9 (88.9%) High
Majewska (2023), American	Y	Y	Y	Y	Y	Y	Y	Y	Y	The research is valuable as it addresses the challenges to global competence instruction and acquisition and opportunities	9/9 (100%) High
Ismail et al. (2023), Europe	Y	Y	Y	Y	Y	Y	Y	Y	Y	The research is valuable as it detects the most relevant global competencies required	9/9 (100%) High
Robertson (2021a), the U.S	Y	Y	Y	Y	Y	Y	N	Y	Y	The research is valuable as it addresses the question of why global competency matters	8/9 (88.9%) High
Robertson (2021b), the U.S	Y	Y	Y	Y	Y	Y	N	Y	Y	The research is valuable as it explores the provenance of the idea of global competence underpinning the OECD-PISA Global Competence framework	8/9 (88.9%) High
Sakamoto (2022), Japan	Y	Y	Y	Y	Y	Y	N	Y	Y	The research is valuable as it examines the nature of global competence and the challenges	8/9 (88.9%) High
Tewari et al. (2021), the U.S	Y	Y	Y	Y	Y	Y	Y	Y	Y	The research is valuable as it shows how Missouri State University's GREAT project promotes responsive and inclusive teaching	9/9 (100%) High
Yu and Duchin (2022), the U.S	Y	Y	Y	Y	Y	Y	N	Y	Y	The research is valuable as it leads to a curriculum for action in the public interest	8/9 (88.9%) High

TABLE 4 Quality appraisal of the quantitative cross-sectional studies.

Author(s), year, country	1. Did the study address a clearly focused issue?	2. Is the research method (study design) appropriate for answering the research question?	3. Is the method of selection of the subjects (employees, teams, divisions, organizations) clearly described?	4. Could the way the sample was obtained introduce (selection) bias?	5. Was the sample of subjects representative with regard to the population to which the findings will be referred?	6. Was the sample size based on pre-study considerations of statistical power?	7. Was a satisfactory response rate achieved?	8. Are the measurements (questionnaires) likely to be valid and reliable?	9. Was the statistical significance assessed?	10. Are confidence intervals given for the main results?	11. Could there be confounding factors that have not been accounted for?	12. Can the results be applied to your organization?	Total score and quality
Butum et al. (2020), Romania	Y	Y	Y	No bias	Y	Y	Y	Y	Y	Y	Y	Y	11/11 (100.0) High
Cao and Meng (2020a), China	Y	Y	Y	No bias	Y	Y	Y	Y	Y	Y	Y	Y	11/11 (100.0) High
Cao and Meng (2020b), Belgium	Y	Y	Y	No bias	Y	Y	Y	Y	Y	Y	C	Y	10/11 (90.9) High
Cao and Meng (2020c), China	Y	Y	Y	No bias	Y	Y	Y	Y	Y	C	N	Y	9/11 (81.8) High
Han and Zhu (2022), China	Y	Y	Y	No bias	Y	C	Y	C	C	C	Y	Y	7/11 (63.6) Good
Kang et al. (2017), US and Korean	Y	Y	Y	No bias	Y	C	Y	Y	Y	C	Y	Y	9/11 (81.8) High
Kjellgren and Richter (2021), Sweden	Y	Y	Y	No bias	Y	Y	Y	C	C	C	Y	Y	8/11 (72.7) Good
Li (2013), China and the U. S	Y	Y	Y	No bias	Y	Y	Y	Y	Y	Y	N	Y	11/11 (100.0) High
Liu et al. (2020), China	Y	Y	Y	No bias	Y	Y	Y	Y	Y	C	Y	Y	10/11 (90.9) High
Mehta et al. (2021), Thai	Y	Y	Y	No bias	Y	C	Y	Y	Y	C	Y	Y	9/11 (81.8) High
Meng et al. (2017), China	Y	Y	Y	No bias	Y	Y	Y	Y	Y	C	N	Y	9/11 (81.8) High
Shuman et al. (2016), the U. S	Y	Y	Y	No bias	Y	C	Y	Y	Y	C	Y	Y	9/11 (81.8) High
Zheldibayeva (2023), Kazakhstan	Y	Y	Y	No bias	Y	C	Y	Y	Y	Y	Y	Y	10/11 (90.9) High

TABLE 5 Type of limitations.

Investigation	Type of limitations
Butum et al. (2020)	(1) Only two fields of study are included (economic and social studies); (2) Research is conducted in a specific country context
Cao and Meng (2020a)	(1) Cross-sectional study design: the relationship studied cannot be called causal. (2) Extrapolation of results to other populations or settings must be done cautiously unless replicated. (3) Participants recruited from only one university
Cao and Meng (2020b)	(1) Cross-sectional study design; (2) The study only tested Chinese students residing in Belgium; (3) The study did not distinguish between different types of online contact, such as video-based and text-based contact; (4) The sampling method solely relies on recruiting participants through Facebook
Cao and Meng (2020c)	(1) Cross-sectional study design. (2) Samples are from a single university. (3) The study uses English learning motivation as a unidimensional scale. (4) Research ignores some important constructs of academic achievement (e.g., self-regulated learning and academic self-efficacy)
Crawford et al. (2020)	Not mentioned
Genau (2013)	No attempt was made to measure global competence skills formally
Han and Zhu (2022)	(1) The research sample is intentionally selected at an international institution; (2) Students are limited to first-year undergraduate students in engineering and natural science disciplines
Kang et al. (2017)	(1) As an attempt at intercultural online projects, it focuses on the local performance of the project. It does not provide students with broader tasks, such as active cooperation with students from other countries. (2) Due to the small sample size, caution should be exercised when generalizing the findings. (3) The items investigated in this study are only available to students enrolled in the Apparel/Textile Marketing course.
Kim (2019)	Not mentioned
Kjellgren and Keller (2018)	Not mentioned
Kjellgren and Richter (2021)	Not mentioned
Li (2013)	(1) The researchers used a convenience sample from the researchers' existing courses, and the participants were not fully representative of our population of interest. (2) Participants were majors in business disciplines or humanities (foreign languages); caution must be exercised when attempting to generalize the findings to the general university population. (3) Foreign language proficiency has long been regarded as an essential component of global competence, but foreign language was not used as a parameter in experimental design.
Liu et al. (2020)	(1) Data come from a sample of graduate students from five universities in Beijing. Some programs may be more suitable for developing and non-English-speaking countries than others. (2) Only self-report tools were used, not tests that directly measure students' global competence knowledge and skills
Majewska (2023)	Not mentioned
Mehta et al. (2021)	(1) Cross-sectional study design, investigating only one discipline. (2) Lack of qualitative research
Meng et al. (2017)	(1) Cross-sectional study design, future instructional intervention, or qualitative research is needed to investigate students' global competence. (2) Collected from different universities in different geographical regions of China, it is challenging to represent the entire population of Chinese college students. (3) There is a lack of empirical research examining the impact of different factors on global competitiveness, and the universality of the results needs further testing. (4) Participants are randomly selected within the school, and students who agree to participate are likely to be more interested and have relatively high global competence, so they are not representative of a population that is not interested.
Ismail et al. (2023)	Not mentioned
Robertson (2021a)	Not mentioned
Robertson (2021b)	Not mentioned
Sakamoto (2022)	(1) The complexity of group membership changes during the study. (2) The reliance of Delphi studies on subjective opinions.
Shuman et al. (2016)	Not mentioned
Tewari et al. (2021)	Not mentioned
Yu and Duchin (2022)	Not mentioned
Zheldibayeva (2023)	(1) The direct target of the GCS tool is graduate students, while 4/5 of the sample in this study are undergraduate students. (2) The sample is small.

reports and research. They highlighted the contributions of previous scholars to shaping the OECD-PISA global competence framework. However, there are also scholars who believed that these definitions may be biased toward a Western perspective and may not adequately consider globalization, particularly in Eastern contexts. Additionally, even within the OECD, different organizers or stakeholders
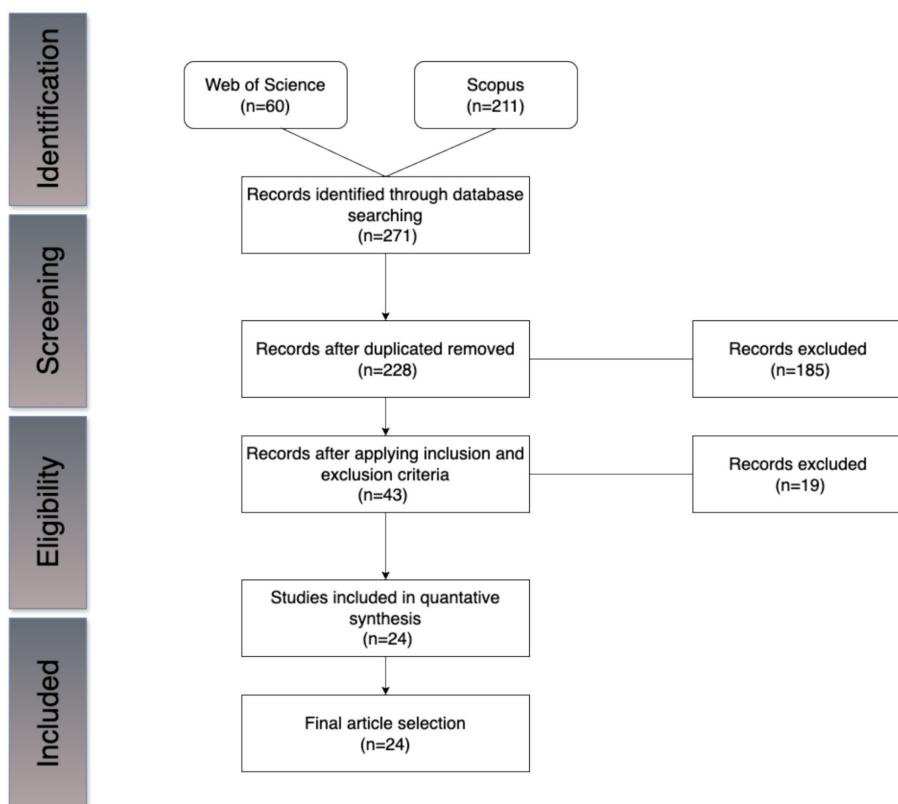
FIGURE 1
PRISMA flowchart: data extraction procedure.

approached global competence from a US-centric perspective, which may limit its adaptability to other cultural contexts (Robertson, 2021a; Sakamoto, 2022).

3.2 Dimensions commonly used to assess the global competence of university teachers and students

Among the 24 selected publications, a variety of instruments with different dimensions were used. Figure 2 represents the types of samples used before presenting the results concerning the dimensions commonly used to assess the global competence of university teachers and students. The corresponding articles can be found in the Appendix.

Of the 24 selected publications, 20 focused on student participants, 2 focused on teacher participants, and 2 studied both teachers and students.

The selected publications employ various aspects and perspectives to assess the global competence of both students and teachers, as presented in Table A in the appendix. Most publications used surveys as their research method. The analysis and comparison of the dimensions outlined in these surveys revealed that 10 out of the 24 selected publications embraced Hunter's global competence dimensions, comprising knowledge, skills, and attitudes (Hunter et al., 2006). Sakamoto expanded on Hunter's three dimensions by adding traits, resulting in the following four dimensions: knowledge, skills, attitudes, and traits (Sakamoto,

FIGURE 2
Results of the category of participants.
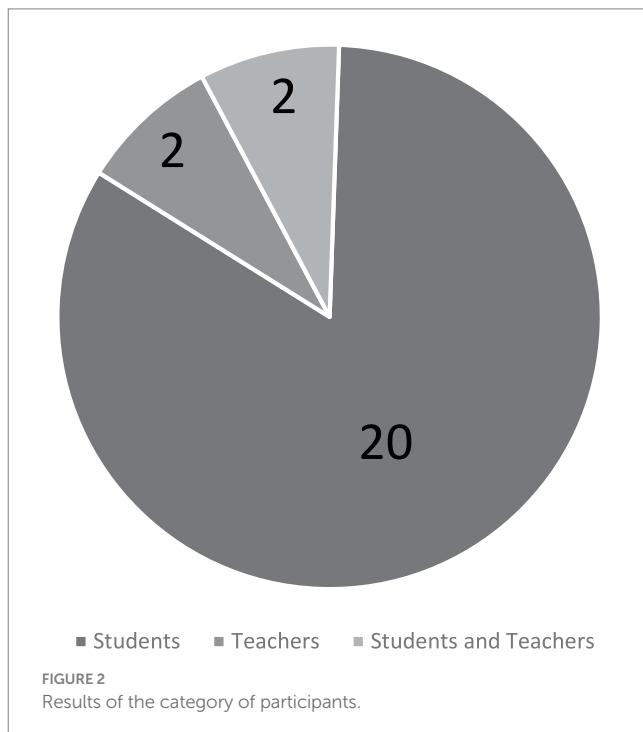
2022). Similarly, Ortiz-Marcos et al. (2020) referenced the four dimensions of the OECD framework, which include knowledge, skills, attitudes, and values.

Some scholars developed their own evaluation dimensions based on their research orientation and established tools using different theoretical frameworks. For instance, Butum et al. (2020) categorized global competence into six categories: international competences, personal competences, competences related to career management, workplace competences, theoretical competences, and practical competences. This observation aligns with Robertson's findings that different scholars employ different dimensions to evaluate global competence (Robertson, 2021b).

3.3 Research purposes, methodologies, and outcomes explored in the last decade on global competence in higher education

To present a comprehensive overview of the advancements made in research on global competence over the past decade, an analysis of the research objectives, methodologies, and outcomes to gather relevant information was conducted.

3.3.1 Research purposes

The categorization of the selected publications was based on their research purposes. The first category aimed to assess participants' perceptions and levels of global competence in higher education. These articles aimed to evaluate participants' understanding and level of global competence within the context of higher education. The second category involved investigating the factors that influence global competence. These publications investigated the factors affecting global competence and how they differ across individuals. The third category centered on evaluating the impact of global competence on student achievement. Articles in this category assessed the effect of global competence on students' academic performance. The fourth category involved analyzing the pedagogical approaches used to develop global competence. These articles presented different teaching methods and strategies employed to cultivate global competence. Lastly, the fifth category examined the reliability and validity of global competence-related instruments. Articles in this category focused on measuring the

reliability and validity of the questionnaires used to evaluate global competence. Figure 3 presents the results of these categorizations.

In this category, 42% ($n = 11$) of the selected publications most frequently represented the research purpose of investigating the participants' perceptions and their level of global competence. The evaluation of students' perceptions was done from multiple perspectives. For example, Butum and Ortiz-Marcos explored perceptions of global competence and international labor market needs (Butum et al., 2020; Ortiz-Marcos et al., 2020). Han and Zhu (2022) examined students' perceptions of global competence as they lived and experienced international education. Sakamoto and Shuman assessed college students' perceptions of their level of global competence and what college students need to be globally competitive (Shuman et al., 2016; Sakamoto, 2022). Genau and Tewari discussed perspectives on global education programs and practices (Genau, 2013; Tewari et al., 2021).

While 31% ($n = 8$) of the selected publications also investigated factors that could influence global competence, marking the second-highest level of research. For example, Cao and Meng examined whether mediated exposure through TV dramas and movies predicts intergroup anxiety and global competence (Cao and Meng, 2020a). They also investigated whether demographic variables (i.e., age, gender, length of stay in Belgium, professional and academic level) are associated with global competence (Cao and Meng, 2020b). Additionally, they examined whether five personality traits are associated with English language achievement and global competence (Cao and Meng, 2020c). Moreover, Kang et al. (2017) examined the effect of a cross-cultural online program on their global competence. Mehta et al. (2021) examined the impact of overseas education and curriculum internationalization on global awareness. Meng et al. (2017) discussed the impact of domestic internationalization efforts and student motivation on global competence. Shuman et al. (2016) explored the impact of demographic factors and pre-university experiences on freshman global competence.

One publication (Cao and Meng, 2020c) evaluated the effectiveness of global competence on students' achievement. They explored the predictive role of the Big Five personality traits
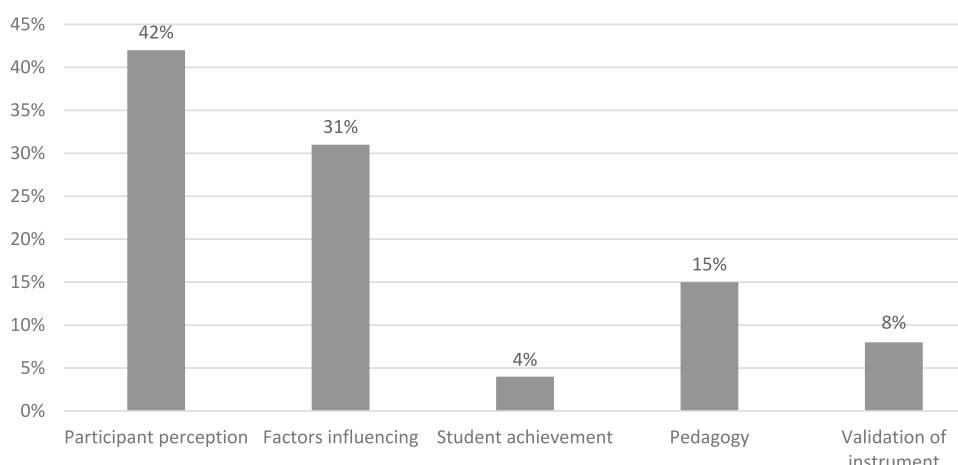
FIGURE 3
Results of the category of the research purposes.

TABLE 6 Research methodology.

Research methods	Number of studies
Quantitative methodology	12
Qualitative methodology	10
Mixed methods	1
Q-methodology	1
Delphi study	1

(conscientiousness, neuroticism, extraversion, openness, and agreeableness) in English achievement and global competence. The findings indicated that extraversion and motivation to learn can synergistically contribute to better results in learning English and acquiring global knowledge.

Four of the selected publications examined pedagogical approaches to global competence. Crawford et al. (2020) described how an instructional design course at one university promotes global competence, providing four student case studies as illustrative examples of how such a course can support students in developing global competence. Li (2013) proposed a teaching intervention that creates opportunities for students from China and the United States to establish virtual connections and collaborate on international business-related research papers. Kjellgren and Keller (2018) adapted program curricula to equip graduates with the skills required for effective and ethical work in socially and culturally diverse environments. Yu and Duchin (2022) developed a student project based on existing courses to enhance students' understanding of the local social context through community and global engagement, fostering comprehension of the Sustainable Development Goals and the development of technical skills. These courses are essential for nurturing cultural awareness, enabling students to thrive in a multicultural world and become productive and fulfilled members of the workforce.

Finally, two selected articles validated instruments related to global competence. Liu et al. (2020) employed quantitative methods to test global competence models empirically. Zheldibayeva (2023) aimed to adapt the global competence scale to local conditions and examine the validity and reliability of the Kazakh version of the scale as a tool for measuring the global competence of Kazakh students.

3.3.2 Research methods

The analysis of the research methods used in the selected publications was undertaken. The findings are presented in Table 6.

Among the selected publications, most scholars investigated global competence-related content using quantitative and qualitative methods. Specifically, 12 publications utilized quantitative methods, with data collection conducted through questionnaires. Ten articles employed qualitative methods, specifically in-depth semi-structured student interviews, for survey research (Kim, 2019; Crawford et al., 2020; Ortiz-Marcos et al., 2020). One of the articles employed a mixed-method approach, incorporating both quantitative and qualitative techniques. Kjellgren and Richter (2021) utilized interviews and questionnaires to investigate ways to enhance the systematic development of global competence in higher engineering education. To explore

perceptions of what Japanese university students need to be globally competitive, Sakamoto (2022) employed Q-methods and Delphi techniques to identify and understand prevailing expert and stakeholder opinions.

3.3.3 Research outcomes

The study also involved analyzing the research outcomes of the articles that investigated students' and teachers' perceptions and assessed their level of global competence (see Table 7).

Five articles mentioned the challenges and areas for improvement in developing global competence. For example, Meng et al. (2017) found that Chinese college students had a positive global attitude but lacked sufficient global knowledge. Robertson (2021b) contended that the narrow presentation of global competence stems from its conceptual basis, which aligns with American corporate interests, as well as its pedagogical focus on shaping the culture of the new capitalism. Another study (Sakamoto, 2022) found that Japanese students struggle to develop global competence due to factors such as limited autonomy, limited self-expression, and insufficient critical thinking to overcome ethnocentrism.

Furthermore, six studies focused on analyzing the factors that influence global competence. These six studies listed factors such as personal characteristics, experience studying abroad, English proficiency, exposure to cross-cultural online communication, internationalized curriculum, school ranking, and contact with individuals from foreign cultures were listed in these six studies. For example, Cao and Meng (2020a) found that exposure to foreign TV series and films has a positive impact on global capabilities. Researchers found that extraversion and openness positively predict all three dimensions of global competence (global attitudes, skills, and knowledge), while agreeableness positively predicts global attitudes (Cao and Meng, 2020c). Another study suggested that intercultural online programs generally increase the global competence of participating students, but the extent of the impact varies across dimensions and countries (Kang et al., 2017). According to Mehta et al. (2021), the desire to study abroad, English proficiency, and curriculum internationalization have a positive impact on global competence. Meng et al. (2017) found that gender, enrollment in 985 and 211 universities in Beijing, social sciences and humanities, experience of contact with foreigners in campus activities, enrollment in internationalization-related courses, and student motivation were predictors of Chinese students' global competence. Shuman et al. (2016) concluded that building on pre-college experience and encouraging students to have multiple international experiences while in college is key to gaining a relatively high level of global readiness or perspective.

Li (2013) asserted that effective teaching of global competencies is possible in the realm of pedagogical approaches. One recommended intervention program for enhancing global competencies is to incorporate cross-cultural education in the classroom. Yu and Duchin (2022) employed a combination of top-down and bottom-up teaching methods to expand students' cultural awareness and sensitivity. Their instructional approach entailed dividing the course into four distinct areas: "Food Aid, Assistance to the Elderly, Assistance to Children and Youth, and Activities to Enrich Community Life."

TABLE 7 Study characteristics and summary of findings from the included studies.

Author(s), year, country	Aims	Study design	Sampling method and participants	Focus and significant findings	Dimensions mentioned
Butum et al. (2020), Romania	To determine students' perceptions of the competencies required in the national and international labor market	Quantitative	Online survey, and undergraduate students	• Global competencies have an impact on employability. • Theoretical knowledge is an advantage of Romanian higher education institutions. • University activities are highly relevant to global capabilities	International, personal, career management, workplace, theoretical, and practical competences
Cao and Meng (2020a), China	To examine whether mediated contact through television series and movies predicts intergroup anxiety and global competence	Quantitative	Online survey, Chinese undergraduate students	• Intergroup anxiety mediates the relationship between contact and global competence. • Mediated contact has a negative effect on intergroup anxiety and a positive effect on global competence	Global knowledge, global skills, and global attitudes
Cao and Meng (2020b), Belgium	To investigate the relationship between online and direct cluster contact and social capital in cross-cultural networks	Quantitative	Random sampling, Chinese students in Belgium	• Online contact is significantly associated with global skills, global attitudes, and bonding social capital. • Direct contact is indirectly related to bridging and bonding social capital via the mediators of global attitudes and skills.	Global knowledge, global skills, and global attitudes
Cao and Meng (2020c), China	To examine whether the five personality traits are related to English achievement and global competence.	Quantitative	Online survey, year 2 undergraduate students	• Conscientiousness and extraversion predict English performance. • English learning motivation is positively correlated with all dimensions of global competence	Global knowledge, global skills, and global attitudes
Crawford et al. (2020), America	To illustrate how instructional design courses promote global competencies	Qualitative	Purposive sampling, four students	• Fostering teachers' global competencies is the sharing and analysis of authentic storytelling via intercultural conversations, documentary film, and immersive experiences. • Storytelling has educational and social–emotional benefits	Knowledge, skills, and attitudes
Genau (2013), German	To increase global competency in engineering students by focusing on world history from a technical perspective	Commentary	Secondary sources	• Students are satisfied with experiential learning. • Students are willing to contact foreign friends through email and social media. • Students involved with the international student community on campus	Not mentioned
Han and Zhu (2022), China	To examine students' perceptions of global competencies while living and experiencing international education	Quantitative	Purposive sampling, first-year undergraduate students	• Highlighting the importance of academic learning and intercultural confidence. • A critical reconceptualization of global competence against the caveat of "Globalization" for "Englishization"	Knowledge, skills, and attitudes
Kang et al. (2017), US and Korean	To investigate the acquisition of global competencies among college students and the impact of inter/intercultural online programs	Mixed methods	Random sampling, university students	• Intercultural Online Program enhances students' global competencies. • The extent of the impact varies by factor and country. • U.S. students' global competencies have improved significantly	Knowledge, skills, and attitudes
Kim (2019), Korean	To understand the relationship between global competence and student identity	Qualitative	Convenience sampling, Undergraduate students	• Cosmopolitanism manifests in ways that are contested, complex, and variegated. • The development of cosmopolitanism to conceptualize global competence	Not mentioned

(Continued)

TABLE 7 (Continued)

Author(s), year, country	Aims	Study design	Sampling method and participants	Focus and significant findings	Dimensions mentioned
Kjellgren and Keller (2018), Sweden	To adapt the program curriculum to equip graduates with the skills required to work	Narrative review	Iintroducing the certificate as well as initial findings from courses. Students	• Extra-curricular certificates help students develop global competence. • Encourage and ensure quality in international mobility. • Fosters cross-disciplinary understanding at home.	Not mentioned
Kjellgren and Richter (2021), Sweden	To explore how to systematically enhance overall global competency development in higher engineering education	Mixed methods	Online surveys, Teachers and Students, Experts	• Strategies and methods for global competency training • The role of institutional diversity • Assess the importance of effort	Not mentioned
Li (2013), China and the U. S	To propose a pedagogical intervention that provided students from China and the U.S. with opportunities to establish contact.	Quantitative	Two universities' students from China and the U.S.	• Global competence is teachable. • The applicability of Erickson and O'Connor's (2000) "intergroup contact theory" in developing student global competence. • American students performed lower than their Chinese counterparts in global competence.	knowledge, skills, and attitudes
Liu et al. (2020), China	To empirically test the global competence model through quantitative methods	Quantitative	Random sampling, Graduate students	• Develop a scale to measure global competence in graduate students. • The theoretical structure, reliability, and validity of the scale pass the test	knowledge, skills, and attitudes
Majewska (2023), American	To discuss global competence and address the challenges to global competence instruction and acquisition and opportunities	Commentary	Secondary sources	• Producing a competitive American workforce relies on higher education producing globally competent students.	Not mentioned
Mehta et al. (2021), Thai	To examine the impact of overseas education and curriculum internationalization on global competence	Quantitative	Convenience sampling, universities' students	• The desire to study abroad, proficiency in English, and curriculum internationalization together have a positive impact on the global-mindedness of students	Not mentioned
Meng et al. (2017), China	To investigate the global competence discrepancies of Chinese undergraduates in universities and regions of different development levels	Quantitativ	Random sampling, universities' students	• Chinese undergraduates have positive global attitudes. • Gender, 985 and 211 project universities, Beijing city, social sciences, and humanities, the experience of contact with foreigners on-campus activities are predictive of Chinese students' global competence.	Knowledge, skills/ experience, and attitudes
Ismail et al. (2023), Europe	To detect the most relevant global competencies required by engineers in the labor market	Qualitative	Semi-structured interview, competencies required for HR interviewing graduates	• Only five global capabilities are common. • International experience is considered a quality. • Flexibility and communication skills are missing among young engineers	knowledge, skills, attitudes, values
Robertson (2021a), the U. S	To address the question of why global competency matters	Commentary	Secondary sources	• Propose a dialogic approach, "A Six-Step Dialogic Approach," to knowing about and acting globally.	Not mentioned

(Continued)

TABLE 7 (Continued)

Author(s), year, country	Aims	Study design	Sampling method and participants	Focus and significant findings	Dimensions mentioned
Robertson (2021b), the U. S	To explore the provenance of the idea of global competence underpinning the OECD-PISA Global Competence framework.	Commentary	Secondary sources	• Global competence can be linked to US corporate interests. • Pedagogical impulse is in shaping the culture of the new capitalism	Different people hold different dimensions
Sakamoto (2022), Japan	To examine the nature of global competence in Japan and the challenges that students face in its development	Qualitative	Q-methodology and the Delphi Technique, expert, and stakeholder	• Elements of global competence deemed important in Japan are often overlooked or minimized in the existing (mostly Western) literature	knowledge, skills, attitudes, and traits
Shuman et al. (2016), the U. S	To understand the global readiness level of incoming students and how it is affected by demographic factors and experiences.	Quantitative	Random sampling, Engineering students	• International experience is important for graduates to gain an acceptable global perspective. • Global preparation or perspective is based on a pre-college experience	Not mentioned
Tewari et al. (2021), the U. S	To discuss how Missouri State University's GREAT project promotes responsive and inclusive teaching	Commentary	Secondary sources	• GREAT project has a positive impact on students and teachers	Not mentioned
Yu and Duchin (2022), the U. S	To lead to a curriculum for action in the public interest	Qualitative	Convenience sampling, community students	• The proposed curriculum can help students develop cultural awareness and become productive and satisfied members of the workforce	Not mentioned
Zheldibayeva (2023), Kazakhstan	To adapt and validate a measure for the assessment of students' global competence in Kazakhstan	Quantitative	Random sampling, undergraduate students	• The internal consistency of the validated scale and its subscales is good. • Measured sample global capabilities are at a moderate level	knowledge, skills, and attitudes

Regarding the validation of global competencies, Liu et al. (2020) developed a comprehensive three-dimensional scale known as the Global Competence Scale for graduate students (GCSG) to validate global competence-related competencies. This scale has gained recognition as a reliable tool for measuring postgraduate global competencies. This scale underwent a rigorous evaluation to assess its reliability and validity. Furthermore, Zheldibayeva (2023) conducted a study that tested a validated global competence scale exhibiting strong internal consistency and satisfactory data fit.

3.4 Limitations of reviewed studies on global competence within higher education

Table 5 presents the types of limitations identified in the investigations. The analysis showed that the sample size was the most common limitation among the 24 selected research studies, appearing in 10 studies ($n = 10$). Additionally, the cross-sectional study design emerged as a frequently encountered research limitation, appearing in 5 articles. Notably, 12 articles exhibited multiple research limitations, whereas 11 selected articles did not specify any research limitations.

It can be seen from Table 6 that: (1) the limitation of most studies is small samples, such as samples from a specific school or a single university. In the future, it is recommended to collect data from different sources and further validate the global competence scale with a larger sample size to improve its universality and usability. (2) Many studies also pointed out the cross-sectional study design. Due to the cross-sectional study design, the research results need to be interpreted with caution as a causal relationship. In the future, conducting longitudinal research on global competence, investigating global competence through teaching intervention, or conducting qualitative research, such as follow-up testing, to reveal the causal relationship between these variables is recommended.

4 Strengths and limitations

This systematic review has numerous noteworthy strengths. The review mostly followed the strict and thorough methods specified by Cochrane criteria. The systematic review had a well-defined scope, which included predetermined criteria for the study population, outcomes, and research design. The review utilized a comprehensive and systematic literature search to achieve comprehensiveness,

implementing a pre-established search strategy. In addition, a complementary manual search was performed by examining the reference lists of the obtained papers and review articles that only discussed global competence in higher education. The search strategy reporting complied with the specifications mentioned in the PRISMA declaration. The data extraction procedure was carried out autonomously by the first and third authors, with any discrepancies handled by consensus or consultation with the second author in cases where consensus could not be achieved.

Despite adhering to the robust systematic review guidelines and protocols, the present systematic literature review does exhibit a few limitations. This literature review systematically presents the current state of research through validated studies. It encompasses an overview of studies included in two databases, Web of Science and Scopus, from the past 10 years (2013–2023). It should be noted that this review only examined publications from these two selected databases, and thus, not all publications on the subject were accounted for. Furthermore, the years were limited to 2013–2023 to emphasize recent findings. Notably, the search was constrained to articles published solely in English to ensure the inclusivity of international literature and compensate for the researchers' limited proficiency in multiple languages.

5 Conclusion

This systematic review provides a comprehensive overview of global competence in higher education. It examines how global competence is defined and used in higher education settings and presents an analysis of current research on global competence, including the research purpose, methodologies, instruments, outcomes, and limitations.

The review highlights that the definition of global competence in the reviewed publications is generally broad, drawing on international organization documents and related research. International organizations commonly use the definitions proposed by the OECD and the EdSteps Global Capability Working Group, while scholars frequently cite Hunter and Reimers' definition. However, it is essential to note that some publications compare global competence with other related terms, such as intercultural competence.

The review of the global competence assessment indicates a preference for studying students rather than teachers. Most studies utilize Hunter's definition of global competence: knowledge, skills, and attitudes.

The selected publications' research objectives focus primarily on investigating global competence among teachers and students and the factors influencing its development. A significant portion of the research aims to survey and assess participants' perceptions, level of global competence, and related factors. However, the number of studies exploring the impact of global competence on student achievement is limited.

Regarding research methodology, most selected publications rely exclusively on quantitative or qualitative methods, with mixed methods being less common. The past decade's outcomes indicate that university teachers and students require comprehensive improvement in global competence. While individuals may exhibit satisfactory global attitudes, they may still lack global knowledge when faced with complex problems. Factors influencing student global competence include personal characteristics, study abroad experiences, English proficiency, cross-cultural online communication, internationalized courses, school rankings, and contact with people from foreign cultures.

To enhance global competence in higher education, it is crucial to consider the positive correlation between global competence and student achievement. Appropriate teaching methods, such as curriculum intervention plans, can contribute to developing higher-level global competence. The review also emphasizes the importance of developing validation tools that facilitate the timely measurement of global competence across different dimensions for university teachers and students.

The limitations identified in the reviewed publications primarily relate to the data collection methods and sample sizes. Future research should address these limitations by conducting longitudinal studies and considering larger sample sizes for experimental participants.

6 Identified gaps and future research

This systematic review highlights several areas for further research and provides valuable insights into global competence in higher education. First, it is important to recognize that the definition of global competence is still evolving and is predominantly influenced by Western perspectives. Therefore, there is a need for more research that focuses on defining and measuring global competence in different cultural contexts.

Secondly, although the selected articles primarily assessed students' levels of global competence, it is crucial to recognize that global competence development does not depend solely on students. Teachers have an essential role to play in fostering students' global competence.

Thirdly, while most articles examined perceptions and levels of global competence and the factors that influence its acquisition, it is equally important to explore how it can be effectively integrated into teaching and learning practices.

Finally, it is worth noting that many articles in the review relied solely on quantitative or qualitative research methods. While these approaches have their merits, using mixed research methods may yield more comprehensive results.

This systematic review presents valuable insights into global competence in higher education. However, further research is needed to define and measure global competence in different cultural contexts, recognize the role of teachers in fostering students' global competence, explore effective integration of global competence into teaching practices, and consider the use of mixed research methods for a more comprehensive understanding of the topic.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix

TABLE A Participants and dimensions of global competence were mentioned in the selected investigations.

Investigation	Participants	Dimensions mentioned
Butum et al. (2020)	Students	International competencies, personal competencies, competencies related to career management, workplace competencies, theoretical competencies, and practical competencies
Cao and Meng (2020a)	Students	Global knowledge, global skills, and global attitudes
Cao and Meng (2020b)	Students	Global knowledge, global skills, and global attitudes
Cao and Meng (2020c)	Students	Global knowledge, global skills, and global attitudes
Crawford et al. (2020)	Students	Knowledge, skills, and attitudes
Genau (2013)	Students	Not mentioned
Han and Zhu (2022)	Students	Knowledge, skills, and attitudes
Kang et al. (2017)	Students	Knowledge, skills, and attitudes
Kim (2019)	Students	Not mentioned
Kjellgren and Keller (2018)	Students	Not mentioned
Kjellgren and Richter (2021)	Teachers and Students	Not mentioned
Li (2013)	Students	knowledge, skills, and attitudes
Liu et al. (2020)	Students	knowledge, skills, and attitudes
Majewska (2023)	Students	Not mentioned
Mehta et al. (2021)	Students	Not mentioned
Meng et al. (2017)	Students	Knowledge, skills/experience, and attitudes
Ismail et al. (2023)	Students	knowledge, skills, attitudes, values
Robertson (2021a)	Teachers	Not mentioned
Robertson (2021b)	Teachers and Students	Different people hold different dimensions
Sakamoto (2022)	Students	knowledge, skills, attitudes, and traits
Shuman et al. (2016)	Students	Not mentioned
Tewari et al. (2021)	Teachers	Not mentioned
Yu and Duchin (2022)	Students	Not mentioned
Zheldibayeva (2023)	Students	knowledge, skills, and attitudes

The impact of Chinese university music teachers' teaching beliefs on creative teaching behaviors: the mediating role of technological acceptance

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This study focuses on college teachers in the Ningxia Hui Autonomous Region of China, aiming to explore the relationships among teaching beliefs, creative teaching behaviors, and technology acceptance. The research adopts a questionnaire survey method, using scales for teaching beliefs, creative teaching behaviors, and technology acceptance to conduct online surveys of college teachers in the Ningxia Hui Autonomous Region of China. Convenience sampling is employed during the survey. The study mainly verifies the theoretical model proposed by using statistical analysis software such as SPSS and AMOS. The results reveal that teaching beliefs of college teachers in the Ningxia Hui Autonomous Region of China positively predict creative teaching behaviors; teaching beliefs positively predict technology acceptance; technology acceptance positively predicts creative teaching behaviors; and technology acceptance has a significant mediating effect between teaching beliefs and creative teaching behaviors.

KEYWORDS

teaching beliefs, creative teaching behavior, technology acceptance, music education, Chinese teacher

1 Introduction

The starting point of educational reform should be from the teaching level, especially in today's rapidly developing modern globalized and information age. Introducing various forms of innovation in teaching is essential for further improving education (Qurbonovich, 2022). Additionally, teaching itself is a creative activity and behavioral process (Cheng, 2001; Sawyer, 2011). Research indicates that creative teaching behaviors (CTB) can effectively enhance students' learning sensitivity and fluency (Hu et al., 2016). The findings of Rankin and Brown (2016) also demonstrate that CTB can stimulate students' interest in learning, foster meaningful learning experiences, and simultaneously cultivate the required cognitive, emotional, and skillful aspects.

Past studies have pointed out a positive relationship between teaching beliefs (TB) and CTB (Northcote, 2009; Kiss and Lin, 2016). Bandura (1982) social cognitive theory and self-efficacy theory emphasize the importance of "belief," which can inspire people to engage in specific tasks and help them utilize their effective capabilities. Keys (2007) noted that teachers' beliefs and habitual ways of doing things can influence their practices in the classroom. Choi and Ramsey (2009) proposed that actual teaching experiences can help novice teachers cultivate appropriate positive beliefs, attitudes, and teaching abilities. Research by Hall and Hord (2011) also indicates

that only when teachers deeply identify with certain beliefs can there be a possibility of truly changing their behavior. In other words, if one hopes for teachers to demonstrate CTB, it is essential to first understand teachers' beliefs about teaching. Literature suggests that the successful execution of CTB in teachers' classrooms depends on their personal beliefs (Bereczki and Karpati, 2018).

However, relying solely on TB is far from sufficient. The COVID-19 pandemic has swept across the globe, compelling schools to integrate technological solutions into education (Sarikaya, 2021). This new technological backdrop, triggered by the pandemic, along with its corresponding challenges, has posed numerous difficulties for both teachers and students in the teaching process. This has prompted educational systems and scholars to reflect, recognizing the inadequacies in teachers' technological application and attitudes (Arslantas, 2021). Paje et al. (2021) argued that effectively utilizing instructional technology in schools is one of teachers' core responsibilities. Moreover, the planning, maintenance, and assessment of these technologies' effective application are crucial for achieving educational goals, ultimately depending on teachers' abilities and commitment (Kara, 2021). Consequently, in today's era, various sectors of society, including parents and students, hold higher expectations for teachers' performance in the classroom than ever before.

The development of creativity in the modern educational process is closely related to the application of information technology, which serves as an effective innovative means to enhance the quality of teaching at all levels (Gorbunova and Govorova, 2018). The adoption of technology-enhanced teaching by educators may also enable students to acquire digital skills or develop an optimistic attitude toward technology. This has a positive impact on the quality of education, akin to its effects in all other domains (Koliouska and Andreopoulou, 2020). Technology has enabled various industries to enhance efficiency and has become an integral part of everyone's life and work (Mendoza et al., 2015).

Not only do teachers' beliefs influence their CTB, but technological acceptance (TA) is also one of the most crucial factors affecting such behaviors (Mirzajani et al., 2016). By utilizing technological tools to help teachers achieve creative solutions and teaching behaviors (Henriksen et al., 2016), teachers' innovative use of information and communication technology, including generating ideas and creative learning applications, allows information and communication technology (ICT) to permeate various aspects of the curriculum, particularly in areas such as learning objectives. When teachers perceive technology as useful and conducive to their productivity, they are more willing to use it. Thus, positive TA has a positive and direct impact on behavioral intentions (Boulton, 2017). Chou et al. (2019) found a significant positive correlation between TA and the use of ICT for CTB.

Although past literature suggests that teachers' beliefs can influence their teaching behaviors, teachers' instructional behaviors may not always align with their beliefs (Assen et al., 2016). Therefore, this study posits that in the process of beliefs translating into behaviors, several factors may influence this process, which could stem from teachers' life experiences, personality traits, work environments, etc. For instance, if teachers hold positive TB, they may be more motivated to adopt new technology-assisted teaching methods, and with stronger motivation, they might exhibit higher levels of TA, thereby leading to higher levels of CTB. Zou et al. (2022) found that preservice teachers' behavioral attitudes play a fully mediating role in the relationship between TB and behavioral intentions. Hence, this study selects TA as an important mediating variable for exploration.

In summary, this study aims to investigate the influence relationships among TB, CTB, and TA, to comprehensively understand how CTB are influenced. This contributes to providing deeper insights into higher education music education and offers practical recommendations and guidance for promoting innovative teaching.

2 Research hypothesis and theoretical framework

2.1 The influence of teaching beliefs on creative teaching behaviors

Based on the studies conducted by Kiss and Lin (2016) and Northcote (2009), it has been indicated that there exists a positive relationship between TB and teaching behaviors. Furthermore, the research conducted by Bereczki and Karpati (2018) suggests that the successful implementation of creative teaching in the classroom by teachers depends on their personal beliefs. Keys (2007) emphasizes that both teachers' beliefs and habitual ways of doing things can influence their practices in the classroom. Additionally, Choi and Ramsey (2009) propose that practical teaching experiences can assist novice teachers in cultivating appropriate positive beliefs, attitudes, and teaching abilities. The research by Hall and Hord (2011) also demonstrates that true behavioral change in teachers is only possible when they genuinely embrace certain beliefs deep within themselves. Hence, this study proposes Hypothesis 1: Chinese university music teachers' TB have a significant positive impact on CTB.

2.2 The influence of teaching beliefs on technological acceptance

Ajzen and Madden (1986) proposed a theory suggesting that beliefs can influence behavior. Subsequently, teachers' TB have been recognized as a key factor influencing their instructional practices (Ng et al., 2010). Research by Taimalu and Luik (2019) found that constructivist TB positively affect teachers' technological integration, while transmission TB have a negative impact on technological integration. Teachers with constructivist TB are more inclined to use technology to support student learning, whereas those with traditional TB tend to use technology to support their own curriculum control (Ertmer et al., 2012). Zou et al. (2022) examined the impact of preservice teachers' TB on their intention to empower student learning using technology from both constructivist and transmission perspectives, with results indicating a positive effect in this research pathway. Therefore, this study proposes Hypothesis 2: Chinese university music teachers' TB have a significant positive impact on TA.

2.3 The influence of technological acceptance on creative teaching behaviors

Research indicates that teachers' TA is associated with their adoption of innovative teaching methods and materials (Nikolopoulou and Gialamas, 2016). TA can be understood as the willingness of certain teachers to pioneer the adoption of innovative educational technologies and methods within the school environment (Agyei and Voogt, 2014;

Teo, 2014; Daniels, 2015). Teachers with high TA are adept at utilizing information and communication technologies as educational tools, seamlessly integrating content and instructional methods. Consequently, they are more inclined to apply ICT to address instructional challenges and select appropriate teaching methods. The extent to which teachers accept innovative technologies also influences their willingness to use these technologies in their daily teaching practices. Teachers who are more receptive to new methods are more effective in introducing new pedagogical approaches, thereby facilitating the dissemination of ICT innovative teaching (Chou et al., 2019). Chou et al. (2019) found a significant positive correlation between TA and the use of ICT for CTB. Therefore, this study proposes Hypothesis 3: TA among Chinese university music teachers has a significant positive impact on CTB.

2.4 The mediating effect of technological acceptance on the relationship between teaching beliefs and creative teaching behaviors

Van Twillert et al. (2020) found that teachers' TB constitute a significant belief that directly predicts their behavioral intentions. Additionally, scholars have observed that different TB have varying degrees of influence on behavioral intentions. Bahçivan et al. (2018) investigated the relationship between TB and attitudes among 1,028 teacher candidates and found significant effects of both types of TB on attitudes, with constructivist TB predicting attitudes more strongly than transmission TB. However, differing viewpoints have been proposed as well. Liu et al. (2017) argued that teachers' constructivist TB significantly influence attitudes, while transmission TB have no significant impact on attitudes. Moreover, scholars have noted that different attitudes have varying degrees of predictive power on behavioral intentions (Wixom and Todd, 2005). Broadly defined, behavioral attitudes are understood as the willingness of individuals to use information technology, use related materials (such as digital textbooks or electronic whiteboards), or engage in teaching practices (Scherer et al., 2018).

Ajzen and Madden (1986) confirmed that behavioral attitudes are more effective predictors of behavioral intentions than attitudes toward objects. In this study, behavioral attitudes refer to teachers' attitudes toward the use of technology to empower teaching practices, which are expected to strongly predict behavioral intentions. Zou et al. (2022) conducted a study with teacher candidates from seven universities in Zhejiang Province, distributing questionnaires through the online platform "Questionnaire Star," with a total of 1,120 valid responses. The study found that the behavioral attitudes of teacher candidates played a fully mediating role in the relationship between TB and behavioral intentions. Therefore, this study proposes Hypothesis 4: TA among Chinese university music teachers serves as a significant mediating factor in the relationship between TB and CTB.

3 Research method and design

3.1 Research framework

Based on the discussions above, this study aims to investigate the influence relationships among TB, CTB, and TA among Chinese

university music teachers. The research framework is designed as depicted in the Figure 1.

3.2 Research participants and sampling procedure

In this study, an online questionnaire survey was conducted using the TB scale, CTB scale, and TA scale among Chinese university music teachers. A total of 3 Chinese universities were selected, including one comprehensive university, one applied university, and one vocational and technical university. Comprehensive universities typically offer a variety of disciplines and majors, including arts, sciences, engineering, medicine, law, etc., and possess the authority to grant complete undergraduate, master's, and doctoral degrees. Applied universities focus on cultivating applied talents, emphasizing the integration of theoretical knowledge and practical application. They usually offer majors closely related to social demands, such as engineering technology, management, design, etc. Vocational and technical universities mainly train talents with technical skills, emphasizing the cultivation of practical skills. The majors offered are often related to specific vocational skills, such as mechanical manufacturing, automotive maintenance, catering management, etc.

Convenience sampling was employed in the survey, which was conducted in two phases. This study collected questionnaires online. Both batches of samples were collected using convenience sampling methods and distributed via the online platform "Questionnaire Star." During the pilot phase, a total of 150 questionnaires were distributed to analyze the item analysis, exploratory factor analysis, and reliability analysis of the scales used in this study. Ultimately, 136 valid pilot questionnaires were collected, resulting in an effective rate of 90.667%.

During the formal survey, questionnaires were distributed with the assistance of colleagues, friends, and through collective activities such as local teacher training. A total of 480 questionnaires were distributed during the formal survey phase. During the data collection process, questionnaires with completion times less than 10 min or incomplete responses were excluded. Eventually, 458 valid questionnaires were collected. When using the questionnaire survey method, the researchers explained the research content, purpose, and requested the participants to sign informed consent forms. Participants were informed that their responses would be anonymous and they could withdraw from the survey at any time.

3.3 Research tools

3.3.1 Teaching beliefs scale

The TB scale developed by Lü and Wang (2004) consists of 38 items in its formal version. The scale comprises four dimensions: beliefs about student management (items 1–12), beliefs about curriculum (items 12–20), beliefs about assessment (items 21–32), and beliefs about student learning (items 33–38). Responses are measured using a five-point Likert scale. The model fit indices for the TB scale in this study are as follows: $\chi^2/df = 1.219$, RMR = 0.030, AGFI = 0.911, RMSEA = 0.022, NFI = 0.944, TLI = 0.989, CFI = 0.989, RFI = 0.940, IFI = 0.989, PNFI = 0.881, PCFI = 0.923. All fit indices meet the standard criteria. The overall Cronbach's Alpha for TB is 0.965.
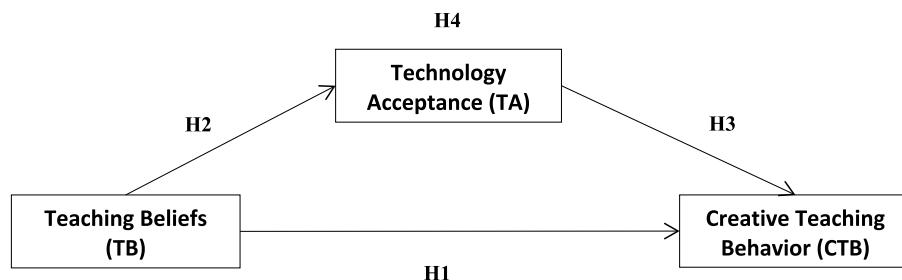
FIGURE 1
Research framework diagram.

3.3.2 Creative teaching behaviors scale

The CTB evaluation scale, developed and revised by Zhang et al. (2008), is used to measure teachers' CTB. The scale consists of 28 items divided into four dimensions: instructional guidance, motivation stimulation, viewpoint evaluation, and encouragement of flexibility. Responses are scored using a 5-point Likert scale. There are no reverse-scored items in this scale.

The model fit indices of the CTB scale used in this study are as follows: $\chi^2/\mathrm{df} = 1.325$, RMR $= 0.029$, AGFI $= 0.924$, RMSEA $= 0.027$, NFI $= 0.939$, TLI $= 0.983$, CFI $= 0.984$, RFI $= 0.933$, IFI $= 0.984$, PNFI $= 0.851$, PCFI $= 0.892$, all fitting indices meet the standards. Cronbach's Alpha $= 0.920$.

3.3.3 Technological acceptance scale

In this study, the TA scale designed by You et al. (2014) was used to assess teachers' acceptance of digital teaching materials. The scale comprises 6 items divided into two factors: perceived usefulness and perceived ease of use, with each factor containing 3 items. Responses are scored using a 5-point Likert scale. The model fit indices of the TA scale used in this study are as follows: $\chi^2/\mathrm{df} = 3.543$, which meets the standard of being less than 5; RMR $= 0.023$, AGFI $= 0.945$, RMSEA $= 0.075$, NFI $= 0.981$, TLI $= 0.977$, CFI $= 0.986$, RFI $= 0.968$, IFI $= 0.986$, PNFI $= 0.588$, PCFI $= 0.592$, all fitting indices meet the standards. Cronbach's Alpha $= 0.910$.

3.4 Data analysis

This study primarily utilizes statistical analysis software such as SPSS and AMOS to validate the proposed theoretical model. The specific research contents include descriptive statistical analysis, common method bias testing, Pearson correlation analysis, structural equation modeling (SEM), and mediation effect testing.

4 Research results

4.1 Basic information analysis

Regarding gender, there were 233 male participants, accounting for 50.900%, and 225 female participants, accounting for 49.100%. In terms of education level, 102 participants had a bachelor's degree, accounting for 22.300%, 211 participants had a master's degree,

accounting for 46.100%, and 145 participants had a doctoral degree, accounting for 31.700%.

4.2 Common method bias testing

As self-reporting was utilized for data collection in this study, there might be a possibility of common method bias. Therefore, both procedural control and statistical tests were employed to address this issue. Firstly, strict procedural control measures were implemented during the questionnaire administration process, emphasizing that the results of the survey were solely for academic research purposes and ensuring absolute confidentiality of the data provided, with responses being anonymous. Subsequently, to examine whether variables exhibited common method bias, an exploratory factor analysis was conducted for Harman's single-factor test. If a single factor explains more than 50% of the variance for all variables, it indicates significant common method bias. The analysis revealed that, prior to factor rotation, 12 factors with eigenvalues greater than 1 were extracted. The first factor accounted for 28.955% of the variance, which was less than 50%. Hence, it was concluded that there was no significant common method bias in this study.

4.3 Correlation analysis of variables

To understand the relationships between predictor variables and to avoid multicollinearity issues, Pearson product–moment correlations were used to explore the relationships among TB, CTB, and TA. The correlations between variables are presented in Table 1. All constructs exhibited significant positive correlations. Moreover, the correlation coefficients between predictor variables were all <0.700, indicating moderate correlations, suggesting the absence of severe multicollinearity issues. Therefore, further examination of the relationships between variables using SEM can be pursued.

4.4 Overall structural model fit assessment

In this study, a total of 458 valid samples from the formal questionnaire were included and subjected to SEM for validation. Maximum likelihood estimation was utilized for estimation. The model fit indices were obtained to assess the model's goodness of fit.

A smaller χ^2 value indicates a higher model fit (Jöreskog, 1970); the χ^2/df ratio should not exceed 5 (Bentler and Bonett, 1980). The GFI should exceed the recommended value of 0.900, while the AGFI should surpass 0.800. Additionally, the RMSEA and SRMR should be less than the recommended value of 0.080. The CFI should exceed 0.800, and the NFI should surpass 0.800. The results, as shown in Table 2, indicate that all model fit indices meet the standards.

4.5 Structural equation modeling analysis

In this study, SEM was employed to investigate the relationships among TB, CTB, and TA, as well as to examine the mediating role of TA and validate the hypotheses proposed in this study.

As shown in Table 3, the standardized path coefficient from TB to CTB is 0.432, with $p < 0.001$, indicating a significant positive impact of TB on CTB. This suggests that stronger TB are associated with higher levels of CTB, thus validating Hypothesis 1.

Similarly, the standardized path coefficient from TB to TA is 0.517, with $p < 0.001$, revealing a significant positive influence of TB on TA. This supports the validation of Hypothesis 2, indicating that stronger TB leads to higher levels of TA.

Furthermore, the standardized path coefficient from TA to CTB is 0.236, with $p < 0.010$, indicating a significant positive impact of TA on CTB. Therefore, Hypothesis 3 is validated, suggesting that higher levels of TA are associated with increased levels of CTB.

4.6 Mediation analysis

To examine the stability of the mediating effect, this study employed the Bootstrap method based on the recommendations of Preacher and Hayes (2008). Specifically, 5,000 bootstrap samples were drawn from the data-set to estimate the coefficients of the mediating effect with a 95% confidence interval.

As shown in Table 4, the results of the analysis confirmed the direct effect of TB on CTB ($\beta = 0.432$, $p = 0.001$). The indirect effect 1, representing the pathway from TB to TA to CTB, had an effect value of 0.122, with a 95% confidence interval ranging from 0.019 to 0.215.

Since this confidence interval does not include zero, it suggests that TA mediates the relationship between TB and CTB, thus further validating Hypothesis 4.

5 Research conclusion

Based on the discussions above, the conclusions drawn from this study are as follows:

1 TB of music educators in Chinese universities positively influence their CTB. The findings are consistent with those of Zielińska et al. (2024). The reason lies in the fact that teaching beliefs constitute a set of attitudes, perceptions, and convictions

TABLE 2 Structural model fit indices.

Index	Fit criterion	Model fit	Fit status
χ^2	Smaller is better	159.636	–
χ^2/df	<5.000	1.400	Fit
GFI	<0.900	0.961	Fit
AGFI	>0.800	0.948	Fit
RMSEA	<0.080	0.030	Fit
SRMR	>0.080	0.039	Fit
CFI	>0.800	0.988	Fit
NFI	>0.800	0.958	Fit

Data source is compiled from this study.

TABLE 3 SEM analysis results.

Path	Standardized path coefficient	S.E.	C.R.
TB → CTB	0.432***	0.045	6.201
TB → TA	0.517***	0.066	9.351
TA → CTB	0.236**	0.048	2.646

*$p < 0.050$; **$p < 0.010$; ***$p < 0.001$.

TABLE 1 Summary table of variable correlation analysis.

Construct	Number of items	A1	A2	A3	A4	B1	B2	B3	B4	C
A1	11	1								
A2	8	0.547***	1							
A3	11	0.526***	0.587***	1						
A4	6	0.530***	0.585***	0.582***	1					
B1	6	0.252***	0.335***	0.329***	0.324***	1				
B2	6	0.276***	0.351***	0.315***	0.284***	0.402***	1			
B3	8	0.304***	0.309***	0.249***	0.356***	0.320***	0.299***	1		
B4	7	0.241***	0.275***	0.242***	0.314***	0.290***	0.391***	0.391***	1	
C	6	0.333***	0.362***	0.358***	0.370***	0.366***	0.380***	0.340***	0.335***	1

A1 represents the dimension of student management beliefs, A2 corresponds to curriculum beliefs dimension, A3 pertains to assessment beliefs dimension, A4 denotes student learning beliefs dimension, B1 stands for learning approach guidance dimension, B2 signifies motivation stimulation dimension, B3 represents viewpoint evaluation dimension, B4 indicates encouragement of innovation dimension, and C denotes the dimension of perceived usefulness. The values on the diagonal represent the square roots of the average variance extracted (AVE) of latent variables, which should be greater than the off-diagonal values. *$p < 0.050$; **$p < 0.010$; ***$p < 0.001$.

TABLE 4 Summary of mediation effects.

Path	Effect size	Standard error	95% Confidence interval (Lower)	95% Confidence interval (Upper)	p-value
Direct Effect 1	0.432	0.066	0.306	0.565	0.001
Indirect Effect 1	0.122	0.050	0.019	0.215	0.022

The sample size for percentile bootstrap confidence intervals is 5000.

that directly influence teachers' instructional practices. If a music educator strongly believes in the benefits of creative teaching for student development and learning, they are more likely to adopt creative teaching methods and strategies.

2 TB of music educators in Chinese universities positively influence their TA. The findings are consistent with those of Gurer and Akkaya (2022). Teaching beliefs may influence teachers' confidence in their technological abilities. If a music educator believes they can master and effectively utilize teaching technology, they are more inclined to accept and experiment with new technologies. Additionally, if teachers perceive technology as necessary and beneficial for music education, they are more likely to actively accept and explore new technological tools and applications.

3 TA of music educators in Chinese universities positively influences their CTB. The findings are consistent with those of Sofwan et al. (2021). Teachers with high levels of technological acceptance may be more inclined to experiment with innovative teaching methods and strategies. These methods may include technology-based creative activities such as music composition, virtual performance, and multimedia presentations. Through technological tools, teachers can more easily adjust teaching content and activities, making teaching more flexible and creative.

4 TA of music educators in Chinese universities mediates the relationship between TB and CTB. The findings are consistent with those of Zou et al. (2022). Teaching beliefs among music educators directly influence their attitudes toward and acceptance of technology. If educators perceive technology as beneficial and essential in music education, they are more likely to utilize various technological tools and applications to support creative teaching practices and behaviors.

6 Research contributions

6.1 Theoretical contributions

This study reveals the mechanism of the influence of teachers' teaching beliefs on creative teaching behavior. Creative teaching behavior is crucial for cultivating innovative talents, and teachers' teaching beliefs are important factors influencing their behavior (Northcote, 2009; Kiss and Lin, 2016). Through the mediating role of technological acceptance, this study delves into the intrinsic mechanism of how teachers' teaching beliefs transform into creative teaching behavior. This finding is of significant importance for guiding teacher education, promoting teachers' professional development, and improving the teaching quality of music disciplines.

6.2 Practical contributions

This study explores the impact of Chinese university music teachers' teaching beliefs on creative teaching behavior and examines the mediating role of technological acceptance. This research not only has theoretical significance but also profound implications in practical applications. Teachers' teaching beliefs not only affect their choice of teaching methods and means but also directly relate to students' learning outcomes and the quality of talent cultivation (Berger et al., 2018). Therefore, by guiding teachers to establish scientific teaching beliefs, it is possible to promote teachers to continuously update teaching methods, improve teaching quality, and cultivate more high-quality talents in the field of music.

7 Practical recommendations

7.1 Strengthening the integration of teaching and music technology

When conducting music teaching, teachers should select suitable music technology tools based on teaching objectives. For instance, if the goal is to enhance students' music composition skills, digital music production software can be used. If the objective is to reinforce students' music theory knowledge, interactive music theory learning platforms may be preferable. To ensure that teachers can fully utilize music technology tools, schools need to provide necessary technical training, which may include software operation guidance and sharing of music production techniques. As music technology continues to evolve, teachers need to continuously update their knowledge and skills to ensure that teaching content remains current. Furthermore, it is essential to pay attention to the potential applications of new technologies in teaching and promptly integrate them into instruction.

7.2 Reinforcing teachers' teaching beliefs

To reinforce teachers' TB, universities can organize a series of teaching training activities to help teachers clarify their teaching philosophies and methods and enhance their teaching skills. Through training, teachers can gain a deeper understanding of their teaching practices. Regularly organizing activities to commend outstanding teaching and inviting experienced teachers to share their teaching experiences and insights can also be beneficial. Through exchanges and discussions, teachers can engage in deeper reflection and understanding of their teaching practices. Additionally, universities can establish teaching incentive mechanisms to recognize teachers who demonstrate excellence in teaching practice. Through incentives, teachers can be encouraged

to remain steadfast in their TB and actively engage in teaching activities.

8 Limitations and future research directions

This study relies on self-reported data from teachers, which may introduce subjectivity and memory bias, affecting the accurate understanding of the relationship between teachers' TB and CTB. While self-reported data provide an intuitive source of information for the study, they may also be influenced by individual subjective perceptions and recollections, thus reducing the objectivity and reliability of the research findings. This limitation arises partially from the choice of research design. In practical research, the use of self-reported data from teachers may be chosen to enhance the feasibility of the study. However, it represents a trade-off made in the research design, sacrificing potentially more objective assessment methods for convenience and practicality, thus resulting in limitations.

Future research can mitigate and avoid this limitation through various means. To alleviate the reliance on self-reported data, future studies can adopt a mixed-methods research design, combining quantitative and qualitative approaches such as in-depth interviews or observations to gain a more comprehensive understanding of the relationship between TB, CTB, and TA. The integrated use of these methods helps enhance the credibility and reliability of the research findings. Overall, by recognizing and analyzing the limitations of the study, future research can systematically and comprehensively explore the relationship between teachers' TB and CTB, providing the field of education with more in-depth and extensive research evidence.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by Dhurakij Pundit University Human Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Analysis of the contribution of critical thinking and psychological well-being to academic performance

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This study examines the influence of critical thinking and psychological well-being on the academic performance of first-year college students. It emphasizes the importance of a model of psychological well-being focused on self-acceptance, environmental mastery and purpose in life, along with a critical thinking approach oriented to problem solving and decision making. A total of 128 first-year psychology students from a Spanish public university participated, assessed by means of Ryff's psychological well-being scale (PWBS) and the PENCRISAL critical thinking test, complemented with grades obtained in a critical thinking course. The results show positive correlations between psychological well-being, critical thinking and academic performance, with a stronger relationship between critical thinking and academic performance. However, psychological well-being also plays a significant role in academic performance. The findings highlight the need for holistic pedagogical approaches that combine cognitive skills and personal development to enhance first-year students' learning.

KEYWORDS

critical thinking, psychological well-being, academic performance, higher education, assessment

1 Introduction

In the context of the increasing demands of contemporary societies, in this study we address how critical thinking (CT) and psychological well-being (PWB) influence academic performance within the university setting. Upon entering university, first-year students are faced with the challenge of adapting to new academic dynamics and demands, which they must balance with the pursuit of personal satisfaction (Acee et al., 2012; Casanova et al., 2018). The adaptation process, which involves the achievement of academic goals and the projection of long-term life objectives, is fundamental to academic performance, considered a key indicator of successful adaptation and a reflection of the competencies required in the professional environment (Alonso-Borrego and Romero-Medina, 2016; Frick and Maihaus, 2016).

The goal of this research is to show the link between CT, which is characterized by analyzing and evaluating information, making evidence-based inferences, and reflecting on one's own thought process for decision making and problem solving (Bailin et al., 1999; Ennis,

2015; Jahn and Kenner, 2018; Saiz, 2020; Halpern and Dunn, 2023), and the PWB, which focuses on personal development (Ryff, 1989, 2013; Ryff and Keyes, 1995); and analyze how both contribute to academic performance. Despite the complexity of the factors that can influence academic performance, in this study we want to combine cognitive and socio-affective variables to better understand these dynamics. Based on The Ryff Psychological Well-Being Scale (PWBS), we examine how well-being, especially through self-acceptance, environmental mastery, and purpose in life impacts academic performance. As a starting point we recognize that CT may have an even greater effect on academic performance. This holistic approach seeks to contribute to the debate on the competencies needed for the 21st century through the relevance of CT and PWB in university education and their role in the formation of individuals capable of coping with contemporary demands.

1.1 Contextualization and characterization of academic performance

In the university context, academic performance is influenced by a series of factors ranging from pedagogical practices and student satisfaction with them to more personal and intrinsic elements. These include the student's motivation and emotional state, academic background, IQ, personality traits and level of psychological maturity. This multi-layered approach focuses the complexity underlying academic performance and emphasizes the interaction between the educational environment and the individual qualities of each student.

A study by Oliván Blázquez et al. (2019) highlights the flipped classroom (FC) method in comparison to traditional lecture-based learning (LB) and shows that FC not only improves students' grades, but also maintains their satisfaction with learning without increasing their perceived workload. Although FC was initially perceived as more difficult, this did not have a negative impact on satisfaction or long-term learning, underscoring the importance of student perceptions and involvement in the learning process. These results support the introduction of FC in higher education and point to the need for continuous adjustments based on student feedback to maximize academic performance and develop critical and practical skills.

Beyond educational practices, Gilar-Corbi et al. (2020) investigated how motivational and emotional factors and prior academic performance influence college students' success. The study used the Motivated Strategies Learning Questionnaire (MSLQ) and the Trait Meta-Mood Scale (TMMS) to measure motivational learning strategies and emotional intelligence. The findings show that scores obtained in the diagnostic tests have a strong influence on academic performance, while emotional attention has a minor influence. The study points out that prior performance, together with self-efficacy and appropriate emotional regulation, plays a crucial role in predicting academic success. Thus, the authors suggest that interventions focused on improving self-efficacy and emotional intelligence may be key to optimizing students' academic outcomes.

In the same context, this time with more variables, Morales-Vives et al. (2020) investigate the influence of intelligence, psychological maturity and personality traits on the academic performance of adolescents, and find that these factors combined explain about 30% of their variability. Intelligence, especially in reasoning and numerical aptitude, emerges as the most significant predictor, while psychological

maturity, reflected in work orientation, and traits such as conscientiousness and openness to experience, have an indirect influence. These findings show that, although intelligence plays a decisive role, maturity and personality are in a lesser proportion.

These conclusions and the recommendations derived from them resemble recent advances in academic research. One example is the work of Mammadov (2022), which draws attention to cognitive ability as the main predictor of academic performance, but also points to the relevance of conscientiousness, a personality trait associated with self-discipline and organization, which explains a significant part of the variability in academic performance. Mammadov also suggests that the influence of personality on performance varies by educational level, showing the dynamics between a student's personality and his or her educational context. These findings demonstrate the need for educational strategies that promote both cognitive development and the reinforcement of positive personality traits.

Recent research on academic performance shows two consensuses. First, there is a growing understanding of the influence of the interaction between intrinsic and extrinsic factors, including pedagogical methods and motivational, emotional and cognitive elements, in improving the performance and satisfaction of students in higher education. The studies reviewed highlight the relevance of cognitive ability and personality traits such as consciousness, and promote a holistic educational approach that integrates the development of cognitive and personality dimensions. Second, academic achievement is recognized as a multidimensional construct, objectively assessed through quantitative indicators such as grade point average (GPA) and standardized assessment scores. These reflect the attainment of educational objectives and the accumulation of knowledge and skills over time.

1.2 Contextualization and characterization of critical thinking

Halpern (1998) argues that intrinsic effort and a willingness to analyze and solve complex problems are key competencies for learning and adapting to a constantly changing environment. According to Halpern (1998) CT transcends the mere acquisition of analytical skills and requires the development of an active predisposition to question assumptions, consider diverse perspectives, and persist in cognitive effort. This disposition is by no means innate, but can be cultivated through a pedagogy that explicitly integrates the teaching of critical skills such as logical analysis, argument evaluation, and information synthesis, and that emphasizes problem structuring to facilitate skill transfer and metacognitive self-regulation. Halpern proposes an educational framework that promotes the acquisition of these skills and encourages reflection on the thinking process so that students are able to apply CT effectively in diverse contexts and continuously improve. This methodical and structured approach characterizes CT as a set of advanced cognitive skills and an exercise of conscious judgment that is essential for informed, evidence-based decision making, which integrates non-cognitive elements (Halpern and Dunn, 2023).

Throughout the development of the discourse on CT, various theories and their empirical foundations have evolved into meaningful educational practices, recognized in diverse academic settings. Meta-analyses, particularly those by Abrami et al. (2008, 2015) have

contributed significantly to the understanding of effective teaching of CT and have emphasized the need for specific and tailored teaching strategies that incorporate clear CT objectives into educational programs. These studies demonstrate that CT, defined as a process of intentional, self-regulated judgment that includes interpretation, analysis, evaluation, and inference, is increasingly recognized as essential in the knowledge era. Abrami et al. (2008) note that critical skills and dispositions are developed through explicit pedagogical interventions, as opposed to spontaneous acquisition, which challenges traditional pedagogical paradigms and fosters a shift towards intentional educational practices, placing students at the center of learning.

In addition, a more detailed analysis by Abrami et al. (2015) identifies that strategies that encourage interactive dialogue, confrontation with real problems, and individual tutorials are particularly effective. This suggests that active and meaningful learning outperforms traditional methods in the development of critical skills. This approach not only enhances students' analytical and synthesis skills, but also facilitates the transfer of knowledge to new contexts, a key skill for the 21st century. The research reinforces the view that CT is a cross-cutting competency, crucial for navigating the complexity of contemporary challenges, and argues for an education that integrates these skills into all areas of learning.

Despite in-depth analyses of the need for CT, the growing discrepancy between rapid progress, the availability of information and the ability to critically analyze it poses a major challenge. Dwyer et al. (2014) point out that the exponential increase in global information has outpaced the ability of traditional education systems to teach effective CT skills, creating a gap that may inadequately prepare students for the challenges of today's world. The authors argue that the ability to critically evaluate, synthesize, and apply knowledge is crucial for academic success and survival in the 21st century. This approach highlights how CT, by fostering analytical and reflective skills, transcends academia to positively impact individual and collective well-being, and argues for educational strategies that bridge the gap between information acquisition and critical analytical skills.

Recent research on this topic points to the indisputable relevance of CT as an essential component of academic performance and points to its role as a key predictor of success in educational processes. Rivas et al. (2023) show that CT transcends conventional cognitive skills. This is because CT is characterized as a rigorous practice that fosters in-depth analysis, critical evaluation and synthesis of information oriented to decision making and problem solving, fundamental skills to understand and apply knowledge in complex contexts. Research shows that CT skills not only maintain a positive correlation with academic performance, but can be significantly improved through targeted educational programs. For this reason, the authors advocate their integration into curricula and educational assessment systems to prepare students for the challenges of the 21st century, especially when phenomena such as artificial intelligence acquire greater prominence in social and professional dynamics (Saiz and Rivas, 2023).

The literature on CT identifies two fundamental consensuses: first, it defines it as an intentional and deep process, oriented to problem solving and decision making, based on meticulous analysis that goes beyond logical reasoning to include a critical evaluation of the basis for judgments. In addition, it involves detailed scrutiny and integration of new information in changing contexts, as well as metacognition, i.e., conscious self-regulation of thinking that facilitates adaptation

and continuous improvement of cognitive strategies in accordance with the major demands and obstacles of our first half century (Dwyer, 2023). In its practical application, CT enables daily challenges to be met through informed judgments and a willingness to question and adjust perspectives in response to new information. Characterized by curiosity and adaptability, CT is essential for making responsible decisions and achieving successful outcomes, underscoring its practical value in both personal and professional settings.

Second, CT, beyond its theoretical value, can be conceived as a key theory of action for academic performance and PWB (Saiz, 2020; Saiz and Rivas, 2023), by enhancing in individuals the ability to face and solve problems in an effective and grounded manner. CT involves crucial skills such as analysis, evaluation and synthesis, indispensable for acquiring and retaining knowledge, and also for applying it in new contexts, which improves academic performance and has, in principle, positive effects on quality of life. Thus, CT emerges as an academic competence and an essential tool for everyday life (Dumitru and Halpern, 2023; Guamanga et al., 2023). Therefore, to synthesize theoretical paths with a practical function, we understand that "to think critically is to arrive at the best explanation of a fact, phenomenon or problem in order to know how to solve it effectively" (Saiz, 2024, p. 19).

1.3 Contextualization and characterization of psychological well-being

The task of relating concepts that are difficult to operationalize, such as well-being, is a major challenge; but it is necessary to approach it, more within a framework of CT understood as a means to achieve broad objectives than as an end in itself. Thinking critically transcends the mere application of skills or the accumulation of goal-oriented knowledge. In fact, it requires a detailed examination of the effect that such management has on the environment and how the satisfaction derived from reaching certain achievements is related to subjective aspects.

CT by its very deliberative and goal-oriented nature goes beyond the search for how to reach effective solutions and addresses a wider range of human and social consequences resulting from these actions (Facione, 1990; Elder, 1997; Jahn, 2019). The idea is to involve non-cognitive aspects that occupy a central place in academia, and that are crucial in the interaction between specific knowledge and skills, elements widely explored in the discourse of CT. In this sense, PWB has been selected as the focus of study, recognizing it as a desirable attribute in educational processes. The challenges this poses are not lost sight of, especially when it comes to quantifying transient, subjective and normatively mediated judgments about what states or conditions are considered good, healthy or desirable in the complexity of human experience, as detailed by Flanagan et al. (2023).

Ryff (1989, 2013), Ryff and Keyes (1995) contribution to the conceptual understanding and dissemination of PWB is notorious and highly valued in different fields of knowledge (Van Dierendonck and Lam, 2023). The imprint of his research has been marked by criticism of a reductionist conception of PWB that simplifies well-being to the presence of positive affective states (Ryff, 1989). Consequently, Ryff defends a much more complex multidimensional concept that seeks to attune the attainment of goals with the development of potentialities. Ryff's thesis is that PWB is a multidimensional construct

that transcends happiness or mere life satisfaction (Ryff and Keyes, 1995).

Carol Ryff's theory of PWB, based on humanistic, clinical and developmental psychology, as well as Aristotelian eudaimonia, focuses on self-actualization, the search for meaning and purpose in life as the core of well-being. As detailed in the text *Happiness is everything, or is it? Explorations on the meaning of psychological well-being* (Ryff, 1989) the model consists of six dimensions that converge in personal development: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance.

The first dimension, self-acceptance, implies a positive attitude towards oneself and an acceptance of all aspects of one's identity, including both positive and negative qualities. As for positive relationships with others, Ryff states that these are interpersonal relationships characterized by warmth, trust and genuine concern for the well-being of others; this dimension is dominated by the value of empathy in human well-being. Autonomy is defined by an individual's capacity to maintain independence and resist social pressures in order to regulate their behavior according to internal personal norms. This dimension emphasizes self-determination as a compass for the pursuit of well-being. On the other hand, environmental mastery emphasizes the ability to effectively manage and control the external environment, which implies a feeling of competence and control over personal and professional life. Finally, purpose in life and personal growth refer to the possession of goals, direction and a sense of development and fulfillment of one's potential. These dimensions reflect the search for meaning and continuous personal evolution as fundamental components of PWB.

Ryff's PWBS has established itself as a key instrument in positive psychology. Research after 1989 (Ryff and Keyes, 1995; Ryff, 2013) has explored the variability of these dimensions with age and across genders. These studies showed the influence of sociodemographic factors on well-being, so the model has been extended to consider the development of PWB across the lifespan and determined by more contextual factors such as health. The approach enriches the understanding of PWB and denotes the practical relevance of the construct in fields such as mental health and social policy. Ryff's work has inspired other researchers to discuss and extend its principles (Van Dierendonck and Lam, 2023). For example, Huppert (2009) complements Ryff's dimensions by emphasizing the management of negative emotions and resilience as key components of sustainable well-being; Huppert aligns this view with the World Health Organization (WHO) definition of health and adds a dynamic dimension on overcoming adversity. This theoretical and practical deepening demonstrates the robustness and adaptability of Ryff's model. The synthesis of these contributions confirms the value and applicability of Ryff's PWBS; they reveal how the eudaemonic model not only reinforces an academic discourse, but also guides practices that promote well-being in different contexts and consolidates itself as a vital field in human development.

However, due to the same complexity and extension of the PWB construct, Ryff's PWBS has different observations that question its theoretical and statistical foundations. On the first aspect, the work of Disabato et al. (2016), by examining the distinction between hedonic and eudaimonic well-being, problematizes the theoretical basis of this dichotomy. Through an analysis incorporating data from 7,617 individuals from 109 countries, the authors find that there is no clear distinction between hedonic well-being experiences, focused on

pleasure, and eudaimonic ones, related to personal fulfillment. The results indicate a high correlation between the two types of well-being ($r = 0.96$). This suggests that people do not significantly differentiate between pleasure seeking and self-fulfillment in their perception of well-being. This implies that the hedonic-eudaimonic dichotomy may not hold empirically and, therefore, a unified model of well-being that reflects the current behavioral dynamics should be sought.

From a statistical perspective, Ryff and Keyes (1995) analyses show that the PWBS, composed of 18 items, meets psychometric criteria and shows strong internal and moderate correlations among different scales. Correlations between dimensions range from low to modest (0.13 to 0.46), suggesting that each dimension addresses unique aspects of well-being. From the theoretical model, this diversity underscores that, although interrelated, the dimensions represent unique aspects of psychological well-being. In terms of specific results, studies indicate that with age the dimensions of environmental mastery and autonomy increase, while purpose in life and personal growth tend to decrease, with no significant changes in self-acceptance and positive relationships with others. Women outperform men on positive relationships with others and personal growth, suggesting that changes in these dimensions reflect evolving priorities and perceptions of personal development across the life span (Ryff and Keyes, 1995).

On the number of dimensions of PWBS, Blasco-Belled and Alsinet (2022) note that the six-dimensional theoretical model has generated debate even among experts in the field. Some suggest that a four-dimensional model-environmental mastery, personal growth, purpose in life, and self-acceptance-might represent a second-order PWB factor, indicating a possible conceptual overlap between Ryff's original dimensions; others exclude positive relationships with others and autonomy from the model. The study of Ryff's PWBS by network analysis conducted by Blasco-Belled and Alsinet (2022) shows four different dimensions, in one of these, the most important node of the network, self-acceptance, purpose in life and environmental mastery are grouped, with special emphasis on self-acceptance because of its centrality in the network at the item level.

In the Spanish-speaking context, Nogueira et al. (2023) identified three main factors: autonomy, positive relationships with others, and competence. This suggests that PWBS may vary according to cultural and contextual factors. Furthermore, although it is not a study analyzing the dimensions of Ryff's PWBS, the study by Páez-Gallego et al. (2020) applied the PWBS to Spanish adolescent students and found a strong positive correlation with the use of adaptive decision-making strategies. Specifically, the findings show that the adaptive approach is significantly associated with improvements in self-acceptance, environmental mastery, and purpose in life. In contrast, maladaptive strategies characterized by impulsivity and avoidance are associated with lower PWB. From this we infer that fostering effective decision-making skills is important for well-being and, in particular, we identify from empirical studies the dimensions of PWBS that correlate with post decisional skills.

Taken together, these findings suggest that Ryff's PWBS, although pioneering and widely used, could benefit from revision to more accurately reflect the structure of PWB and its application in diverse cultural and educational contexts. The convergence of evidence from factorial and network analysis perspectives points to the need for a more integrated and adaptive model capable of capturing the complexity and dynamics of the underlying constructs.

This underscores the continuing interest in PWB in research and practice. It is also an indication of the ongoing scholarly debate about its conceptualization and measurement. The recurrence of dimensions such as self-acceptance, environmental mastery, and purpose in life across analyses suggests a common core of PWB. This raises the question of whether these dimensions can be conceptually aligned with academic achievement and CT. In addition, questioning the boundaries between hedonic and eudaimonic raises the issue of whether a broader construct is needed to analyze well-being in educational settings. In this context, we start from the premise that self-acceptance, environmental mastery, and purpose in life are sufficient to explore college students' PWB. These dimensions reflect students' ability to recognize their strengths and weaknesses, set goals, and navigate effectively in their educational environment, aspects that could be considered part of the dispositional component necessary for the development of higher-level competencies such as those of the CT.

The research brings to empirical analysis the complex interplay between CT, PWB, and academic performance in the university context. We seek to answer how CT skills and PWB influence college students' academic performance; and, how CT practices can be aligned with PWB to improve academic performance. We propose that the study variables converge in both a theoretical and an empirical model. The argumentative strategy consists of analyzing the direct impact of CT on academic performance, assessing whether PWB correlates with better academic outcomes, examining in detail the predictive factor of the relationship between CT and PWB on academic performance, and finally, according to the data obtained, proposing some dialogic bridges between cognitive and non-cognitive aspects of CT.

2 Methodology

2.1 Participants

The study involved 128 first-year psychology students from a Spanish public university. The vast majority were women (83.1%), with only 16.9% men, which is usual in social sciences and humanities degrees. Age ranged from 18 to 33 years, with a mean of 19.28 (SD = 1.73). The sample was essentially composed of students who had completed secondary education (75.3% of the students were 19 years old). Between the ages of the students according to sex — females (M = 19.09, SD = 0.814) and males (M = 20.20, SD = 3.78) — there were no statistical differences, but the age of the males was not only higher, but also more dispersed.

2.2 Instruments

The instruments applied were Ryff's PWBS in its Spanish adaptation (Díaz et al., 2006) and the PENCRISAL critical thinking test (Saiz and Rivas, 2008; Rivas and Saiz, 2012). For academic performance, the academic records of the students participating in the critical thinking course in the first year of the psychology graduation were collected. The grades have an ascending interval from 1 to 10.

Ryff's PWBS as mentioned in the previous discussion has different models. This instrument aims to measure psychological well-being, focusing on students' own evaluations of their situations and perceived success in various aspects of life and personal development. It explores

well-being through six main dimensions, self-acceptance (α: 0.83), positive relationships with others (α: 0.81), environmental mastery (α: 0.71), autonomy (α: 0.73), purpose in life (α: 0.83) and personal growth (α: 0.68). The questionnaire consists of 39 items, presented in a Likert scale format ranging from 1 (strongly disagree) to 6 (strongly agree) (Díaz et al., 2006).

Consistent with the complexity of the scale and some data in common with other studies, we have chosen to consider only self-acceptance, environmental mastery and purpose in life. In support of this methodological decision, we have performed with our sample an exploratory factor analysis (principal components method) to see if these three dimensions converge in the same factor. The data confirm this convergence and show that this single factor has an eigenvalue of 2.43 and explains a very high value of the variance of its results (81.1%).

In the case of the PENCRISAL, the full version was applied, and the score was taken for each of the five dimensions and the total score. The PENCRISAL was applied to measure CT skills. This test consists of 35 problem situations that participants answer in an open-response format. The test is organized into five key areas: deductive reasoning, inductive reasoning, practical reasoning, decision making and problem solving.

The deductive and inductive component tests different forms of reasoning, such as propositional, categorical, causal, analogical and hypothetical. Decision-making measures the ability to make probabilistic judgments and to effectively use heuristics to identify potential biases. The problem-solving section poses participants with general and specific problems that require appropriate solution strategies. These sections are intended to encourage the application of strategies necessary for effective problem planning. The open-ended question format encourages participants to justify their answers, which are evaluated using a scoring system that rates the quality of their responses on a scale of 0 to 2. Responses are converted into numerical scores using item-specific criteria. These are used to describe and identify the thinking mechanisms underlying each response. A score of 0 indicates that the answer is incorrect, 1 indicates that the answer is correct but no or inadequate justification is provided, and 2 indicates that the answer is correct and adequate justification is provided. The PENCRISAL yields an overall score of the CT ranging between 0 and 70 and between 0 and 14 for each dimension. Reliability assessments show satisfactory accuracy, with a minimum Cronbach's Alpha of 0.632 and a test–retest reliability of 0.786 (Rivas and Saiz, 2012). The test is administered online through the SelectSurvey.NET V5 platform.

2.3 Procedures

Students gave their free and informed consent to participate in the study. The PWBS was carried out at the beginning of the semester of the CT course. The PENCRISAL test was taken at the beginning and at the end of the academic period. Only the results of students who completed both instruments are considered. Academic performance is represented by the grade obtained by students at the end of the course. Statistical analyses were performed with IBM/SPSS version 29.0. After performing the descriptive statistics, we proceeded to a correlation analysis and, finally, we evaluated the impact of the PWBS and the CT on the variance of academic performance by performing a regression analysis.

3 Results

Table 1 presents the descriptive data of the students' scores on the two instruments applied, and the measure of academic performance. In addition to the minimum and maximum values, the mean, standard deviation and indicators of skewness and kurtosis of the distribution of the results are presented.

Observing the results, we can see a distribution with a slight tendency towards values above the mean (m = 79.80) for the PWBS, which is reflected in a negative skewness (−0.437). With respect to the five dimensions of CT, it can be stated globally that the mean value of DR, IR and PS is moving away from the maximum value observed and towards the minimum value, which represents a positive symmetry. The opposite situation occurs with the RP dimension. Regarding the TCT, the data show a tendency to scores around the mean (m = 37.21), as can be deduced from the residual values of skewness and kurtosis. Regarding the AP, the data suggest a balanced distribution of academic scores around an intermediate value between 3.66 and 9.01 as scores at the lower and upper extremes (m = 6.10), with very low skewness and kurtosis.

In general, the results show good variability or dispersion, since the mean of each variable is located in the center of the data interval, which is desirable in research to adequately represent the population studied. Skewness and kurtosis indices close to zero for academic achievement are especially indicative of a normal or Gaussian distribution of values. The slightly higher kurtosis in the IR dimension of CT (2.248) is still acceptable.

Table 2 shows the correlations between the variables in this study. Since these were interval metric variables, Pearson's product x moment method was used to calculate the correlations. For statistical significance, the two-tailed test was used and $p < 0.05$ was set as the limit of significance.

According to the data, the highest correlation is found between TCT and AP, with the lowest correlation being between CT and PWBS measurement (no correlation). At an intermediate level is the correlation between PWBS and AP. Likewise, all the dimensions of the CT correlate with the AP with values between 0.183 (PS) and 0.337 (PR). As can be seen, there are variations in the correlations among the five dimensions of the CT, but all have high correlations with the total score (between 0.502 and 0.668). In this sense, only the TCT score is used for the regression statistical analysis.

In summary, the data suggest that there is a significant and positive relationship between PWBS and AP, as well as an even stronger and more significant relationship between TCT and AP. There is no evidence of a significant relationship between PWBS and TCT. To further explore the relationships between cognitive and noncognitive variables in AP, we turned to a regression analysis. We opted for a linear regression with PWBS and TCT as predictors and AP as the criterion or dependent variable. Table 3 presents the regression values obtained.

The regression model was found to be statistically significant, with an F-value (2, 88) = 18.571, $p < 0.001$. This indicates that, collectively, PWBS and TCT provide significant prediction of AP. The coefficient of determination (R^2 adj.) is 0.285, which means that approximately 30% of the variability in AP can be explained by the independent

TABLE 1 Descriptive statistics for the measures used (n = 128).

Variables	Minimum	Maximum	Mean	Standard deviation	Skewness	Kurtosis
PWBS	39	103	79.80	13.41	−0.437	0.076
DR	1	14	5.56	2.59	0.395	0.173
IR	2	16	6.36	2.10	0.858	2.248
PR	2	14	10.20	2.41	−1.002	1.338
DM	4	13	8.52	1.83	0.080	0.031
PS	2	16	6.87	2.32	0.409	0.797
TCT	19	56	37.21	7.17	−0.012	−0.293
AP	3.66	9.01	6.10	1.05	0.204	−0.155

Psychological well-being scale (PWBS), deductive reasoning (DR), inductive reasoning (IR), practical reasoning (PR), decision making (DM), problem solving (PS), critical thinking total (TCT), academic performance (AP).

TABLE 2 Correlations between study variables.

Variables	PWBS	DR	IR	PR	DM	PS	TCT	AP
PWBS	–	−0.082	−0.167	−0.041	−0.132	0.040	0.039	0.336**
DR	−0.082	–	0.450***	0.271	0.227**	0.118	0.589***	0.211*
IR	−0.167	0.450***	–	0.362***	0.218*	0.129	0.622***	0.205*
PR	−0.041	0.669***	0.362***	–	0.381***	0.132	0.668***	0.337***
DM	−0.132	0.593***	0.218*	0.381***	–	0.295**	0.593***	0.217*
PS	0.040	0.502***	0.129	0.132	0.295**	–	0.502***	0.183*
TCT	0.039	0.589***	0.622***	0.668***	0.593***	0.502***	–	0.514***
AP	0.336**	0.211*	0.205*	0.337***	0.217*	0.183*	0.514***	–

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (two-tailed).

variables in the model. As can be seen from the *t*-values and significance, both variables have a significant impact on AP, although TCT has a greater impact.

In a complementary manner, with the objective of enriching the analysis of the influence of the CT on the PA, we have included additional measures to the grade obtained by the students in the course (NCT), such as the selectivity grade with which they entered the university (NEBAU), the average grade of the transcript (NMEXP), that is, the grades of the other courses that the students must take, and the pretest results obtained with the PENCRISAL (PCT). The data obtained are recorded in Table 4.

Table 4 shows that the relationship between PWBS and NMEXP has a Pearson correlation of 0.075, with a *p*-value of 0.372. This low correlation indicates that the connection is minimal. In contrast, the relationship between TCT and NMEXP shows a stronger correlation of 0.464**, suggesting a moderate positive association. The significance of this correlation, less than 0.001, indicates a statistically significant relationship, which implies that this result is not likely to be a coincidence. A similar case occurs with the relationship between NEBAU and NMEXP.

Given this context, if we perform a multiple linear regression analysis with NMEXP as the dependent variable and PWBS and TCT as independent variables, we would expect TCT to have a more significant impact on NMEXP. This projection is based on the statistically significant correlation of these variables. On the other hand, NEBAU has a slightly lower correlation with NMEXP compared to TCT (0.455 vs. 0.464), but the difference is very small, indicating that both have similar impact capacity for NMEXP in terms of linear correlation.

Confirmation of these hypotheses by appropriate regression analysis will provide a more detailed and accurate understanding of how PWBS and TCT individually contribute to the prediction of NMEXP, considering the influence of interrelated variables. However, in performing this procedure, a reduction in sample size to only 64 cases were observed. This increases the risk of failing to detect significant differences or could lead to unstable effect estimates.

4 Discussion and conclusions

The CT seeks to understand and effectively solve problems, through a correct approach, the generation of solution alternatives filtered by the mechanism of explanation and the selection of a solution, all with the aim of achieving a desired change. The PENCRISAL test is based on this defining framework of the CT (Saiz and Rivas, 2008; Rivas and Saiz, 2012). Therefore, if we start from this concept and look at the data, we can conclude that the CT is a good predictor of academic performance.

Table 2 shows a positive and moderate correlation (0.514) between the CT and academic performance, suggesting that an increase in the CT is associated with an improvement in academic performance. Meanwhile, Table 3 shows — with a B coefficient of 0.074 and a Beta of 0.473 — that CT has a stronger relationship with academic performance compared to PWBS. This means that for every unit increase in CT, academic performance increases on average 0.074 units, and this effect is considerably significant in the model. The robust correlation and the impact indicated as a dependent variable highlight that the CT is a determinant competence of academic performance and is suggested as a relevant diagnostic and formative tool in the educational field. Although it is not the only factor that influences academic performance, the CT is presented as a significant predictor and one that can be worked on or trained in the classroom.

Declaratively, the current study coincides with other results obtained and recorded in Rivas et al. (2023). On that occasion, the authors found that CT is a predictor of academic performance and that the benefits of instruction can be sustained over time. The study showed a correlation between CT and academic performance of 0.32. The main difference between these two studies concerns the objectives. The previous study did not attend to the explicit discussion of how CT could influence well-being, or vice versa. The current work recovers this line and incorporates non-cognitive variables in the analysis framework to account for well-being, under the assumption that this construct should have a significant impact on academic performance.

More generally, if we consider that, although the construct intelligence is not the same as CT, they do have several points of convergence (Butler et al., 2017), then we can establish a dialogue with other studies on the factors that influence academic performance. Intelligence represents the intrinsic capacity to learn, understand, reason, and meet challenges through problem solving to adapt to the environment (Sternberg, 1985). This cognitive potentiality manifests itself in various ways, being the CT one of its most relevant

TABLE 3 Impact of psychological well-being and critical thinking on academic performance.

		B	Error	Beta	*t*	Prob.
1	(Constant)	1.653	0.793		2.085	0.041
	PWBS	0.022	0.007	0.271	3.004	<0.01
	TCT	0.074	0.014	0.473	5.252	<0.001

TABLE 4 Correlations between study variables and complementary measures.

Variables	PCT	TCT	NCT	NMEXP	NEBAU	PWBS
PCT	–	0.477***	0.196*	0.271***	0.089	−0.142
TCT	0.477***	–	0.512***	0.464***	0.177*	−0.128
NCT	0.196*	0.512***	–	0.642***	0.288**	0.194*
NMEXP	0.271**	0.464***	0.642***	–	0.455***	0.075
NEBAU	0.089	0.177*	0.288***	0.455***	–	0.008
PWBS	−0.142	−0.128	0.194*	0.075	0.008	–

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (two-tailed). PCT, PENCRISAL total PRE; TCT, total of PENCRISAL POST; NCT, critical thinking course note; NMEXP, grade point average; NEBAU, selectivity score; PWBS, Psychological Well-Being Scale.

expressions, particularly in situations that demand deep analysis, evaluation, and decisions based on logical reasoning (Saiz, 2024). The CT, therefore, acts as an essential tool that intelligence employs to effectively navigate through complex and challenging real-world situations (Halpern and Butler, 2018).

In this conceptual line, the current results partially coincide with studies that have shown that the best predictors of academic performance are cognitive components, such as measures of general intelligence, analogical reasoning, fluid intelligence, logical, verbal and quantitative reasoning (Morales-Vives et al., 2020; Mammadov, 2022); as well as scores on the diagnostic and university entrance test (Gilar-Corbi et al., 2020).

In our study the other factor of analysis was the PWB. Although due to its non-cognitive nature it would be *per se* at a disadvantage compared to cognitive factors, the data also show that its inclusion in educational research, especially to account for academic performance, is significant. In Table 2, the analysis of the correlation between PWBS and academic performance reveals a positive relationship with a correlation coefficient of 0.336. Although the correlation is moderate and not as strong as that observed between CT and academic performance, it is still significant and should not be ignored in the pursuit of improving students' academic performance. Table 3 shows that PWBS has a positive and significant influence on the dependent variable. The standardized coefficient (Beta) of 0.271 indicates that there is a positive relationship between PWBS and academic achievement. The unstandardized coefficient (B) shows that, holding all other variables constant, for each unit increase in PWBS, academic performance increases on average 0.022 units. This relationship, supported by a low standard error of 0.007, points to a moderate but significant contribution of PWBS compared to other variables.

These findings show that the integration of some aspects of PWBS could be an effective strategy to improve academic performance, evidencing a beneficial and significant relationship between both aspects. PWB can influence academic performance through non-cognitive conditions or factors involved in learning, such as motivation, academic satisfaction, effective coping with stress or anxiety, and the acceptance and management of limitations related to the process of appropriation and adaptation to one's own identity.

However, it is important to emphasize that the PWB is a construct that requires careful theoretical and empirical review in the educational context, as the Ryff scale has open debates and the lack of uniqueness of criteria on the number of dimensions influences these results. To cite just one case, we have used three dimensions out of six, with statistical and literature support, but the data may be different with a different selection approach. This finding highlights the importance of students' PWB as part of a comprehensive educational strategy, but also shows that the direct impact of PWB on academic performance may be less pronounced than the impact of cognitive skills, and that due to its very multidimensional and complex nature, it is not easy to converge in an instructional design. Despite this, higher education institutions can take care of the institutional and relational climate so that students feel good and take advantage of the formative and educational opportunities of the academic environment. In the case of CT, there are concrete and validated training strategies that make it possible to improve skills such as argumentation, explanation,

problem solving and decision making (Guamanga et al., 2023; Saiz, 2024). On the PWB side, the same cannot be said due to the lack of empirical support; however, some studies have proposed a path that incorporates socio-emotional competences in the training of CT, a proposal characterized by the cognitive-emotional methodology, with interesting results that still need to be explored and debated (Hanna, 2013).

Table 2 shows low and non-significant correlations between PWBS and the different forms of reasoning (deductive, inductive and practical), as well as with decision making and problem solving. For example, the correlation between PWBS and deductive reasoning is −0.082, which is not only low, but also lacks statistical significance. Additionally, the correlation between PWBS and decision making is −0.132, which is also a low correlation and not significant. Although there is a positive correlation between PWBS and problem solving (0.040), it is very low and not statistically significant, so there is not enough evidence to claim a positive relationship between these variables. This reinforces the idea that there is not a direct and significant relationship between how a student feels psychologically and CT skills or, nuanced is not supported by the data from this sample. It is possible that there are unexamined mediating factors that influence these relationships or that the relationship exists in a different context or with different measures.

The results of the present study do not coincide with other research that has shown positive relationships between decision-making and PWBS, especially with self-acceptance, environmental mastery, and purpose in life. The study by Páez-Gallego et al. (2020) addresses this issue by exploring how the PWBS of adolescents in Madrid, Spain, is linked to their decision-making methods. The research concludes that there is a positive correlation between the use of adaptive decision-making strategies and PWBS. Adolescents who opt for a rational and systematic evaluation of available options report higher levels of well-being. Specifically, adaptive decision-making style correlates significantly with overall well-being (0.544) and with aspects such as self-acceptance (0.485), positive relationships with others (0.242), environmental mastery (0.472), autonomy (0.359), purpose in life (0.473), and personal growth (0.346). In contrast, those who resort to maladaptive strategies, marked by impulsivity or avoidance, show reduced PWBS (−0.458).

The discrepancy in results with this study could be due to the difference between the instruments used to assess decision making. While Páez-Gallego et al. (2020) used the *Flinders Adolescent Decision Making Questionnaire* (FADMQ), which focuses on personal perceptions and experiences of decision making, our study uses the PENCRISAL, which although not limited to decision making, does include this ability as an essential component of the CT. The latter measures the ability to identify, analyze and solve everyday problems through items that simulate real situations, assessing the ability to choose the best solution or action strategy. Because the PENCRISAL responses are open-ended, it allows for a detailed assessment of how participants describe or explain their decisions. Ultimately, the fundamental difference between these two measures is that one is a self-report of perceptions and experiences, while the other is a set of problems to be solved correctly; in other words, one collects impressions of decision making and the other collects realized decision making. Therefore, although both studies applied Ryff's

PWBS, the differences between instruments and approach to decision making explain the variations in the results. This divergence evidences the relevance of considering the context and the specific instrument when interpreting the relationship between the PWBS and decision making.

Despite these findings, the need to further explore these interactions persists, especially given that the three selected dimensions-self-acceptance, environmental mastery, and life purpose-theoretically align with CT approaches focused on explanation and the development of post decisional skills, such as decision making and problem solving (Guamanga et al., 2023). A CT approach that emphasizes the development of these skills must consider effects that transcend immediate or tangible outcomes. Therefore, it is crucial to understand how the concept of PWB, as examined above, relates to CT. Specifically, it must be determined whether some of these dimensions align directly to foster effective CT, or whether they instead lean more towards a conception of well-being in a more general sense, which could include hedonic aspects.

The emphasis on CT oriented to decision making and problem solving through the analysis of explanations and causalities should be evaluated for its pragmatic effects on PWB. At first glance this idea seems to confront parallel concepts paradoxically united by the same diachronic nature. In the case of the CT, this nature explains the high demands placed on it. For example, it is not enough to say that it contributes to tangible improvements in academic performance, but its usefulness is expected to transcend beyond academia and materialize in skills of interest to organizations in all sectors of the economy (Casner-Lotto and Barrington, 2006; Atanasiu, 2021). However, their practical impact still presents serious challenges, especially when students, as active subjects of learning, face limitations in anticipating the usefulness and applicability of these critical skills for the future. This is partly explained by the fact that the educational system prioritizes academic performance over the comprehensive development required later in the professional sphere (Saiz, 2020). Which means that the CT can be interpreted as an unfulfilled or partial promise. It is certainly a reading that omits the particular contexts, interests, motivations and concerns of students while they are part of these instructional programs and then the same factors analyzed by a student who knows that he or she must make the transition to the professional field.

A similar case happens with PWB as a diachronic phenomenon. An instant in time is not enough to understand and analyze students' PWB. It is necessary to focus on how it changes and evolves through different stages, including through feelings of achievement or frustration in the academic process. Thus, it is recognized that PWB is not static and, therefore, evolves through lived experiences, among them, those comprising the applicability of a series of learned skills. This implies that as diachronic phenomena they can evolve and influence each other over time. This approach requires longitudinal studies to follow the evolution of the impact of curricular interventions aimed at strengthening cognitive skills such as those of the CT, in order to understand how these may influence the PWB in the long term.

The limitations of this study, beyond having a small sample that prevents the generalization of the results or having examined only certain dimensions of the PWBS, added to the theoretical impossibility

of performing regression analyses with other performance measures, lie in the diachronic nature of the constructs studied. This characteristic makes it difficult, as has been argued, to give a definitive answer on the relationship.

Within the framework of the PWBS triad model we are analyzing, it is possible to theoretically group several key concepts. The development of the CT involves a process of self-acceptance, which is crucial given our inherent tendency for error. This process allows us, through a reflective evaluation of our past and present, to recognize and accept beliefs that we have discarded as erroneous. This self-acceptance facilitates deeper introspection, allowing us to see these errors as essential learning opportunities in our lives. On the other hand, any model that emphasizes post-decisional skills must also consider the non-linear complexity of our reality, and provide solid criteria for problem solving and decision making to master our environment more effectively. This is what allows us to adapt better, both biologically and socially. Finally, this approach to TC inevitably values purpose in life by seeking to ensure that it is in part determined by integrating the best tools of science, philosophy and education for a more effective life orientation, grounded in the principles of rationality. The importance of setting clear goals, recognizing that their achievement requires effort, discipline and determination, is essential to being an effective critical thinker.

Therefore, although each dimension proposed by Ryff's PWBS possesses a conceptual richness that requires empirical validation, the dimensions selected for this study are aligned with a model of CT focused on problem solving and real-world decision making. Although we aspired to discover stronger links between PWB and CT, and to deepen their interrelationship, the theoretical parallelism analyzed is also reflected in the empirical results. Moreover, PWB as an operational concept, due to its complexity and multidimensionality, is subject to continuous revisions or possible unifications into a broader notion of well-being.

In future research on this topic, it is essential to include a broader set of variables predictive of academic performance. This includes, but is not limited to, students' selectivity record and cumulative grades in other subjects. In addition, a more solid and theoretically robust concept of well-being must be adopted, one that fits contemporary educational and professional demands. This concept must transcend the simple distinction between eudaemonic and hedonic well-being, and address its diachronic nature. It is important to explore how these dimensions of well-being are interrelated, either as cause or effect; and to examine whether CT fosters a virtuous circle with well-being.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding author.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

MG: Writing – original draft, Conceptualization, Investigation, Methodology, Writing – review & editing. CS: Investigation, Methodology, Project administration, Validation, Writing – original draft. SR: Data curation, Investigation, Supervision, Validation, Writing – review & editing. LA: Formal analysis, Methodology, Validation, Writing – review & editing.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Relevance of objective and subjective profile: creative behavior assessment in higher education students

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Creativity is a 21st Century skill. Promoting problem-solving and attending to global complex issues in formative learning experiences and professional endeavors is considered necessary. The assessment of creativity in higher education is a challenge itself due to few objective instruments for Spanish speakers and Latin populations considering this skill as key for current and future challenges. In addition to formal creativity training, which is based on curricula formed by a set of tools and processes, there is also the role of self-perception over this skill. The objective profile is the expected performance, while the subjective is seen as a self-declared ability. In this sense, having a proper assessment of creative behavior allows to align the intentions of institutions and educators toward an integrated professional profile in a multidisciplinary manner. In this study, the Creative Behavior Assessment Instrument was applied to pre-graduates from Creative Studies (CS; Design, Architecture, Digital Animation, and Communication) areas and other disciplines to answer three main research questions (1) Are CS students more creative than other discipline students?; (2) How does fluency vary between students from different disciplines?; (3) Is there coherence between the objective and subjective responses to the instrument? The methodological approach for this study is mixed methods, focusing on total score, visuospatial ability, fluidity, and self-perception. Results are discussed in terms of the difference shown by the students' objective/subjective profiles in relation to their discipline, the relevance of promoting creativity in higher education, and the implications of individual differences regarding the subjective profile.

KEYWORDS

creativity, creative behavior, creativity assessment, students, Creative Studies, higher education, 21st century skills

1 Introduction

Guilford's conception of creativity emphasizes divergent thinking as a key cognitive process leading to original and valuable outcomes. Divergent thinking involves four dimensions: fluency (quantity of responses), originality (going beyond commonly accepted ideas), flexibility (variety of responses), and elaboration (number and quality of details provided; Guilford, 1950, 1956, 1966, 1973). These dimensions provide a framework for understanding creative thought and action, suggesting that creativity emerges from the ability

to generate a variety of responses, to think originally, to shift between categories, and to elaborate on ideas (Weiss and Wilhelm, 2021). Guilford's model has been influential in the field of psychology and other disciplines, shaping the understanding of creativity as a cognitive process that is essential for producing novel and valuable outcomes. His work laid the foundation for subsequent research into the nature of creativity and its measurement (Jaarsveld et al., 2012). Currently, creative behavior is associated with diverse indicators referring to skills, attitudes, and capabilities that shape the workforce of the current production paradigm.

Creativity is also seen as a necessary skill for achieving effective solutions to complex global problems of the 21st Century, and it is incorporated into many formative educational experiences in the context of higher education. When combined with other relevant competencies, it contributes to a set of skills that are related to the current model of production and development (van Laar et al., 2017). Competencies of Industry 4.0 include a combination of skills and knowledge that allows a professional to do their job; the list is exhaustive (Hernandez-de-Menendez et al., 2020, 1,517), and it is aligned with the context of the current global challenges and the technical demands derived from them. In addition, studies have found a relationship between the presence of creative behavior and a proactive personality as a promoter of success in the work environment (Alikaj et al., 2021). It has also been highlighted that in order to achieve productivity and competitiveness, human talent is selected to match a general list of competencies, supported by intelligence and personality, and can provide social value to an individual and economic value to a company (Kipper et al., 2021). Very few studies have considered individual perception on their own performance, and the role it plays the 'objective competence profile' evaluation. Some of these studies refer to this perception on cognitive performance (Lam et al., 2011) levels of achievement (Carletto and Zezza, 2006) or the description of one's physical condition (Méndez-Giménez et al., 2020) or disease (Vicent-Gil et al., 2023). When this profile, or list of competences, relates to the knowledge, skills, and attitudes required according to a preset framework, it constitutes an "objective profile," as it sets the expected performance of an individual when a task is presented to be completed.

This study considers that for competences evaluation the "subjective profile," as a self-declared set of skills, knowledge, and behavior, plays a relevant role in the results of tasks fulfillment. This self-perception of our own capacities is shaped by a combination of experience, training, and development context (Arslan and Alanur, 2020). Conducting a self-evaluation of our competence profile allows us to retrieve key aspects of our practice, enabling us to recognize strengths and areas for improvement (Biencinto et al., 2021). In addition, the ability to assess our performance facilitates adaptation and improvement in meeting the demands of the work environment, while promoting the development of problem-solving strategies (Abdillah et al., 2023). These conditions are aligned with those required to develop the mega-competence of complex thinking and the sub-competence of innovative thinking (Ramírez-Montoya et al., 2024), based on creative behavior. Then, a "subjective competence profile" can be used as input for specific actions aimed at developing and scaling up the objective profile of a group or an individual.

Moreover, the comparison of these two profiles' evaluation can show relevant variations related to what is required for a professional position (Forsman et al., 2020). Having a proper assessment of creative behavior allows one to align the intentions of institutions and educators

toward an integrated professional profile (Lensing and Friedhoff, 2018). Recognizing the importance of promoting sustained creative behavior within a company has been linked to improved outcomes regarding the organization's creative performance (Kim, 2020), which is a high-value indicator in our contemporary context. Hence, this study proposes to apply the Creative Behavior Assessment Instrument to pre-grads from Creative Studies (CS) area (first year of Design, Architecture, Digital Animation, and Communication pre-grad programs) and other disciplines to answer three main research questions: (1) How do creativity levels compare across students from different disciplines, including Computer Science?; (2) In what ways does fluency in idea generation manifest across students from various academic disciplines?; (3) To what extent do objective and subjective responses to the creativity assessment instrument align across different participant groups? The findings have a potential value to address development strategies for HiEd students, not only for CS areas but for every other discipline, since creative behavior is a transversal competency.

2 Materials and methods

The methodological approach followed in this study was mixed methods to consider the nature of creative behavior among undergraduate first-year students in the CS area of a Mexican private university. This research leverages quantitative and qualitative data to gain comprehensive insights (Åkerblad et al., 2021). Initially, the study employed a convenience sample of 53 students, comparing the results of creative disciplines students with students in other disciplines through the administration of the Creative Behavior Assessment Instrument (CBAI)®. The quantitative phase aims to provide objective, numerical data on the students' creative capabilities. While the objective profile cannot be directly assessed, a very accurate approximation can be achieved through the evaluation of visuospatial abilities, cognitive flexibility, problem-solving skills, and other cognitive processes related to this domain. These assessments provide insight into an individual's capacity to interpret and manipulate visual information, adapt to new or changing situations, and find effective solutions to challenges. By examining these cognitive functions, it is possible to gain a better understanding of the underlying qualities that contribute to the objective profile, allowing for a more informed approach to identifying and developing these traits.

The qualitative analysis delves deeper into the subjective profile, focusing on the type and quantity of answers in the fluency dimension, as well as the self-perception of the level of creativity through self-reporting. This qualitative data complements the quantitative profile by adding depth and context, allowing for a richer understanding of creative behavior that numbers alone cannot convey (McKim, 2017). The analysis represents an integration (Creswell et al., 2007) of data collected in both forms quantitative (number of answers) and qualitative (type of answers and self-report). The integration of quantitative and qualitative data in this mixed-methods approach provides a comprehensive understanding of creative behavior in undergraduate students.

2.1 Participants

Fifty-three university students (female gender 52.83%; male 45.28%; other 1.89%) between 18 and 30 years old (84.91% between

18 and 25 years old) participated in this study. Most of the sample reported being enrolled in a bachelor's degree program (94.34%) and the rest in a master's or doctoral program (3.77%) or another educational level (1.89%), belonging to private institutions (84.91%) and public ones (15.09%). Likewise, the majority (81.13%) reported being in the first phase of their educational program with 25% of credits completed, and the rest with 50% of credits or more. Regarding the area of knowledge, 45.28% belonged to the discipline of Creative Studies (including Design, Architecture, Digital Animation, and Communication) and the rest of the sample was made up of students from the areas of physical–mathematical sciences and engineering (3.77%), biological and health sciences (11.32%), social sciences and humanities (5.66%), engineering (3.77%), business (26.42%), biotechnology (1.89%), and information technologies (1.89%).

The presence of students from not only creative fields but also from sciences, humanities, engineering, business, biotechnology, and IT allows for a comprehensive examination of creativity across various domains of knowledge, assessing its expression and appreciation in technically oriented versus more traditionally creative disciplines. These characteristics make the sample well-suited for exploring educational, developmental, and cognitive research questions, particularly those that benefit from a multidisciplinary approach. This strategic choice enhances the study's ability to generalize findings across different student groups and educational contexts.

2.2 Instrument

The Creative Behavior Assessment Instrument (CBAI) consists of 10 items whose general objective is observing elements that constitute creative behavior in university adults 18 and older. It scores between 1 and 100 points, where 1 represents the lower degree of creativity and 100 the highest, and measures creative behavior per elements of fluency, novelty, flexibility, synthesis and analysis capacity, reorganization of objects, complexity, and evaluation ability, as Guilford (1950) proposed. In addition, it considers the following elements: innovation, problem-solving, language, visuospatial processes, mental rotation, logical reasoning, cognitive flexibility, and convergent and divergent thinking. In a previous study (Suárez et al., 2024), the validation process of the Creative Behavior Assessment Instrument (CBAI) consisted of two phases: construct validation and a pilot test. During the construct validation, the CBAI, featuring 10 items, was refined using the modified Delphi method, engaging experts from psychology, pedagogy, and education. These experts ranged in age from 26 to 60 and had professional experience up to 30 years.

In terms of validity, the instrument achieved a Content Validity Coefficient (CVC) for items between 0.930 and 0.999, and an overall CVC of 0.971, indicating excellent validity. The pilot test involved 386 Spanish-speaking participants predominantly from private educational institutions, with a majority aged 18 to 25 years. The reliability of the instrument was confirmed with a Spearman-Brown Prophecy coefficient of 0.870, showcasing high internal consistency. The beginning of the instrument has a section dedicated to a privacy notice and an informed consent form to guarantee the informed and voluntary participation of the respondents. Once accepted, the subjects answered six questions for their sociodemographic profile, providing data on the variables age, gender, institution, country, e-mail, and professional area.

The instructions for answering the instrument were: "Please answer each of the following sections individually." **The Creative Behavior Assessment Instrument is valid and highly reliable with a content validity coefficient of $CVC = 0.971$ and a reliability coefficient of 0.870 for the Spearman-Brown Prophecy Formula statistic.** It is registered in the Public Registry of Copyright in Mexico City with Record number: 03–2023–060809274400-01 (López Caudana et al., 2024).

2.2.1 Scoring

The CBAI items include Likert-type, open-ended, and multiple-choice questions. Table 1 shows the CBAI items, their type, and maximum score.

Items 7 and 8 present images created specifically for this instrument. The image in item 7 presents two teal geometric bodies in the shape of an irregular hexahedron (RGB #008080) with a gradient effect, created with Microsoft Office 365 PowerPoint. The side-by-side configuration of the figures allows their comparison of identical physical characteristics but with possible perceived qualitative differences due to the gradient effect and the 180° rotation of one figure next to the other. The final size of the image used on computer equipment for item 7 is 12.35 × 32.99, with a resolution of 640 × 480; it maintains its proportion and color when presented on screens of mobile technological devices.
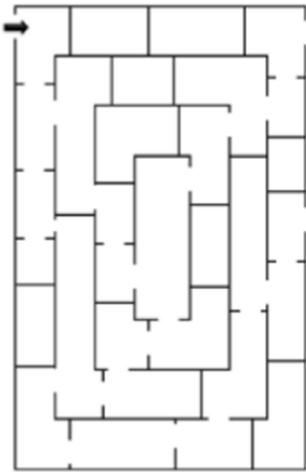
On the other hand, the figure used in item 8 is a maze with one entrance, two exits, and four possible routes for its resolution, digitally traced in two dimensions in black on a white background. It was designed using Microsoft Office 365 PowerPoint™.

2.3 Procedure

Participants were first-year students from various areas of knowledge, all at the undergraduate level, contacted via invitations from two professors during the semester from June to December 2023. Professors played a crucial role in the recruitment process by identifying and inviting potential participants who they believed would provide meaningful insights into the study. This method of recruitment ensured that a diverse and relevant group of students was engaged, reflecting a wide range of disciplines and perspectives. Once accepted, the application took place in a single scheduled session. The students participated voluntarily in the study and were presented with a digital informed consent form. This document detailed the nature of the study, the procedures involved, the confidentiality of their responses, and their rights as participants, including the right to withdraw from the study at any point without any negative consequences.

After reading the consent form, students had the opportunity to ask questions or express any concerns they might have had. Once all queries were addressed, and the students felt comfortable proceeding, they digitally signed the consent form, thereby agreeing to participate. The session then moved on to the actual application of the instrument through the SurveyMonkey™ tool. Each professor was present throughout the session to provide instructions, answer any further questions, and assist with any difficulties the participants might encounter. Upon the completion of the instrument, the data were analyzed. During pre-processing empty or incomplete responses are

TABLE 1 Type and scoring of each CBAI item.

#	Item	Type	Score	Max score
Q1	¿Qué tan creativo te consideras? *[How creative do you consider yourself?]*	Likert	0 to 10	10
Q2	¿Qué tan fácil es para ti proponer soluciones a distintos tipos de problemas? *[How easy is it for you to propose solutions to different types of problems?]*	Likert	0 to10	10
Q3	¿Qué tan fácil es para ti pensar en más de una ruta para llegar a un lugar nuevo? *[How easy is it for you to think of more than one route to get to a new place?]*	Likert	0 to 10	10
Q4	Escribe todos los usos que se te ocurran para el siguiente objeto: Pelota. *[Write down all the uses you can think of for the following object: Ball.]*	Open-ended	1 point per given answer	10
Q5	Escribe todos los usos que se te ocurran para el siguiente objeto: Taza. *[Write down all the uses you can think of for the following object: Cup.]*	Open-ended	1 point per given answer	10
Q6	Escribe todos los títulos que se te ocurran para un cuento sobre un robot que tiene sentimientos. *[Write as many titles as you can think of for a story about a robot that has feelings.]*	Open-ended	1 point per given answer	10
Q7	Las imágenes que se presentan a continuación, ¿corresponden al mismo objeto? *[Do the images below correspond to the same object?]* 	Multiple choice	Answer Score Yes* 10 No 5 I don't know 1 *correct answer	10
Q8	¿Cuántas rutas existen para resolver el siguiente laberinto? *[How many routes are there to solve the following maze?]* 	Multiple choice	Answer Score a) 4* 10 b) 2 7 c) 3 5 d) 6 3 e) I don't know 1 *correct answer	10
Q9	Resuelve el siguiente acertijo: Alex vive con Dany en un departamento antiguo. Un día Alex llegó después de hacer unas compras, saludó a un gato que miraba por la ventana del vecino, entró a su departamento y cerró la puerta. Después, dejó las llaves en la mesa y pensó: "Más tarde, cuando llegue Dany, le recordaré que mañana haremos reparaciones." En la noche notaron que la puerta estaba abierta. ¿Por qué estaba abierta la puerta? *[Solve the following puzzle: Alex lives in an old apartment with Dany. One day, Alex came home from shopping, said hello to a cat looking out the neighbor's window, entered his apartment, and locked the door. Afterward, he left the keys on the table and thought, "Later, when Dany arrives, I'll remind her that we are doing repairs tomorrow." In the evening, they noticed that the door was open. Why was the door open?]*	Multiple choice	Answer Score a) The door opened on its own 7 b) Alex did not close the door 5 c) Dany left the door open* 10 d) It was the cat 3 e) None of the above 1 *correct answer	10
Q10	Responde nuevamente la siguiente pregunta: ¿Qué tan creativo(a) te consideras? *[Please answer again the following question: How creative do you consider yourself?]*	Likert	0 to 10	10
			Total	100

identified and removed. Total and item scores were obtained for the total sample and by group according to discipline. Likewise, mean comparisons were performed with the student *t-test* for assessing differences between responses to items 1 and 10, and between groups.

3 Results

The results of the CBAI instrument obtained by the total sample will be presented differentiating the configuration of Objective and Subjective Profiles with respect to creative behavior, and subsequently, a comparison between the Creative Studies and Other disciplines groups will be shown.

3.1 General score

Regarding the total score obtained in the instrument, an average score of 64 points ($SD = 10$) out of a possible total of 100 was observed, with a range between 43 and 90 points. Figure 1 shows the distribution of frequencies with respect to this score, in which horizontal axis categorizes the scores into specific intervals that help in visualizing how the scores are distributed across different ranges. The vertical axis shows the number of participants that fall into each score interval. This axis is quantified with a maximum value of "$n = 20$," which means the highest number of participants in any given score range is 20.

3.2 Objective profile findings

To configure the Objective Profile, items 7 *Rotated images*, 8 *Maze*, and 9 *Puzzle* were considered, obtaining the following findings: for item 7 *Rotated images*, 75.47% answered correctly indicating that the images presented correspond to the same object, vs. 20.75% who answered "no"; and 3.77% answered "I do not know."

For item 8 *Maze,* only 11.32% responded correctly to the option of 4 possible routes to solve the maze. The rest of the responses were distributed among the options as shown in Table 2.

Likewise, for item 9 *Puzzle*, only 24.53% of the participants answered correctly. Table 3 shows the distribution of responses (in percentage and frequency) among the possible response options for the item.

3.3 Subjective profile findings

Questions 2, 3, 4, 5, 6, 1 and 10 were used to form the Subjective Profile. The results to item 2 *How easy is it for you to propose solutions to different types of problems?* showed an average of 7.4 points ($SD = 1.67$) out of a maximum possible total of 10, indicating that in general the participants reported ease in proposing solutions to different types of problems according to their self-perception. In question 3 *How easy is it for you to think of more than one route to get to a new place?* participants reported an intermediate ease with an average of 6.9 ($SD = 1.75$) points out of a possible total of 10, to think of more than one route to get to a new place.

Items 4 and 5 have been classified under the subjective profile because they measure fluency, but with an emphasis on its qualitative rather than quantitative nature. These items aim to assess the richness or diversity in the type of responses given. In assigning these items to the subjective profile, the need to verify the content of the responses was emphasized to ensure that participants did not include random or irrelevant text. This involved a review process in which each response was individually examined for its quality and its connection to the question, a task that inherently involves subjective judgment. To carry out this review effectively, a set of criteria was established to guide the evaluators in assessing the responses. These criteria focused on the coherence, and pertinence of each response, ensuring that it directly addressed the question and provided insightful or meaningful content. No responses were found that appeared random, out of context, or inconsistent, which speaks to the effectiveness of the initial data collection phase and the attentiveness of the participants. The authors of this study were the evaluators, ensuring a high level of familiarity and expertise with the subject matter being assessed. This level of analysis ensures that the fluency measures genuinely capture creative ability and not merely the capacity to produce meaningless text.

For fluency item 4 *Write down all the uses you can think of for the following object: Ball*, an average of 6.1 responses ($SD = 2.76$) out of a possible total of 10 was observed; and for fluency item 5 *Write down all the uses you can think of for the following object: Cup*, an average of 5.7 ($SD = 2.65$) responses out of a possible total of 10 was observed. Figure 2 shows two *word-clouds* with the frequency of occurrence of responses to items 4 and 5. A larger size of the written word represents a higher frequency of occurrence in the participants' responses. Most of the words were verbs like *play* and *drink* respectively, and nouns such as *football, circus,* and *coffee* appear less frequently.
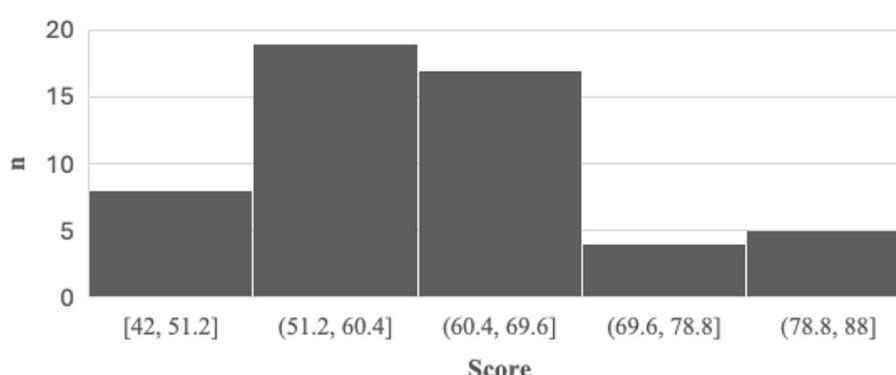

FIGURE 1
Frequency distribution of total score obtained by the participants in this study.

For fluency item 6 *Write as many titles as you can think of for a story about a robot that has feelings,* an average of 3.9 responses ($SD = 2.42$) out of a possible maximum of 10 was observed. A sentiment analysis was performed in which it was qualitatively observed that the titles proposed by the students used formal and correct language, but also included some elements of informal and creative language. The titles were mostly original both in Spanish and English, did not repeat each other much, and each participant expressed his or her own ideas and feelings. Most of the titles were positive in connotation, for example *Un robot con corazón* [*A robot with a heart*], *Sentimientos de hierro* [*Iron feelings*], and *Heart of steel*. Students expressed their enthusiasm for robots, curiosity about artificial intelligence, and belief that robots could feel emotions. In contrast, only one title with a negative connotation was observed, which expressed a feeling of sadness: *Circuitos tristes* [*Sad circuits*].

Quantitatively, the most frequent words were: *Robot* appearing 46 times, *Sentimientos [feelings]* 33 times, *Corazón [heart]* 23 times, *Amor [love]* 10 times, *Metal* 9 times, *No* 8 times, *Yo [I]* 8 times, *Sentía [felt]* 6 times, and *Robots* also 6 times. Some of the least frequent words, each appearing only once, include *Cop, Robosensible [sensitive robot], Botones [buttons], Más [more], Alla [over there], Llorar [cry], Senbot, Robosent,* and *Roboticos [robotics]*.

Finally, items 1 and 10 consist of the same question presented at the beginning and at the end of the CBAI to know the estimation of self-perceived creative behavior before answering the instrument, as well as to know the influence of the items on the estimation of self-perceived creative behavior at the end of the application. In these items, the results showed that, at the beginning of the test, participants reported an average of 7.1 points ($SD = 1.63$), and an average score of 6.3 ($SD = 1.66$) was observed at the end. This difference was statistically significant ($t = 4.50$, gl 51, $p < 0.001$) implying that students perceived themselves as less creative at the end of the instrument compared to the beginning, regardless of their discipline.

3.4 Differences between disciplines

To determine whether there are differences in creative behavior between different professional disciplines, comparisons were made of the scores of the Creative Studies vs. Other disciplines (physical–mathematical sciences and engineering, biological and health sciences, social sciences and humanities, engineering, business, biotechnology, and information technologies).

First, the differences between groups in the Objective Profile were analyzed and it was observed that the Other Disciplines group showed higher scores in items 7 *Rotation* and 8 *Maze*, indicating a greater ability to solve visuospatial problems. In contrast, the same group

TABLE 2 Distribution of responses for item 8 Maze, of the CBAI.

Answer options	Score	Answers (%)	Frequency
4*	10/10	11.32%	6
2	7/10	43.40%	23
3	5/10	20.75%	11
6	3/10	11.32%	6
I do not know	1/10	13.21%	7

*Correct answer.

exhibited lower scores on item 9 Puzzle, suggesting a lower aptitude for tackling logic problems compared to the Creative Studies group.

In relation to the Subjective Profile, significant differences were evidenced between the groups such that the "Other Disciplines" group obtained higher scores on items 3, 4, 5 and 6, indicating better performance in terms of fluency compared to the Creative Studies group.

On the other hand, when examining the responses to items 1 and 10, which evaluate the subjective estimation of one's own creative behavior, it was observed that both groups perceived themselves as more creative at the beginning of the instrument (item 1) than at the end (item 10); this difference being statistically significant ($p < 0.05$ and $p < 0.01$). Comparing both groups, participants in Other Disciplines estimated self-perceived creative behavior to a lesser extent than participants in the Creative Studies group.

Figure 3 shows the results of each item for the total sample and for both groups, differentiating those of the Objective Profile and the Subjective Profile. The highest scores for each item are indicated with a yellow star icon, and lower scores with a gray star icon to facilitate comparison. Given that the Shapiro–Wilk results showed that the data from items 1 and 10 were not normally distributed (for de CS group: p-values of 0.003 and 0.030, respectively; for Other disciplines group: p-values of 0.297 and 0.073, respectively), intra- and inter-group mean comparisons are also presented, with Wilcoxon signed-rank tests for items 1 and 10 contrasts.

4 Discussion

First, this study focuses on understanding if Creative Studies students, i.e., first-year students of Design, Architecture, Digital Animation, and Media Communication programs are more creative than other discipline students. The answer will depend on the measurement approach, and in this study, it was observed that CS students perceive themselves as more creative than students from other disciplines. However, there were no statistically significant

TABLE 3 Distribution of responses for item 9 Puzzle, of the CBAI.

Answer options	Score	Answers (%)	Frequency
La puerta se abrió sola [*The door opened by itself*]	7/10	13.21%	7
Alex no cerró de hecho la puerta [*Alex did not close the door*]	5/10	28.30%	15
Dany dejó la puerta abierta* [*Dany left the door open*]	10/10	25.53%	13
Fue el gato [*It was the cat*]	3/10	18.87%	10
Ninguna de las anteriores [*None of the above*]	1/10	15.09%	8

*Correct answer.

	Item	Sample N=53	Arts & Design (n=24)		Other disciplines (n=29)	
Objective Profile	**7 (Rotation)**					
	Correct answer	75.47%	☆	70.83%	⭐	79.31%
	Incorrect	20.75%,		25%		17.24%,
	I don't know	3.77%		4.17%		3.45%
	8 (Maze)					
	Correct answer	11.32%	☆	8.33%	⭐	13.79%
	I don't know	13.21%		8.33%		17.24%
	9 (Puzzle)					
	Correct answer	24.53%	⭐	29.17%	☆	20.69%
Subjective Profile	**2 (Solutions)**	7.4	⭐	7.54	☆	7.28
		(SD=1.67)		(SD=1.09)		(SD=1.98)
	3 (Routes)	6.9	☆	6.88	⭐	6.93
		(SD=1.75)		(SD=1.66)		(SD=1.76)
	4 Fluency (Uses *Ball*)	6.1	☆	5.79	⭐	6.28
		(SD=2.76)		(SD=1.67)		(SD=3.33)
	5 Fluency (Uses C*up*)	5.7	☆	5.13	⭐	6.24
		(SD=2.65)		(SD=1.61)		(SD=3.14)
	6 Fluency (Titles)	3.9	☆	4.04	⭐	4.45
		(SD=2.42)		(SD=2.37)		(SD=2.62)
	1 (How creative)	7.1	⭐	7.46	☆	6.72	t= 32.29, gl 48, p<.05*
		(SD=1.63)		(SD=1.44)		(SD=1.66)	
	10 (How creative)	6.3	⭐	6.54	☆	6.17	t= 1.11, gl 43, p=.26
		(SD=1.66)		(SD=1.23)		(SD=1.89)	

t= 3.99, gl 22, p<.001*   t= 1.92, gl 27, p=.06

Significant differences

FIGURE 2
Word clouds for fluency items 4 (left) and 5 (right). Larger words represent higher frequency.

differences between the groups when considering both the subjective and objective profiles at the end of answering the instrument, as shown in Figure 3. The tasks to be completed showed the ability of all participants to solve problems with creative behavior (Weiss and Wilhelm, 2021), without a specific influence of their background discipline. However, it is noteworthy that none of the groups ranked especially high and the mean of all participants was 64 out of 100 (Figure 1). The subjective profile then, this is their own perception of what they can achieve might play a role (Lam et al., 2011; Arslan and Alanur, 2020; Méndez-Giménez et al., 2020; Vicent-Gil et al., 2023) after the experience of being able to perform differently or better. Therefore, we can infer that creative behavior is not necessarily stimulated by the discipline of study, rather it is a set of skills that allow cognitive processes to connect resources as problem-solving abilities.

Second, regarding fluency variation between students' disciplines, might relate to their subjective profile, although it yields a quantitative measure (number of uses of a given object), the type and number of responses also play a role in estimating fluency according to Guilford (1950, 1956, 1966) pioneering work. For the work environment, a creative person would gather information from their surroundings in

a variety of ways to propose innovative solutions (Hernandez-de-Menendez et al., 2020), then fluency allows to create more solutions according to the task. The results of the study showed that participants from Other Disciplines performed better than CS participants on all fluency items. The identification of such findings relies on the possibility of performing a modification in the curricula to foster the creative behavior and the proactive associated with it, in the line of what companies are looking for as core essential competencies in Industry 4.0.

Finally, this study found that responses to the instrument showed coherence between the objective and subjective profile. In general terms, those from Other Disciplines showed higher performance in the objective and subjective profiles for most of the items. However, the level of self-perceived creativity is much lower in other disciplines than in CS. This finding is of great relevance since the application of the instrument itself contributed to minimize these differences to the point of not presenting statistical significance. It can be said that the perception of CS students regarding their creative ability "adjusted" to a more "objective" estimate once they answered questions that, as a whole, account for the performance of a subject's creative behavior.

FIGURE 3
Scores for each item of the CBAI instrument, differentiated by Objective and Subjective Profiles, and by the groups of Creative Studies and Other disciplines. *Significant differences.
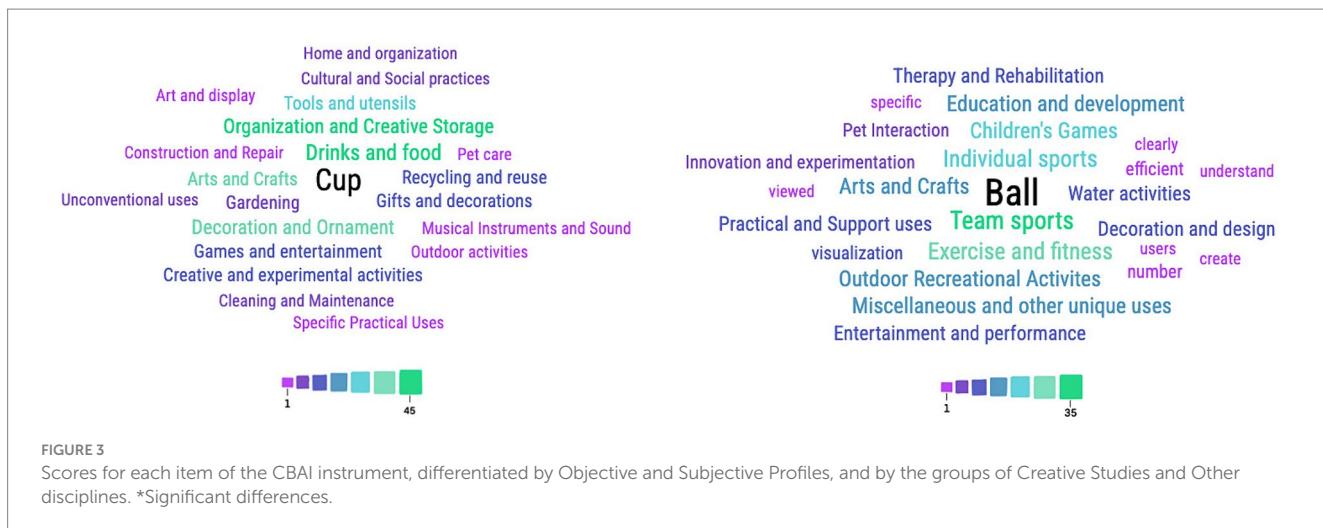
5 Conclusion

Promoting creativity in higher education is crucial for fostering innovation and adaptability in students, while recognizing and addressing individual differences in subjective aspects is essential for personalized and inclusive approaches to creativity development. In this study, we have made an approach to the evaluation of creativity in higher education; by the Creative Behavior Assessment Inventory (CBAI), we propose studying creativity as a cognitive process observable through specific behaviors. As observed, creative behavior does not depend on the disciplinary areas, although as there is enough relation between the self-perceived competence and the objective evaluation results, a fair consideration could be promoting the practice in students toward developing creative behavior. Based on the results, we suggest considering both objective performance aspects and subjective self-perception properties into any evaluation of creativity to achieve a more comprehensive understanding of this skill. Because of the above, it is crucial to question the reliability of perceived creativity levels collected through self-reports, as they may not reflect actual performance in this domain.

Creativity is a key competence in this century, and its proper assessment and encouragement are crucial for preparing students from any discipline for future and complex challenges. We propose using the CBAI as a valuable tool for assessing creative behavior and creativity as a desired skill. Future work to be developed is enlarging the sample and designing an intervention to improve the objective profile and to evaluate the correlation between the assessment of the objective profile.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because the instrument and its application were non-invasive in any sense and sensitive information was not collected. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

IA-I: Conceptualization, Formal analysis, Investigation, Supervision, Visualization, Writing – original draft, Writing – review & editing. PS-B: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. JA: Validation, Writing – review & editing. JM-E: Data curation, Investigation, Methodology, Writing – review & editing.

Funding

Acknowledgments

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Faculty support and students' academic motivation

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This study investigates the relationship between students' perceptions regarding faculty support and their overall level of academic motivation. Other aspects like types of academic motivation (intrinsic and extrinsic motivation or amotivation) grounded in self-determination theory are also addressed. The findings indicate that there is a significant positive correlation between faculty support and the overall level of student's academic motivation. At the same time, the results show that both psychological and functional support, as indicators of faculty support, have influence on different types of academic motivation. In this sense, faculty support has a moderate positive influence on student'sintrinsic academic motivation, respectively a moderate negative influence on academic amotivation. These results can be of interest for faculty decision makers. In other words, any educational policy or strategy adopted by faculty-level decision makers designed to help students improving their academic performance must include elements and activities related to providing support (at social, psychological, and functional level).

Introduction

Understanding academic motivation and the antecedents of the educational motivational process is necessary for identification and implementation of different actions that would contribute to the increase of students' academic performances. The process of motivating students represents an important concern for academics, an issue that possibly is one of the most important sources of professional frustration. Students need guidance and help regarding their personal and academic development, and this requires, among other things, a significant involvement of universities/faculties in students' learning environment, providing the necessary support that would lead to a better academic motivation and a high level of engagement in learning. The importance of faculty support for students' academic success cannot be denied, as this support plays an important role in promoting students' learning process, with major impact on their academic performance (Watt and Richardson, 2020; Wilson et al., 2020). Here, two major aspects should be considered: (1) the overall level of students' academic motivation (level of motivation intensity), and (2) the types (forms) of students' academic motivations. In this sense, academic motivation should be analyzed from a differentiated multidimensional perspective because both the overall level of motivation (as a component) and the different types of motivations could influence student's learning activity and subsequently their academic performance.

In this paper we analyze students' perceptions regarding the relationship between faculty support and academic motivation. In other words, the study investigates and analyzes the extent to which students' perceptions of faculty support influence both their overall level of

academic motivation and the diverse types of motivation. Furthermore, we argue that it is necessary that any educational strategy adopted by faculty-level decision makers must include support actions in order to improve academic performance and ensure better educational outcomes. This support must include social, psychological and functional support.

Literature review

Academic motivation

While motivation as a concept involves a multitude of definitions, academic motivation implies a more specific definition, and it is related not only to those aspects that determine a more enthusiastic school attendance but also an increased engagement in someone's own learning process and academic development. It is important to examine the factors that can influence students' academic performance in order to identify the low academic performances that can have a negative effect on the number of students who graduate.

If we take into consideration that the number of students graduating (relative to the number of enrolled students) is, for many universities, a quality and performance indicator, we could argue that students' academic performance is one of the factors that influence the quality indicator of the university systems. That's why, in our opinion, the educational strategies must concern very seriously students' academic motivation.

One of the most common approaches regarding the academic motivation process involves the perspective of Self-Determination Theory (SDT). For Deci and Ryan (2013) self-determination is a capacity but also a need, underlining the importance of three basic human needs in intrinsic motivation – autonomy, competence, and relatedness. Self-determination theory focuses on the relationship between intrinsic motivation and extrinsic factors that may increase or decrease intrinsic motivation. For example, in education, in proper conditions, teachers may channel intrinsic motivation of students toward the promotion of learning using extrinsic factors (learning climate, the use of rewards or punishments, supportive teachers' behavior, trusting interpersonal context etc.).

Academic motivation may be one of the most important psychological aspects that influence learning and personal development of students. While some studies identify academic motivation as one among other significant factors that positively affect student performance (Froiland and Worrell, 2016; Madison et al., 2018), other studies consider motivation the only factor that has a direct impact on academic achievement; the rest of the factors influencing the students' performances are achieved through motivation (Ünal-Karagüven, 2012).

According to self-determination theory, applied on the academic field, three forms of academic motivation can be distinguished: intrinsic motivation, extrinsic motivation and non-motivation (amotivation); these types of motivation are located on a continuum, and reflect the extent to which the behavior voluntarily adopted by an individual is in accordance with her own interests (Burgueño et al., 2017).In Figure 1 we can see the connection Ryan and Deci (2020, p. 72) made between autonomous, controlled, different types of motivation (intrinsic motivation, extrinsic motivation or amotivation) and regulatory styles. Amotivation reflects the lowest degree of

autonomy, amotivated individuals lack the intention to act, while motivated behavior may take various forms depending on the level of autonomy. For example, the least autonomous behavior is externally regulated (individuals' behavior is oriented toward external demands) and if individuals internalize regulations their autonomy will increase.

Several educational research indicated that certain types of motivations (e.g., autonomous motivation) positively influence academic outcomes (Guay et al., 2010; Datu, 2017; Sivrikaya, 2019), and confirms that academic motivation is one of the factors that influence a person's success or failure in the learning process (Moenikia and Zahed-Babelan, 2010; Maurer et al., 2013; Hafizoglu and Yerdelen, 2019; Motevalli et al., 2020). Also, academic motivation was associated both with mental health features of students (Lee et al., 2019) and the attitude towards the learning process (Tasgin and Coskun, 2018). Regarding academic motivations Chakraborty (2016) showed that some of extrinsic motivation types (extrinsic motivation - external regulation and extrinsic motivation - identified regulation) are important dimensions of academic motivation. At the same time, some other studies confirmed that, overall, students are motivated rather by extrinsic motivation (Hegarty et al., 2012; Komarraju, 2013) suggesting the importance of examination grades among other factors. While some research focuses on the role and importance of academic motivation, other studies analyzed factors that influence the process of academic motivation. In this regard, Ryan and Deci (2020) identified two clusters of factors that influence academic motivation: internal factors related to student characteristics (like social class, expectations), or student beliefs and external factors related to social factors (family members), academic related factors (courses, assignments, examination, feedback) or environment.

Faculty support

The faculty support provided to students can be considered one of the aspects that affect not only the level of students' academic performance but also the process and level of school dropout. From another point of view, low support activities negatively influence the attrition rate. According to Pavelea and Moldovan (2020) the attrition rate is one of the most important indicators for universities systems, because financing higher-education institutions is correlated with the number of students enrolled. In this sense the decision makers must include in their educational strategy a suitable level of support for maintain or increase the attrition rate. Einhellig (2015) considers that both financial support and emotional support from supervisors and management encourages students' academic success. Several studies (Hart, 2012; Orsini et al., 2016; Johnmarshall and Sung, 2021) have found that both appropriate and constructive feedback (as a form of support and encouragement to students) and autonomy-supportive teaching influence the persistence and motivation.

Support should not be limited to providing certain activities of relaxation, fun or socialization but involves a series of complex processes and activities aimed at achieving high levels of personal and academic development by students. From another point of view, supportpredicts both students' academic performance and involvement. In this regard, Wilson et al. (2020) showed that faculty support is positively and significantly correlated with all forms of student engagement. In other research, faculty support appears to mediate the relationship between student effort and satisfaction

FIGURE 1
Different types of motivation and regulatory styles. Source: Ryan and Deci (2020), p. 72.
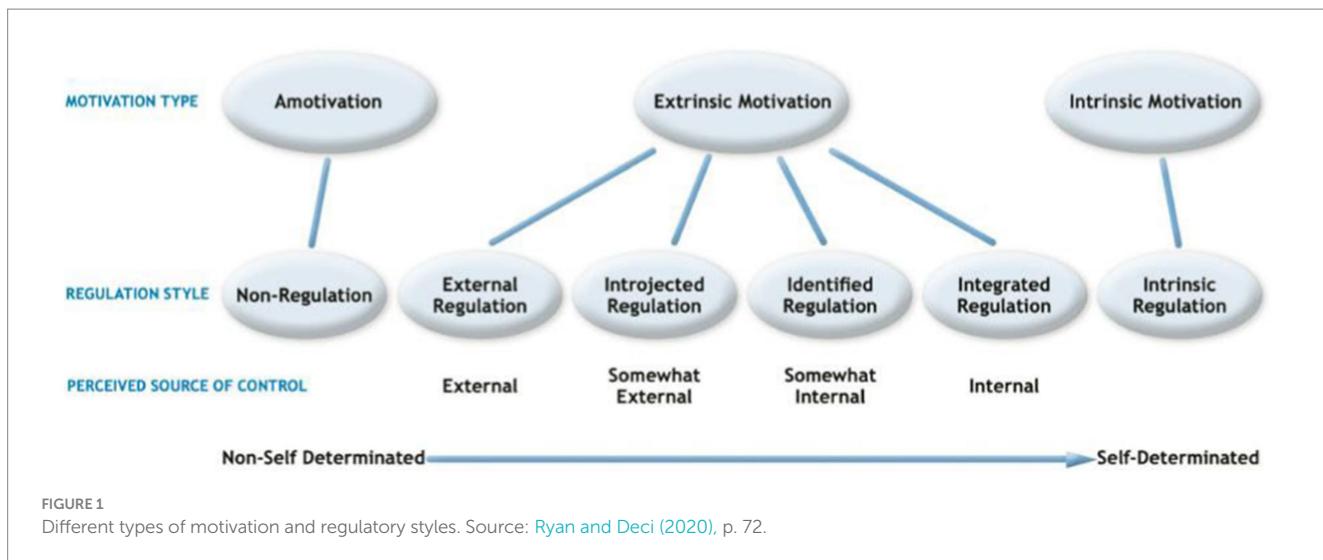
(Fredrickson, 2012). From the perspective of student-faculty interaction, some studies confirm that there are several specific types of student-faculty interactions that can be seen as predictors of student performance and academic success (Komarraju et al., 2010).

Also, Henderson et al. (2020) indicates that the way in which faculties are concerned about their students along with setting a propitious learning environment influences not only the students' intention to graduate but also their level of motivation for learning. The reinforcement and faculty social support were also positively associated with the level of students' academic results (Wen and Li, 2022; Hassan et al., 2023). At the same time, a better understanding of students' needs and preferences by faculty (or university) is related to enhanced student satisfaction regarding courses and better attitude toward learning (Snijders et al., 2021).

Finally, Holland et al. (2020) showed that the development of a wide range of support strategies for students, including academic support, pastoral support (social orientation) and employability counselling encourages learning and contributes to improving academic performance.

Faculty support takes many forms and depends on the institution's ability to understand the needs and desires of the students, the amount and types of resources that the institution has, and the capacity to allocate support. In terms of activities, a large part of the faculty support is oriented toward the development of a student-faculty relationship based on respect, courtesy, accessibility, and empathy and on promoting processes and activities that may help and guide students in the field of personal and academic development.

In fact, faculty support can be defined as the support resulting from teacher-student interactions (Goodwin et al., 2019). Thus, the support of the faculty can be materialized through a series of counseling activities, especially psychological counseling, and personal development, tutoring and academic development activities, support and social support activities, actions for faster integration of students and finally the organization of various recreational or socializing activities. Therefore, the range of support activities is extremely varied, and it is not limited to the main learning activities but should also cover different other interrelated educational activities.

TABLE 1 Characteristics of the surveyed population.

Year of study	No. of students (%)
Year 1	46 (39,3)
Year 2	71 (60,7)
Total	117 (100)

Method

In this study we investigate the extent to which faculty support influences the overall level of motivation and different types of academic motivation, based on a quantitative method of research – survey.

Sample

The surveyed population consists of 117 students enrolled in FSPAC's master programs in public administration at the Babeș-Bolyai University Cluj-Napoca, from a total of 130 students enrolled. The ratio of teachers to students is 1:18, indicating small classes and possibility for support providing. The response rate was 90%. The demographics of students are 60% female and 40% males, from the total survey population, with more than 90% representing working students. Ethical aspects include voluntary participation, informed consent, anonymity, confidentiality, potential for harm, results communication for each participant in the study. Due to the large number of working master students, the courses are organized on Monday to Friday afternoons (from 16:30 to 20:10), to give them the possibility to work and come to school. The master program offers teaching classes but also provides direct mentorship to students for research and thesis.

Masters students have been chosen for this study because they have specific characteristics (many responsibilities, more academic experience and work engagement) which make them different from undergraduate students, in terms of motivation and support required.

Most respondents were in the final year of the master program (Table 1).

Instruments

For evaluating the level of academic motivation, we used Academic Motivation Scale - AMS (Miulescu, 2019), often applied to measure motivation according to SDT. Although we used all 28 items from the original instrument, we operated a series of changes and adjustments to fit the questionnaire as well as possible to the context and specificity of the master program in public administration offered by Faculty of Political, Administrative and Communication Sciences (FSPAC). We applied AMS because this instrument measures motivation in a multidimensional approach considering also academic context (Barkoukis et al., 2020). On the other hand, AMS has, from the point of view of psychometric properties, a high level of reliability and validity (Miulescu, 2019). AMS evaluates academic motivation on 7 subscales: 3 types of intrinsic motivation (intrinsic motivation related to knowledge, achievements, and stimulation), 3 types of extrinsic motivation (identified, introjected, external motivation) and amotivation.

For analyzing the support level of the faculty, we used the Perceived Faculty Support Scale (SPFSS). In this sense, support provided by the faculty was measured on two dimensions (Wilson et al., 2020): (1) psychological support (involving the encouragement, support, and promotion of a sense of competence among students); (2) functional support (which involves activities that help the student to complete different tasks and achieve their proposed objectives).

Procedure

S.P.S.S analysis was conducted, namely statistical correlation analysis, between variables that were inserted in the questionnaire. The survey was conducted based on a face-to-face procedure, with questionnaires being completed by students directly.

Results

The influence of faculty support on the overall level of motivation

In analyzing the relationship between the faculty support and the level of academic motivation we used statistical correlation analysis, and the results (Table 2) show two major aspects.

First, the results confirm that there is a statistically significant relationship between the overall level of academic motivation and faculty support, significance level of $p < 0.000$ and 001 indicates that the correlation is strong. Second, psychological support, as a dimension of faculty support, seems to influence more the overall level of academic motivation compared to functional support dimension.

The influence of faculty support on different types of academic motivation (intrinsic and extrinsic)

We used statistical correlation for analyzing the relationship between faculty support and different types of academic motivation (extrinsic and intrinsic). The results confirm that faculty support

TABLE 2 Relationship between the level of academic motivation and faculty support (statistical correlation analysis).

		Academic motivation
Academic motivation	Pearson correlation	1
	Sig. (2-tailed)	
	N	117
Psychological Support	Pearson correlation	0.565**
	Sig. (2-tailed)	0.000
	N	117
Functional Support	Pearson correlation	0.508**
	Sig. (2-tailed)	0.001
	N	117

**Correlation is significant at the 0.01 level (2-tailed).

(functional and psychological) has a different influence on intrinsic and extrinsic motivation. In this sense, functional support tends to influence more intrinsic and extrinsic motivation, compared to psychological support (Table 3).

The faculty support has a certain negative influence on amotivation; although only the psychological support negatively influences this type of motivation (correlation is also weak). Thus, given that academic amotivation (AMOT) represent the lack of students' motivation in learning engagement, one method for reducing this form of academic motivation is to provide psychological support to them. Still, offering only the psychological support may not help too much in decreasing academic amotivation among students if it is not supplemented by other measures.

Second, regarding academic extrinsic motivation, faculty support has little influence; only functional support seems to influence certain types of extrinsic motivations. In this sense, the findings confirm that there is a relationship only between functional support and some forms of extrinsic motivation: (1) Extrinsic motivation – introjected regulation (EMIN); and (2) Extrinsic motivation– identified regulation (EMID). Although the relationship is statistically significant, the correlation between them is weak. Instead, the third form of extrinsic motivation - Extrinsic motivation – external regulation (EMER), is not influenced by any of the two dimensions of faculty support.

Third, the results of this study indicate that faculty support is more associated with intrinsic academic motivation, compared with extrinsic motivation, and can be seen as a factor that positively influences different forms of academic motivation.

Indeed, a series of forms of intrinsic and extrinsic motivation (IMTK - Intrinsic Motivation to Know; IMTS - Intrinsic Motivation to Stimulate) have a direct and statistically significant relationship with functional support, although the correlation is moderate. At the same time, we could observe that Intrinsic Motivation to Accomplish (IMTA) is not influenced by any of the two dimensions of the faculty support.

Discussion

In order to achieve a high academic performance it is necessary to take into consideration the role of academic motivation. In fact, the

TABLE 3 Relation between the types of academic motivations and the faculty support (statistical correlation analysis).

		Psychological support	Functional support
AMOT - Amotivation	Pearson correlation	−0.374**	−0.154
	Sig. (2-tailed)	0.001	0.098
	N	117	117
EMER - Extrinsic motivation, external regulation	Pearson correlation	0.096	0.089
	Sig. (2-tailed)	0.302	0.342
	N	117	117
EMIN - Extrinsic motivation, introjected regulation	Pearson correlation	0.148	0.197*
	Sig. (2-tailed)	0.110	0.033
	N	117	117
EMID - Extrinsic motivation, identified regulation	Pearson correlation	0.169	0.194*
	Sig. (2-tailed)	0.069	0.025
	N	117	117
IMTA - Intrinsic motivation to accomplish	Pearson correlation	0.090	0.159
	Sig. (2-tailed)	0.332	0.086
	N	117	117
IMTK - Intrinsic motivation to know	Pearson correlation	0.407**	0.516**
	Sig. (2-tailed)	0.001	0.001
	N	117	117
IMTS- Intrinsic motivation to stimulate	Pearson correlation	0.207*	0.483**
	Sig. (2-tailed)	0.025	0.001
	N	117	117

** Correlation is significant at the 0.01 level (2-tailed).

causal chain between motivating factors and student performance is understandable. If factors that contribute to academic motivation of students aren't properly identified, the entire process will suffer leading to students' lower performances and finally to school dropout. Perhaps that is the reason why research on the factors that affect students' academic motivation continue to be an important topic for education.

Based on self-determination theory, and the findings of this study, it can be concluded that there is a relationship between academic motivation and faculty support. The results confirm that there is a direct and positive correlation between students' perception of faculty support (described on two levels: psychological support and functional support) and the overall level of academic motivation. These results suggest that a greater concern for providing both psychological support and functional support contributes to students' higher level of academic motivation and eventually to increased involvement in the learning process.

At the same time, results confirm that faculty support is associated differently with academic motivation. Psychological support leads to a decrease of amotivation, even though the relationship is weak. Considering that amotivation could be defined as the absence of motivation and could be linked with a series of negative academic consequences (poor academic performance, higher incidence of problem behaviors, low academic self-esteem, intention to school dropout), faculty support can be viewed as a practical solution for preventing these.

In addition, the study confirms that faculty support has different influence on intrinsic and extrinsic academic motivation. In this sense, it seems that the major influence of faculty support is on intrinsic forms of academic motivation. In this sense, the influence of faculty support, especially functional support, on the various forms of intrinsic academic motivation could be considered an extremely important aspect.

Although the relationship is rather moderate, faculty support remains a valuable solution to one of the most acute problems related to academic motivation of students - low level of intrinsic academic motivation. Indeed, one of the problems faced by faculties regards the unbalance between extrinsic motivation compared to intrinsic motivation in learning, and students' tendency to learn only due to factors of an extrinsic nature. Even though extrinsic motivation may stimulate the engagement in learning, a high level of extrinsic motivation without a high level of intrinsic motivation does not help too much on the medium and long term.

The results can be of interest not only for public administration scholars, but also for faculty decision makers. Based on this research it can be concluded that the faculties should better reconsider their educational strategy for a better involvement in providing support to their own students. Obviously, this involvement would contribute to the creation of a much more inclusive, academically stimulating environment for all students.

Secondly, the results of the study can help to outline and develop a set of actions and initiatives to create a series of more effective mechanisms to promote and stimulate students' behavior towards academic performance. For example, the involvement of decision-makers at the higher faculty level in providing of social support will contribute not only to the reduction of school dropout and maintain a suitable attrition rate, but also contribute to changing the behavior and attitude of students towards learning.

Thirdly, the involvement of decision makers (at faculty level) in providing support to their own students can be used as a form of promoting the image of the institution among students. Indeed, any action of support offered to students clearly constitutes evidence that the faculty is concerned and involved in helping its own students, evidence that (sooner or later) is perceived by students as an action promoted by the slogan "the faculty cares about its own students."

All this, in the end, will contribute to maintaining and promoting a good image among students. This image will contribute to the development of a high level of satisfaction among students, but also to an increased interest manifested by potential future students. In this sense educational strategies for higher education need to take into consideration the necessity for increasing faculty support and also for maintaining a high level of academic motivation among students.

Limitations of this research include collecting cross-sectional data, and the particular educational context in which the data was collected (COVID-19 restrictions, class attendance of working students). In addition, generalizability may be limited because the present study has included only Romanian masters-level students; it is therefore recommended that the AMS be employed in other countries with different educational cultures. A different approach to data collection and analysis in further research might provide insights about how institutions can provide support specifically to working students. For example, working students may require different types of support depending on their schedules, family obligations, and financial considerations. It would also be valuable to examine different correlates of academic motivation such as academic performance, graduate outcomes, and future employment. A more qualitative approach might even explore indicators of life satisfaction and career trajectories following graduation, particularly in relation to perceptions of prior faculty support.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1406611/full#supplementary-material

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Student Evaluation of Teachers' Effectiveness (SETE) scale: translation, cross-cultural adaptation and psychometric properties in a Latin American sample

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Introduction: Teacher effectiveness is a burgeoning field. Those responsible for educational policies seem increasingly committed to this fact, since it is one of the most important factors that influence the success of a university student; for this reason, the study of this topic has gained relevance in recent years. Therefore, an instrument with adequate psychometric properties is needed to measure this construct in Spanish-speaking countries.

Objective: The study had the purpose of translating, adapting, and evaluating the internal structure, providing evidence of reliability and validity of the Student Evaluation of Teachers' Effectiveness (SETE) Scale in a Latin American sample.

Methods: An instrumental study was carried out and through convenience sampling, data were collected from 1,000 university students from South America belonging to a private educational network. The participants were between 18 and 40 years old (M = 21.25, SD = 2.99). Analyzes used Structural Equation Modeling (SEM) with AMOS 24 statistical software.

Results: Confirmatory Factor Analysis provided a 4-factor, 28-item fit model (CMIN/DF = 4.359; CFI = 0.956; SRMR = 0.030; RMSEA = 0.058). The results demonstrated good internal consistency (α = between 0.927 and 0.961; CR = between 0.927 and 0.962; AVE = between 0.646 and 0.799). Evidence of validity and reliability was obtained for the total sample.

Discussion: This adaptation and validation of the SETE scale makes it a valid, useful, reliable, and necessary tool that can be considered to evaluate teachers' effectiveness from the perspective of university students.

KEYWORDS

teaching effectiveness, higher education, Latin America, psychometric properties, SETE

1 Introduction

Teaching-learning is fundamental in higher education (Knol et al., 2016) and plays a crucial role in developing individuals, societies, and communities (Al Kuwaiti et al., 2021). Its importance lies in several aspects: Acquisition of knowledge, development of skills, socialization, economic development, innovation and progress, social mobility, autonomy and decision-making, improvement of quality of life, and social and cultural change (dos Santos et al., 2018; Martínez-Huamán et al., 2022; Oweis et al., 2022). Unfortunately, university reality reveals that many undergraduate students do not learn meaningfully, and scientific evidence confirms that the reasons are born in a culture and methodology of teaching and evaluation, where teachers and students are key pieces (Tadesse et al., 2021). On the other hand, longitudinal studies have shown that intensive programs on the professional development of teaching practice may not be effective in achieving changes in favor of teaching practice, even in this era where knowledge has grown (Hobbiss et al., 2021).

Recent studies suggest that, to improve teaching practice, qualitative feedback is invaluable. This is similar to feedback offered to students, arising from a teacher's careful observation of students during cooperative learning activities. Thoughtful, critical commentary from students can help educators identify the root cause of joy or frustration in a class session and use it to improve the next episode of teaching and learning (Harrison, 1987; Holland, 2019; Bardach and Klassen, 2020; Imron, 2024). Consequently, some academics have developed teaching effectiveness models to understand this topic's behavior better. The models have included characteristics such as teacher personality, content knowledge, communicative competence, organizational and preparation skills, and performance evaluation. These models have been used to support various empirical studies. The theoretical models of Stronge (2007) and Danielsons (2007) have been applied in school environments, while Witcher et al. (2003) and Faranda and Clarke (2004) designed theoretical models for higher education.

There is a debate in academia about whether teachers are more effective as their classroom experience increases (Coady et al., 2020; Galmes-Panades et al., 2021). A teacher's teaching ability comes not only from classroom experience, but from other sources such as a healthy student-teacher relationship (Kyrgiridis et al., 2014; Shahzad and Mehmood, 2019), by a conscious attitude with students' emotions (Kuzmanovic et al., 2012; Shahzad and Mehmood, 2019), and through the enthusiasm reflected by the teacher in and out of class (Rocha, 2013), among others. However, some highly experienced teachers do not do their job effectively, while other novice teachers can become more dynamic, innovative, and effective (Debets et al., 2020; Hoque et al., 2020; Musodza et al., 2020; Saeeda et al., 2021; Shin and Bolkan, 2021; Wulandari et al., 2021). In general, however, if you have a teaching team with significant experience, the team can provide a variety of benefits to their students (Podolsky et al., 2019).

The effectiveness of an educational system depends mainly on the effectiveness of the teaching staff, which in turn has a significant influence on student learning (Avalos, 1980). As a result, measuring teacher effectiveness is important in promoting educational quality and improving students' quality (Sánchez and Craig, 2007), which means that, in the education sector, evaluating teacher effectiveness is similar to assessing student learning (Ayaneh et al., 2021). Considering the role of teaching effectiveness, various investigations have analyzed

its importance in educational environments. Some researchers have analyzed its importance with a review of the literature (Yamamoto, 1963; Avalos, 1980; Reynolds, 1998; Podolsky et al., 2019; Sofyan et al., 2021; Bardach et al., 2022; Mastrokoukou et al., 2022) and others empirically. Because teaching tasks demand certain activities that occupy a large part of the time, their association with other constructs has been investigated. This includes their association to behavior management and support training (Monzalve-Macaya et al., 2023), the interaction between emotional intelligence (Anwar et al., 2021), habit formation (Hobbiss et al., 2021), school management practices and academic performance (Arop et al., 2020), neurolinguistic programming and teacher identity (Javadi and Asl, 2020), preparation of students to learn (Kearney and Garfield, 2019), personality and teaching support (Kim et al., 2019), structured collaboration (Graham, 2007), teacher preparation (Darling-Hammond et al., 2005); the role it plays in the influence of the minimum wage and the timely payment of wages (Adekanmbi and Ukpere, 2021), and on the impact of contextual distractors (Aslantas, 2020).

Teacher effectiveness is closely related to providing quality education, which is Sustainable Development Goals (SDGs) established by the United Nations in its 2030 Agenda (Bantekas, 2023; Pedraja-Rejas et al., 2023). It is known that these are a set of 17 integrated goals that seek to address global challenges, such as poverty, gender equality, health, education, environmental sustainability, and other areas (Ocaña-Zúñiga et al., 2023; Tomasella et al., 2023). Teaching effectiveness in higher education is associated in various ways with the SDGs (Miranda-Gonçalves, 2023; Bray, 2024; Rose and Sayed, 2024). For example, SDG 4 is based on ensuring inclusive, equitable, and quality education for all without exception. This translates into the development of high-performing teachers and educational institutions, aiming at the promotion and achievement of these objectives through its educational work and its impact on society (Leal et al., 2023; McCowan, 2023; Morris et al., 2023).

For many years now, various studies affirm that teaching effectiveness in higher education entails numerous benefits for students, educational institutions, and society. It is a crucial component to the success of higher education institutions and student development. Some of the key benefits include quality learning, motivation and engagement, developing critical skills, individualized feedback and support, improving retention and completion rates of academic programs, fostering diversity and inclusion, research and development, prestige and institutional reputation, and significant contributions to society through specialized areas or programs (Bridgwater, 1982; Kyriacou and Newson, 1982; Ngala and Odebero, 2010; Welsh, 2011; Gabriel and Allington, 2012; Darling-Hammond et al., 2013; Grant et al., 2013; Skourdoumbis, 2013; Joyce and Magesh, 2016). Therefore, teaching effectiveness in higher education positively impacts students, the institution, and society (Darza and Tesfaye, 2020; Latif et al., 2021).

According to the background mentioned, there is evident interest in developing scales to measure this construct, therefore, previous research has disclosed its contributions (Gusthart et al., 1997; Rocha, 2013; Mohebbi et al., 2022). Empirical studies on teacher effectiveness have been conducted in countries such as the United States, the United Kingdom, Australia, Cyprus, India, Iran, Nigeria, South Africa, Canada, and China. Therefore, this bibliometric review demonstrates the need to make greater efforts for its study and implementation in Latin America, since there is no contextualized metric in the scientific

literature with evidence of validity and reliability where teaching effectiveness is evaluated from the university student's perspective. To fill this knowledge gap, an instrumental study was considered appropriate to adapt the Student Evaluation of Teachers' Effectiveness (SETE) scale of Ethiopian origin, to be applicable to higher education students, given that the joint evaluation of the reliability and validity of measurement scales is classified as "psychometric properties," considered the most important characteristics for the evaluation of any scale; guaranteeing the quality and integrity of a measurement scale (Mohajan, 2017; Asiamah et al., 2021). In that sense, the present study aimed to translate, adapt, and evaluate the validity and reliability of the SETE scale in a sample of university students from Latin America.

2 Literature review

2.1 Teaching effectiveness

Some scholars have made efforts to distinguish the difference between "teaching effectiveness," "teacher's quality," and "teaching quality" (Al Ansari et al., 2020; Cai and Wang, 2022; Cherng et al., 2022). Teaching quality refers to a teacher's innate qualities, skills, and competencies (Chan, 2002), while when considering practices and instruction, emphasis is placed on the quality of teaching (Bradney, 1996; Hansen, 2023). Teaching effectiveness is analyzed in light of student outcomes, ensuring students learn and achieve specific outcomes (Sofyan et al., 2021). The latest studies on this topic have been used to offer new knowledge and concepts about performance evaluation, effectiveness (Al Kuwaiti et al., 2021), and the pedagogical skills of teachers in higher education (Hansen, 2023; Monzalve-Macaya et al., 2023; Pham et al., 2023). On the other hand, the review of the literature shows that various theoretical models measure this construct (Sánchez-Cabrero et al., 2021; Sofyan et al., 2021; Matosas-López, 2023); such as the one proposed by Rocha (2013) that evaluates teaching effectiveness from 4 approaches: teacher-student relationship, teacher's personality, student evaluation performed by the teacher, and his teaching method. His proposal is close to that of other specialists who in turn analyze the variable from 4 perspectives (Calaguas, 2012; Shahzad and Mehmood, 2019; Ayaneh et al., 2021). However, Aleamoni and Hexner (1980) suggest a 3-component theoretical model: Instructor evaluation, course-specific teaching procedure, and student perceptions of learning outcomes. Resembling other studies that propose the study of this construct from 3 factors (Marshall et al., 2016).

However, for this study, the four dimensions proposed by the Ministry of Science and Higher Education of Ethiopia (MOE) and the latest scientific contributions of Ayaneh et al. (2021), who consider a better theoretical model of four dimensions: subject matter knowledge (SK), professional competence (PC), ethical competence (EC), and time management (TM). Subject matter knowledge (SK) is the ability of the teacher to meet the content of the course, demonstrating preparation and using common examples to achieve the objectives of each session. Professional competence (PC) refers to the degree to which the teacher uses his or her knowledge, skills and good judgment related to professional skills to perform his or her main task with acceptable quality. Ethical competence (EC) is understood as the teaching competence that reconsiders promoting ethical education in

classroom activities, conferences and through extracurricular activities. And time management (TM), known as the ability to make effective use of teaching time to efficiently fulfill their academic responsibilities.

2.2 Instruments to evaluate teaching effectiveness

Most of what has been reported on this construct has been of great contribution to improving the quality of education at all educational levels. In this sense, a review of previous research confirms the importance of providing valid instruments that can measure teaching efficacy in the context of higher education. These measurement instruments must comply with valid psychometric properties in order to be used in different realities. However, it is important to note that so far, teaching efficacy remains one of the most difficult constructs to measure. Various researchers have carried out studies on teaching effectiveness using different instruments (Adekanmbi and Ukpere, 2021; Anwar et al., 2021; Tadesse et al., 2021; Monzalve-Macaya et al., 2023). These studies can be separated into two groups. The first group of studies reviewed present reliability and validity.

In Ethiopia, a previous study presents the validity of the Student Evaluation of Teachers' Effectiveness (SETE) scale that was applied to a sample of university students, which presents a 2-factor model, 18 items and $\alpha = 0.79$, and a second 4-factor model, 20 items and $\alpha = 0.80$ (Ayaneh et al., 2021). In 2019, Shahzad and Mehmood designed the Teaching Effectiveness Scale (TES), which was applied to university students in Pakistan; it has 32 items and 4 dimensions ($\alpha = 0.71$ to 0.87). Marshall et al. (2016) developed and validated the Teacher Intentionality of Practice Scale (TIPS) in secondary school teachers in the United States; the scale confirmed 22 items and 3 dimensions ($\alpha = 0.96$). Kyrgiridis et al. (2014) developed the Self-Evaluation of Teacher Effectiveness in Physical Education (SETEQ-PE) questionnaire and applied it to Greek physical education teachers. This questionnaire has 25 items and 6 dimensions ($\alpha = 0.87$). Moreover, in Rocha (2013) study, he designed a Student Opinion about Teacher Effectiveness (SOTES) questionnaire and applied it to Mexican undergraduate students. It has 17 items and 4 dimensions ($\alpha = 0.947$). Calaguas (2012) developed and evaluated the psychometric properties of the Teacher Effectiveness Scale in Higher Education (TESHE) in university students in the Philippines; it has 67 items and 4 dimensions ($\alpha = 0.972$). In addition, the Student Evaluation of Educational Quality (SEEQ) presented 35 items discriminated in 8 dimensions ($\alpha = $ between 0.88 and 0.97): (1) Learning, (2) Enthusiasm, (3) Organization, (4) Interaction with the group, (5) Updated presentation of the subject, (6) Interaction of the teacher with the students individually, (7) Evaluation, (8) Feedback (Marsh, 1983; Marsh and Roche, 1997).

A second group was identified, which was made up of some studies that did not describe the validity or reliability of the instrument. This is the case with Mohebbi et al. (2022), who investigated the factors contributing to the effectiveness of language teachers in Iran and designed an instrument (EFL Language Teachers' Effectiveness) with 18 items and 6 dimensions. On the other hand, in the study by Nema et al. (2023) they used the Student Evaluations of Teachers (SET) as a measurement tool, which has been widely used for students in colleges and universities in India (Aleamoni and Hexner, 1980). The metric

consists of 33 items subdivided into 3 factors: instructor evaluation, teaching procedure in a specific course, and students' perceptions of learning outcomes. Based on the above, the purpose of this research is to translate, adapt and evaluate the validity and reliability of the SETE scale in a sample of Latin American university students. Several specialists argue that the SETE scale captures multiple aspects of a university teacher's good practices and that its periodic revision in different cultural contexts could help educational leaders to improve their educational and teaching management policies and strategies.

3 Materials and methods

3.1 Study design and participants

The work responds to psychometric research, defined as the science of evaluating the characteristics of tests designed to measure psychological attributes (Price, 2017). The study population was composed of university students from four South American countries, Peru, Bolivia, Chile, and Colombia, belonging to a private educational network. A condition to be part of the study was that the university students were studying the academic semester in person at the time of the survey. It should be noted that this study was approved by the Ethics Committee of the Postgraduate School of a private university (2023-CE-EPG-00071) and was conducted under the ethical standards of the Declaration of Helsinki (Manzini, 2000; Puri et al., 2009). The study was applied from September to December 2023. Non-probabilistic convenience sampling was applied (Otzen and Manterola, 2017), and the survey was carried out through a virtual link; the questionnaire was hosted on a Google form, and a Likert-type response format was utilized, ranging from (1) never to (5) very frequently. The questionnaire was self-administered, and informed consent was obtained from each participant before its administration ('I acknowledge that by completing this questionnaire, I am giving my consent to participate in the study'). The questionnaire was shared virtually (via Email, WhatsApp, Messenger, Instagram) and in a personalized way. The total sample was 1,000 university students, who provided their answers anonymously and voluntarily. Table 1 shows the frequencies and percentages by categories (sex, age range, marital status, country of origin, university campus, year of study, and religious inclination).

3.2 Instrument

The SETE scale is a harmonized instrument used to measure teacher effectiveness. Highly qualified experts originally developed it by the Ministry of Science and Higher Education (previously, Ministry of Education) of Ethiopia (MOE, 2018). Ayaneh et al. (2021) later evaluated its psychometric properties analyzing 2 models (4 and 2 factors), managing to confirm 2 factors (CFI = 0.999, TLI = 0.999, SRMR = 0.056; RMSEA = 0.008). The scale demonstrated good internal consistency (α = between 0.87 and 0.93) in a sample of Ethiopian university students.

3.3 Translation process

The original version of the SETE scale required translation from its original English language to Spanish using a bilingual trial

TABLE 1 Sociodemographic characteristics (*n* = 1,000).

Characteristic	Category	Frequency	Percentage (%)
Sex	Female	474	47.4
	Male	526	52.6
Age range	18–20 years	478	47.8
	21–30 years	508	50.8
	31–40 years	14	1.4
Marital status	Single	956	95.6
	Married	24	2.4
	Cohabitant	10	1.0
	Divorced	5	0.5
	Widowed	5	0.5
Country of origin	Peru	367	36.7
	Colombia	124	12.4
	Chile	245	24.5
	Brazil	2	0.2
	Bolivia	234	23.4
	Argentina	3	0.3
	Ecuador	8	0.8
	Venezuela	8	0.8
	Other	9	0.9
University campus	Peru	366	36.6
	Bolivia	250	25.0
	Chile	250	25.0
	Colombia	134	13.4
Year of study	First	351	35.1
	Second	237	23.7
	Third	168	16.8
	Forth	186	18.6
	Fifth	32	3.2
	Sixth	10	1.0
	Seventh	16	1.6
Religious inclination	Adventist	452	45.2
	Catholic	339	33.9
	Evangelical	58	5.8
	Other Christian denomination	49	4.9
	Not religious	102	10.2

back-translation method. Three bilingual (Spanish-English) Spanish-speaking individuals completed English-to-Spanish translations of the SETE scale individually. The translations were compared, discussed, and reviewed in a focus group of six university students (Peru, Bolivia, Chile, and Colombia) who met the study's inclusion criteria to obtain the first complete version in Spanish of the scale and its contextual application to the four selected South American countries. The English and Spanish versions of the SETE scale were tested on a target

3.4 Data collection and analysis

Two statistical software were used to analyze the data: (1) SPSS software version 25 for descriptive analysis (sociodemographic profile of the participants, among others.) and Exploratory Factor Analysis (EFA), and (2) then Structural Equation Modeling of covariance (CB-SEM) to perform Confirmatory Factor Analysis (CFA), evaluate convergent and discriminant validity, and adjust the measurement model. This required AMOS version 24 software. This method is highly recommended to evaluate the psychometric properties of measurement models (Fornell and Larcker, 1981). Likewise, reliability was evaluated using Cronbach's Alpha coefficient and composite reliability.

4 Results

4.1 Content validity

From the validation of Ayaneh et al. (2021), the proposal of 20 items was taken as a basis, where a group of educational specialists evaluated the saturated items. The scale was organized according to the content validity (Table 2) process by expert judgment (30 items), structured in 4 dimensions (SK = subject knowledge, PC = professional competence, EC = ethical competence, and TM = time management). For this analysis, six experts in university higher education with a minimum of 10 years of experience were recruited to serve as judges. At the expert committee's suggestion, 2 items were removed (16 and 19). To analyze the results, Aiken's V Coefficient (V > 0.50; 95% CI) was used, considering the criterion value for deciding which items should be eliminated, revised, or withdrawn. Finally, the scale was left with 28 items to be included in the virtual questionnaire. All the items

TABLE 2 Content validity in the SETE scale.

Measurement items	V for Aiken			CI 95%		
	Clarity	Pertinent	Relevance	Clarity	Pertinent	Relevance
SK1	0.88	0.96	0.96	[0.69–0.96]	[0.80–0.99]	[0.80–0.99]
SK2	0.96	0.88	0.88	[0.80–0.99]	[0.69–0.96]	[0.69–0.96]
SK3	0.96	0.96	0.96	[0.80–0.99]	[0.80–0.99]	[0.80–0.99]
SK4	0.88	0.88	0.92	[0.69–0.96]	[0.69–0.96]	[0.74–0.98]
SK5	1	1	1	[0.86–1]	[0.86–1]	[0.86–1]
SK6	0.92	0.96	0.92	[0.74–0.98]	[0.80–0.99]	[0.74–0.98]
PC1	0.88	0.88	0.96	[0.69–0.96]	[0.69–0.96]	[0.80–0.99]
PC2	0.96	0.92	0.92	[0.80–0.99]	[0.74–0.98]	[0.74–0.98]
PC3	0.92	0.96	0.96	[0.74–0.98]	[0.80–0.99]	[0.80–0.99]
PC4	0.96	0.92	0.96	[0.80–0.99]	[0.74–0.98]	[0.80–0.99]
PC5	0.96	0.96	0.96	[0.80–0.99]	[0.80–0.99]	[0.80–0.99]
PC6	0.92	0.92	0.96	[0.74–0.98]	[0.74–0.98]	[0.80–0.99]
PC7	0.96	0.96	0.92	[0.80–0.99]	[0.80–0.99]	[0.74–0.98]
PC8	1	1	1	[0.86–1]	[0.86–1]	[0.86–1]
PC9	1	1	1	[0.86–1]	[0.86–1]	[0.86–1]
PC10	1	1	1	[0.86–1]	[0.86–1]	[0.86–1]
PC11	1	1	1	[0.86–1]	[0.86–1]	[0.86–1]
PC12	1	1	1	[0.86–1]	[0.86–1]	[0.86–1]
PC13	0.92	1	1	[0.74–0.98]	[0.86–1]	[0.86–1]
PC14	0.96	0.96	1	[0.80–0.99]	[0.80–0.99]	[0.86–1]
EC1	0.88	0.96	0.96	[0.69–0.96]	[0.80–0.99]	[0.80–0.99]
EC2	1	1	1	[0.86–1]	[0.86–1]	[0.86–1]
EC3	1	1	1	[0.86–1]	[0.86–1]	[0.86–1]
EC4	0.92	0.96	0.96	[0.74–0.98]	[0.80–0.99]	[0.80–0.99]
TM1	0.96	1	1	[0.80–0.99]	[0.86–1]	[0.86–1]
TM2	0.92	0.92	0.92	[0.74–0.98]	[0.74–0.98]	[0.74–0.98]
TM3	0.92	0.92	0.92	[0.74–0.98]	[0.74–0.98]	[0.74–0.98]
TM4	1	1	0.96	[0.86–1]	[0.86–1]	[0.80–0.99]

were evaluated regarding clarity, relevance, and relevance to the construct (Table 2).

On the other hand, indicators such as mean, standard deviation, skewness, and kurtosis were obtained for each of the items applied in this study. The skewness and kurtosis results are nearly zero, meaning the distributions are symmetrical. Furthermore, variability is denoted in the mean, which shows the diversity of responses regarding perceptions among the study participants, as shown in Table 3.

4.2 Exploratory factor analysis

To identify the factorial condition of the scale, an Exploratory Factor Analysis (EFA) was carried out on each element, observing that the items were distributed into four factors according to the construct analyzed (Table 4). The difference is quite clear between the four factors. The KMO and Bartlett test (Kaiser-Meyer-Olkin correlation coefficient = 0.975) has a value greater than 0.7 and the Bartlett test (Sig = 0.000) is very significant for performing factor analysis. The

total variance explained in the model is 73.66%, which is greater than 50%, with Subject Knowledge (SK) = 57.15%, Professional Competence (PC) = 7.59%, Ethical Competence (EC) = 5.21%, and Time Management (TM) = 3.71%. All items have been grouped according to their original dimensions. Next, Confirmatory Factor Analysis (CFA) was performed.

The validation of the final measurement model is shown in Table 5 along with the convergent reliability and validity. Cronbach's Alpha (α) values range between 0.927 and 0.961, considered satisfactory values since all levels of this coefficient must be above 0.70 for the model to be valid (Agbo, 2010). Furthermore, the reliability values (CR) were found between 0.927 and 0.962, which is favorable because this value must be greater than 0.70 to be considered a perfect model (Bagozzi and Yi, 1988). Likewise, the AVE values are between 0.646 and 0.799, which are considered acceptable since this index must be equal to or greater than 0.50 (Hair et al., 2014). In that sense, these values translate as an acceptable measurement model that meets favorable levels of reliability and convergent validity.

TABLE 3 Descriptive analysis of the items (n = 1,000).

Code	Mean ± Standard Deviation	Skewness	Kurtosis
SK1	3.9490 ± 0.95567	−0.870	0.543
SK2	4.0460 ± 0.88582	−0.878	0.661
SK3	3.9970 ± 0.90764	−0.775	0.285
SK4	3.9380 ± 0.98241	−0.764	0.051
SK5	3.9350 ± 0.94640	−0.829	0.468
SK6	3.9700 ± 0.93379	−0.857	0.540
PC1	3.6740 ± 1.06624	−0.553	−0.339
PC2	4.0240 ± 0.95201	−0.892	0.380
PC3	3.9680 ± 0.96535	−0.832	0.264
PC4	4.0310 ± 0.96279	−0.945	0.542
PC5	3.8590 ± 1.01101	−0.781	0.181
PC6	3.9700 ± 0.96230	−0.804	0.255
PC7	4.0290 ± 0.97113	−0.893	0.239
PC8	4.0110 ± 0.93689	−0.834	0.325
PC9	3.9270 ± 0.94476	−0.725	0.078
PC10	3.7530 ± 1.10146	−0.666	−0.277
PC11	3.8020 ± 1.05447	−0.743	0.017
PC12	3.8290 ± 0.99436	−0.650	−0.081
PC13	3.9630 ± 0.96673	−0.859	0.363
PC14	4.0080 ± 0.95438	−0.854	0.294
EC1	4.1600 ± 0.97845	−1,128	0.771
EC2	4.1410 ± 0.96023	−1,026	0.499
EC3	4.1610 ± 0.96748	−1,097	0.620
EC4	4.1360 ± 1.03758	−1,228	0.997
TM1	3.9610 ± 0.97387	−0.795	0.200
TM2	3.9910 ± 0.98686	−0.840	0.146
TM3	3.8630 ± 1.05610	−0.726	−0.104
TM4	3.9370 ± 1.00898	−0.811	0.135

Table 6 shows each indicator of model fit that measures teaching effectiveness, showing acceptable and excellent measures.

Regarding discriminant validity (Table 7), the results show that the confidence intervals, in none of the cases, reach unity. Additionally, the quantile covariances do not exceed the AVE; therefore, there is clear evidence of discrimination between the constructs subjected to evaluation (Fornell and Larcker, 1981).

To provide further strength in evaluating discriminant validity as a requirement for analyzing the relationships between the latent variables, Table 8 presents the results regarding discriminant validity using the heterotoit-monotrait relationship criterion (HTMT); in this case, the values are less than 0.90. Therefore, it is stated that the discriminant validity between two reflective constructs has been established (Henseler et al., 2015). Additionally, Figure 1 shows the factor structure of the SETE scale in a sample of university students from Latin America.

Finally, the final version of the instrument, which underwent rigorous content validity, EFA, and CFA processes to ensure reliable psychometric properties for use, is described (Table 9). It is made up of four factors: 06 items for Subject matter Knowledge (SK), 14 items for Professional Competency (PC), 04 items for Ethical Competence (EC), and 04 items for Time Management (TM).

5 Discussions

5.1 Discussion of findings

The objective of the present study was to evaluate the validity and reliability of the SETE scale (Ayaneh et al., 2021) in the Latin American context. This is the first study in which the evidence and reliability of this scale are published in this context. Other validations of the same construct

TABLE 4 Exploratory factor analysis (EFA) pattern matrix.

	Factor			
	1	2	3	4
PC13	0.878			
PC9	0.825			
PC7	0.818			
PC6	0.815			
PC8	0.812			
PC14	0.788			
PC12	0.784			
PC4	0.782			
PC11	0,773			
PC3	0.758			
PC10	0.727			
PC2	0.715			
PC5	0.706			
PC1	0.513			
SK4		0.838		
SK5		0.825		
SK6		0.802		
SK3		0.743		
SK1		0.742		
SK2		0.734		
EC2			0.918	
EC3			0.914	
EC1			0.889	
EC4			0.763	
TM3				0.875
TM4				0.852
TM2				0.758
TM1				0.720

Extraction method: maximum authenticity. Rotation method: Promax with Kaiser normalization. ªThe rotation has converged in 7 iterations.

TABLE 5 Validation of the final measurement model with reliability and convergent validity.

Predictor	Items	Estimate	Alpha	CR	AVE
SK	SK1	0.813 ***	0.928	0.928	0.682
	SK2	0.817 ***			
	SK3	0.803 ***			
	SK4	0.808***			
	SK5	0.851***			
	SK6	0.861 ***			
PC	PC1	0.732***	0.961	0.962	0.646
	PC2	0.830***			
	PC3	0.845 ***			
	PC4	0.877 ***			
	PC5	0.637***			
	PC6	0.802***			
	PC7	0.817 ***			
	PC8	0.842 ***			
	PC9	0.810 ***			
	PC10	0.703 ***			
	PC11	0.775 ***			
	PC12	0.818 ***			
	PC13	0.854 ***			
	PC14	0.869 ***			
EC	EC1	0.918 ***	0.938	0.940	0.799
	EC2	0.927 ***			
	EC3	0.933***			
	EC4	0.788 ***			
TM	TM1	0.847 ***	0.927	0.927	0.762
	TM2	0.898***			
	TM3	0.855 ***			
	TM4	0.890***			

Cronbach's alpha (α) for all variables is > 0.9, the composite reliability (CR) > 0.90, and the mean–variance extracted (AVE) > 0.60; ***$p < 0.001$ (significance level), indicating a significant validity of the model.

TABLE 6 Statistical goodness-of-fit indices of the SETE scale.

Measure	Threshold	Estimate	Interpretation
CMIN	–	1,499,529	–
DF	–	344	–
CMIN/DF	Between 1 and 3	4,359	Acceptable
CFI	>0.95	0.956	Excellent
SRMR	<0.08	0.030	Excellent
RMSEA	<0.06	0.058	Excellent

CMIN, Chi-square; DF, Degrees of Freedom; SRMR, Standardized Root Means square Residual; RMSEA, Root Mean Square Error of Approximation; CFI, Comparative Fit Index.

TABLE 7 Validation of the discriminant validity of the measurement model (Fornell-Lacker Criteria).

	CR	AVE	SK	PC	EC	TM
SK	0.928	0.682	**0.826**			
PC	0.962	0.646	0.786***	**0.803**		
EC	0.940	0.799	0.657***	0.672***	**0.894**	
TM	0.927	0.762	0.705***	0.710***	0.750***	**0.873**

***$p < 0.001$ (significance level). The square root of AVEs is shown diagonally in bold.

TABLE 8 Discriminant validity of the model using the heterotroit-monotrait (HTMT) relationship criterion.

	SK	PC	EC	TM
SK				
PC	0.787			
EC	0.653	0.664		
TM	0.702	0.705	0.753	

have been carried out in other latitudes (Calaguas, 2012; Rocha, 2013; Kyrgiridis et al., 2014; Marshall et al., 2016; Shahzad and Mehmood, 2019; Adekanmbi and Ukpere, 2021; Mohebbi et al., 2022). The scales review found a diversity of factors associated with this construct, ranging from single-factor scales to scales with 10 factors (Shahzad and Mehmood, 2019; Li et al., 2024). The dimensions presented in these scales share characteristics with others that measure the same construct, although to date there is no consensus on their dimensionality.

Originally the SETE scale was validated in university students from Ethiopia with 20 items, however, in this new version for Latin America the items went through a rigorous adaptation process, resulting in 30 items. This is because the original scale items were found to address more than one specific topic, saturating them. To take an example, the factor "Professional Competence" (PC), originally had the item "Follows the continuous evaluation approach and gives feedback on continuous evaluations on time." This item, when going through the process of semantic validation by expert judgment, it was considered that the item structure should be reformulated to make it clearer and more specific (PC9: Permanently evaluates students, PC10: Resolves tests when an evaluation is concluded). Based on the opinion of psychometric specialists who argue that by analyzing, eliminating or reformulating saturated items, the validity and reliability of the scale can be improved, ensuring that the instrument measures what it is intended to measure accurately and consistently (Matas, 2018). This explains why the 4-factor model lacked discriminant validity and

probably better explains why the CFA was deficient. The adaptation carried out in the present study showed that the factors SK = Subject knowledge, PC = Professional competence, EC = Ethical competence, and TM = Time management, fit the model. Although two items (items 16 and 19) had to be eliminated from the initial 30, the results demonstrated good internal consistency (α = between 0.927 and 0.961; CR = between 0.927 and 0.962; AVE = between 0.646 and 0.799). The final version of the scale consists of 28 items.

5.2 Theoretical and practical implications

The SETE scale is now ready to be used as a valid and reliable tool to evaluate the effectiveness of teachers in the university teaching process. Teachers can use this measurement tool to understand what students perceive as their strengths and weaknesses. College students can also use this information to make more informed course selections. This can be applied in future research to find correlations, predictors, and moderators of this construct. Institutions can also use it to make decisions about their teachers. Although the SETE scale has good psychometric properties, it is recommended that its revision be reconsidered in the future. It needs to be revised and updated periodically to meet the rapidly changing needs of university students, teachers, and educational institutions. In addition, these results can be the platform for the creation of innovative policies, strategies and educational programs that increase university students' perception of teaching effectiveness, thus contributing to an increase in the quality of education in Latin American countries.

5.3 Limitations and future research

The results of this study should be considered taking into account the following limitations: One limitation is that, although the scale was adapted and harmonized to be applied to all private universities in the Latin American countries of South America (whose languages derive from Latin, mainly Spanish and Portuguese), this analysis only used data from some countries (4/10), which may not be generalizable to other private universities in South America. In this sense, this study highlights the need to obtain a large amount of data from multiple universities and representative samples from each South American country to strengthen existing findings further. On the other hand, the questionnaire assumed that students' evaluations of teachers were free of prejudices or stereotypes. However, university participants with high grades in their subjects are likely to give higher scores on the questionnaire. In contrast, participants who obtained low grades in their subjects consider this evaluation a form of retaliation against their teachers.

In addition, the physical attractiveness of the teacher, the time taken to complete the survey, the proximity to a teacher, the difficulty of the course, and the teacher's age, performance, and personality can become determining factors in students' evaluations (Calaguas, 2012; Kim et al., 2019; Shahzad and Mehmood, 2019; Sofyan et al., 2021). It is also recommended to consider the semester for the application of the questionnaire, given that taking it in the first (students are not entirely familiar with the teacher's methods) or last (students with failing grades, in a spirit of retaliation, among others) weeks of class can create study bias. In addition, in future studies, it is recommended that some indication or filter be included in the questionnaire to determine whether the subjects considered are all the subjects of the academic period or only the compulsory ones, since this could influence the evaluation of the students.
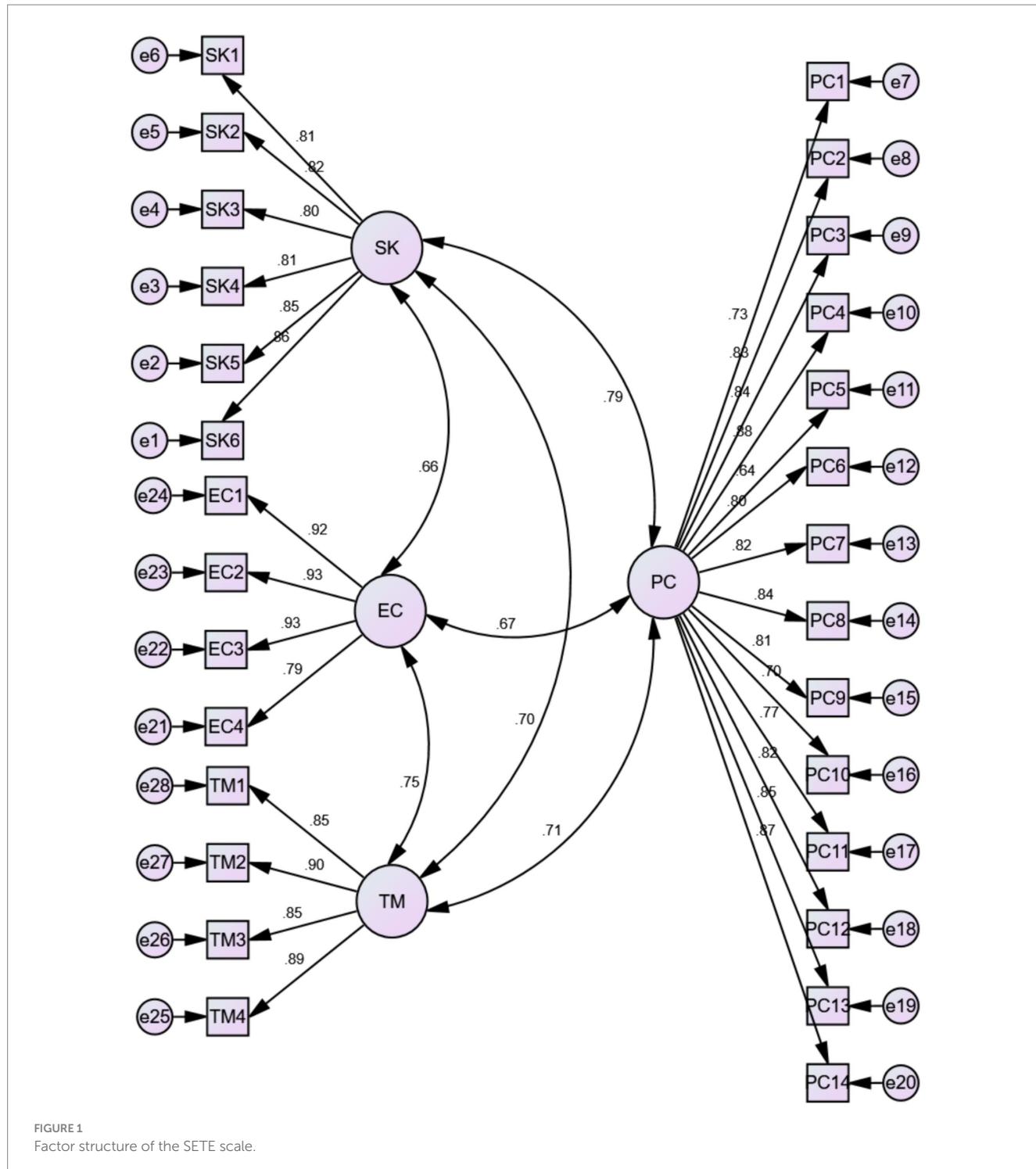
FIGURE 1
Factor structure of the SETE scale.

Finally, the "Professional Competence" (PC) factor was validated with 14 items, the broadest dimension of the scale, which may be another limitation of this study. However, despite these limitations, the study's findings will significantly help university education professionals address teacher effectiveness problems.

6 Conclusion

The SETE scale's translation, adaptation, analysis of validity, and reliability were performed on a sample of 1,000 South American university students of both sexes. After having passed through a diligent process of content validity, EFA, and CFA, the results presented reliable psychometric properties for the application. The scale confirmed 28 items distributed in 4 factors (SK, PC, EC, and TM). In terms of convergent and discriminant validity, the factors showed acceptable values. In addition, the internal consistency of the scores was determined by observing adequate values for Cronbach's Alpha coefficient (α = between 0.927 and 0.961). In this sense, the SETE scale is considered a scientific tool with accessible language for practical, useful, reliable, and necessary applications.

TABLE 9 28-item instrument (Spanish version).

Predictor	Measurement items	Affirmations
Subject matter Knowledge (SK)	SK1	Explica los objetivos y las unidades del curso/materia a tiempo.
	SK2	Demuestra dominio del curso/materia.
	SK3	Proporciona apuntes y material de lectura del curso/materia.
	SK4	Considera en el sílabo del curso, libros disponibles en la biblioteca y direcciones web accesibles.
	SK5	Enseña en función de la naturaleza del curso/materia e imparte sesiones prácticas.
	SK6	Imparte el curso/materia de tal manera que los estudiantes lo entienden.
Professional Competency (PC)	PC1	Utiliza materiales didácticos adicionales.
	PC2	Responde a las preguntas planteadas en el salón de clase.
	PC3	Asigna trabajos para desarrollar en el salón de clase.
	PC4	Plantea preguntas en el salón de clase.
	PC5	Deja tareas para la casa.
	PC6	Los alumnos exponen como parte del desarrollo de la clase.
	PC7	Los alumnos trabajan en grupos.
	PC8	Prepara exámenes según el contenido del curso/materia, incluyendo varios modos de evaluación.
	PC9	Evalúa permanentemente a los estudiantes.
	PC10	Resuelve los exámenes cuando concluye una evaluación.
	PC11	Brinda orientación a los estudiantes, sobre todo a los que tienen necesidades especiales y de bajo rendimiento.
	PC12	Da retroalimentación.
	PC13	Permite que los estudiantes interactúen en determinados momentos de la clase.
	PC14	Demuestra compromiso para la transferencia del conocimiento.
Ethical Competence (EC)	EC1	Respeta a los estudiantes.
	EC2	Demuestra una conducta ética.
	EC3	Demuestra buen comportamiento.
	EC4	No discrimina por motivos étnicos, religiosos o de sexo.
Time Management (TM)	TM1	Llega a tiempo durante el horario de clase.
	TM2	Usa el tiempo de clase apropiadamente.
	TM3	Establece horarios de atención a los estudiantes.
	TM4	Resuelve a tiempo los problemas académicos de los estudiantes.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Comité de Ética de la Escuela de Posgrado de la Universidad Peruana Unión, Lima, Perú. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MV-G: Conceptualization, Investigation, Project administration, Resources, Visualization, Writing – original draft, Writing – review &

editing. JHL-S: Methodology, Resources, Supervision, Writing – review & editing. EEG-S: Data curation, Formal analysis, Software, Supervision, Validation, Writing – review & editing. IF-M: Investigation, Visualization, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict.

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Self-regulated learning and engagement through emergency remote teaching in EFL undergraduate students

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Introduction: An important concern of research about self-regulated learning is to determine the most effective methods for its instruction in different educational settings. This also happens in foreign language learning as improving proficiency is challenging for students and self-regulation has proven effective in different educational levels.

Methods: A quasi-experimental study was designed with a treatment and a control group, and pre- and post-test for 70 undergraduate students majoring in English as a foreign language at a Chilean university. A 10-week intervention was conducted to develop self-regulation during emergency remote teaching.

Results: Findings revealed that the intervention, as implemented in the study, was successful in improving self-regulated learning, and in participants' recognizing the practical utility of tools acquired. On the other hand, while the level of engagement remained similar after the intervention, this was seen as a protective effect of the teaching-learning strategy on motivational states.

Discussion: This research underscores the importance of self-regulated learning training in higher education to allow for students' autonomy and agency, as well as connectedness with instructors and peers, especially during the harsh teaching conditions of sanitary confinement.

KEYWORDS

self-regulated learning, engagement, EFL, motivation, emergency remote teaching, competences

1 Introduction

Successful undergraduate students display a diverse set of skills that empowers them to achieve academic goals more efficiently and effectively. Within the framework of self-regulated learning (SRL), these skills include metacognitive strategies such as goal setting, time management, self-monitoring, and planning (Zimmerman, 2013; Cai and Zhao, 2023). Additionally, learners' positive self-efficacy perceptions about their own competence, another component of SRL, helps them become more confident and persistent when undertaking tasks and assignments (Semilarski et al., 2021; Al-Abyadh and Abdel Azeem, 2022). On a different note, academic engagement, a

meta construct involving behavioural, motivational and cognitive aspects, is also believed to affect motivation level and to enhance learning that fosters greater students' dedication (Fredricks et al., 2004). Research has shown that engagement, as an operational construct of motivation, relates positively to academic success (Caruth, 2018; Serrano et al., 2022). By developing these aspects, namely SRL and engagement, students could maximize their learning potential to become more independent and competent (Agranovich et al., 2019; Handoko et al., 2019; Karlen et al., 2020; Cherng-Jyh et al., 2022).

Traditionally, in the Chilean context, undergraduate students generally struggle to deal with their academic workload. They display low autonomy and motivation levels resulting in limited academic engagement and high dropout rates (Díaz-Mujica et al., 2018; Lobos et al., 2021). Students might lack tools such as those inherent to SRL, which would enable them to take control of their learning. Amidst the COVID-19 crisis, these issues seemed to worsen with the enforcement of emergency remote teaching (ERT; Brooks, 2021; Quang et al., 2022; Aydin, 2023). During that period, mounting evidence from learning management system (LMS) platform-generated analytics revealed students' dwindling attendance levels, reduced active participation in virtual classes, and decrease in performance while in online modality.

A way to address these exacerbated problems during ERT conditions might be through deliberate instruction of self-regulation. Teachers could play a major role, as SRL is a trainable skill (Zimmerman and Moylan, 2009). Successful interventions to develop self-regulation have already been implemented in several academic fields, for example, to help children with attention deficit / hyperactivity disorder (ADHD; Reid et al., 2005); in neuroscience studies, when trying to encourage behaviours consistent with being a good group member (Heatherton, 2011); or also at the workplace, when self-regulation is understood as an in-person process that develops over time (Lord et al., 2010). Meanwhile, in the field of L2 [second language, it refers to any language learned after one's native language (L1)] research, several studies have shown the relationship between SRL and linguistic competence (Zhang and Zhang, 2019; Öztürk and Çakıroğlu, 2021; Tomak and Seferoglu, 2021); though it is unclear how to best incorporate elements of SRL into instruction. Previous meta-analyses studies report that research on SRL in English as a Foreign Language (EFL) has been mostly concerned about achievement rather than its development resulting from focused instruction (Chen, 2022; Teng, 2022). It could well be that instructing EFL undergraduate students on SRL could help them build up their own self-regulation toolkit, and thus help them adapt to the adversities of the pandemic, maintain engagement, and succeed academically.

This research paper outlines the implementation of an intracurricular pedagogical intervention which attempts to improve SRL and engagement levels in EFL undergraduate students during ERT. We hypothesize that self-regulation and engagement levels will increase after its application. This study is expected to provide educators with valuable insights into the effects of purposeful instruction and implementation of SRL in the EFL classroom.

2 Literature review

2.1 Self-regulated learning

Zimmerman (2000a, p.14) defines SRL as "self-generated thoughts, feelings, and behaviours that are oriented to attaining goals."

Within this conceptualization, mechanisms and stages of SRL are described as a cyclical model which distinguishes three phases: forethought, performance and self-reflection, each comprising clear processes that self-regulated learners undertake to successfully complete academic tasks. At the forethought phase, individuals will perform influential operations, such as setting goals and planning strategic actions, which precede the efforts to act, and whose aim is to get the stage ready for action. During the performance phase, students will actively execute tasks in a controlled environment, creating conditions to remain focused and engaged while also monitoring progress; these include strategies at specifically addressing the task: self-instruction, imagery use, time management, environmental structuring, help seeking, interest incentives, among others. The phases of self-reflection refer to the learners' responses to the task experience itself, as they judge the effectiveness of their learning process, and explore factors that might explain their outcomes (Zimmerman, 2000a,b; Zimmerman and Moylan, 2009).

Another important attribute associated to academic achievement and found to interact with SRL, is self-efficacy. This is posed to be a crucial factor in academic achievement, involving dynamic and integrated processes, and which utilize skills and capabilities to effectively navigate and interact with the environment in order to achieve objectives (Bandura, 1982). This construct is identified as students' sense of agency referring to the beliefs in their own capacity or power to learn under self-regulated conditions. In other words, efficacious learning is not just about having certain abilities, but also about the mindset and application of those abilities, which makes a difference in their success (Zimmerman, 2000b). For example, when learners engage in independent study or practice, or when they set clear objectives that they feel capable of attaining (Zimmerman et al., 2017). Bandura (1995) underscores the impact of self-efficacy on shaping goals which individuals set for themselves, the level of effort exerted, perseverance in challenging situations, and resilience to setbacks. High self-efficacy appears to correlate positively with increased effort and persistence, leading to improved performance and outcomes (Lee et al., 2020).

Moreover, it is suggested that self-efficacy and SRL are closely intertwined concepts exerting a reciprocal and mutually reinforcing relationship (Chen, 2022), that is, when students have a strong sense of self-efficacy, they are more likely to engage in SRL strategies. This proactive approach to learning allows students to take charge of their own education and perceive themselves as more capable, thus, increasing the effectiveness of SRL strategies (Zimmerman, 2002).

The synergistic relationship between SRL and self-efficacy presents opportunities to devise instructional approaches that support learning processes. By fostering a strong sense of self-efficacy and teaching effective SRL strategies, instructors can help students take control of their learning and maximize their academic capabilities (Lee et al., 2020). This suggests that SRL involves a social aspect and nature, enabling participating agents (teachers, parents, coaches, peers, among others) to instruct and model SRL strategies, helping learners develop greater self-efficacy and become more competent (Zimmerman, 2002; Ewijk et al., 2015).

2.2 Engagement

Another variable to consider when analysing university students' performance is engagement, which is understood as a high

motivational state that manifests itself in student behaviour (Maluenda-Albornoz et al., 2022): engaged individuals show an interest in educational activities, make an effort and dedicate time to learning (Fredricks and McColskey, 2012).

Engagement positively relates to favourable educational indicators, such as achievement (Pineda-Báez et al., 2014; Gómez et al., 2015), social integration with peers/teachers, and students' involvement in the classroom (Maluenda-Albornoz et al., 2020a, 2021). On the other hand, engagement also shows a negative relation with burnout in academic contexts (Schaufeli et al., 2002a,b), exhaustion (Salanova et al., 2009) and university dropout (Chang et al., 2014; Díaz-Mujica et al., 2018; Maluenda-Albornoz et al., 2021, 2022). This concept is also considered a dynamic variable since it is susceptible to modification through effective designed interventions within the university context. (Maluenda-Albornoz et al., 2022).

More particularly, and for the purposes of the present study, engagement is defined as the range of expressions of motivation for study, across three primary dimensions (Fredricks et al., 2019). The behavioural dimension encompasses the actions taken by students who are eager to learn. The cognitive dimension involves the set of thoughts, beliefs, and perceptions regarding the significance of academic tasks and effort required; whereas the emotional dimension encompasses the feelings and attitudes students have towards learning (Antúnez et al., 2017). During the ERT period, evidence suggests that the fully virtual instruction modality adversely affected students' motivation and participation (Oyedotun, 2020; Zaccoletti et al., 2020) as well as their engagement (Pasion et al., 2020; Daniels et al., 2021). Therefore, it also became crucial to assess the impact of intervention strategies on engagement, so as to understand their effect on motivation and mitigate their negative impact under the conditions of the pandemic.

In the present study, we anticipate an impact not only on students' SRL, but also more indirectly, on engagement, resulting from a change in the teaching method. The new strategy would allow participants to satisfy basic psychological needs: (1) when students share their performance and receive feedback in a protected environment, *relatedness* is being satisfied; (2) when students can practice, and can prove their own ability to produce language, *competence* is being satisfied; and (3) when they choose their own ways to produce language and show their achievements, *autonomy* is being satisfied.

To direct the actions of the study, the research will be guided by the following research questions:

(1) To what extent does self-regulation increase after the implementation of an intracurricular intervention aiming at SRL development?
(2) To what extent does engagement increase after the implementation of an intracurricular intervention aiming at SRL development?

3 Method

3.1 Design

A quantitative quasi-experimental design was conducted involving both an experimental and a control group, each subjected to pre- and post-tests. The pre and post-test evaluation included the use of an *ad hoc* questionnaire made up of the instruments described in the materials section.

3.2 Participants

The target population was defined by intentional sampling. This included 70 undergraduate students from English majoring programs at a Chilean university. The intervention group was comprised of 54 pedagogy students, organized into 3 sections, while the control group consisted of 16 students from a translation program. From a linguistic competence point of view, all students exhibited an intermediate English level minimum, B1+ or above, according to the Common European Framework of References for Languages (CEFR; Council of Europe, 2020). All students were in their second year of university studies, having completed the prerequisite courses, which was considered to be an indicator of a relatively similar linguistic attainment level in the L2. This intentional sampling ensured a homogeneous group in terms of their language proficiency. Additionally, demographic variables showed that 22.6% of participants were men, 72.6% women, and 4.8% did not indicate sex, while their ages ranged between 19 and 27 (x = 20.1; SD = 1.52; Table 1).

TABLE 1 Intervention and control groups.

Group	Program	Section No.	No. of students
Intervention Group	English Pedagogy	1	20
		2	21
		3	13
Control Group	Translation	1	16

3.3 Materials

An *ad hoc* questionnaire was developed based on two main components, engagement and self-regulated learning. Engagement was measured by using the University Student Engagement Inventory (USEI). Self-regulated learning was measured by using a combination of the SRL Practices Scale and the Self-Efficacy for SRL Questionnaire. The combination of both scales produced a compound measure as an indicator for SRL levels. The reason for this combination was to include different indicators (items) in the same measure that consider a wider perspective on the cognitive and behavioural components of SRL to gain a better understanding of this variable.

These original scales show good psychometric properties which have been tested on university students. Below are their key features:

1 The University Student Engagement Scale is made up of 15 items with a 7-level Likert scale response format (1 = never, 7 = always), distributed in three subfactors: interest (5 items), effort (5 items), and participation (5 items). It was created by Maroco et al. (2016) and adapted to Chilean university students by Maluenda-Albornoz et al. (2020b). In the Chilean university version, the fit indices showed satisfactory performance of the bifactorial model [$\chi^2 = 210.276$, $p < 0.001$; RMSEA = 0.047 (95% IC, 0.040–0.055, CFI = 0.967, TLI = 0.954)] as well as reliability ($\alpha = 0.841$; $\omega = 0.843$) and criterion validity.

FIGURE 1
Intervention stages and components.
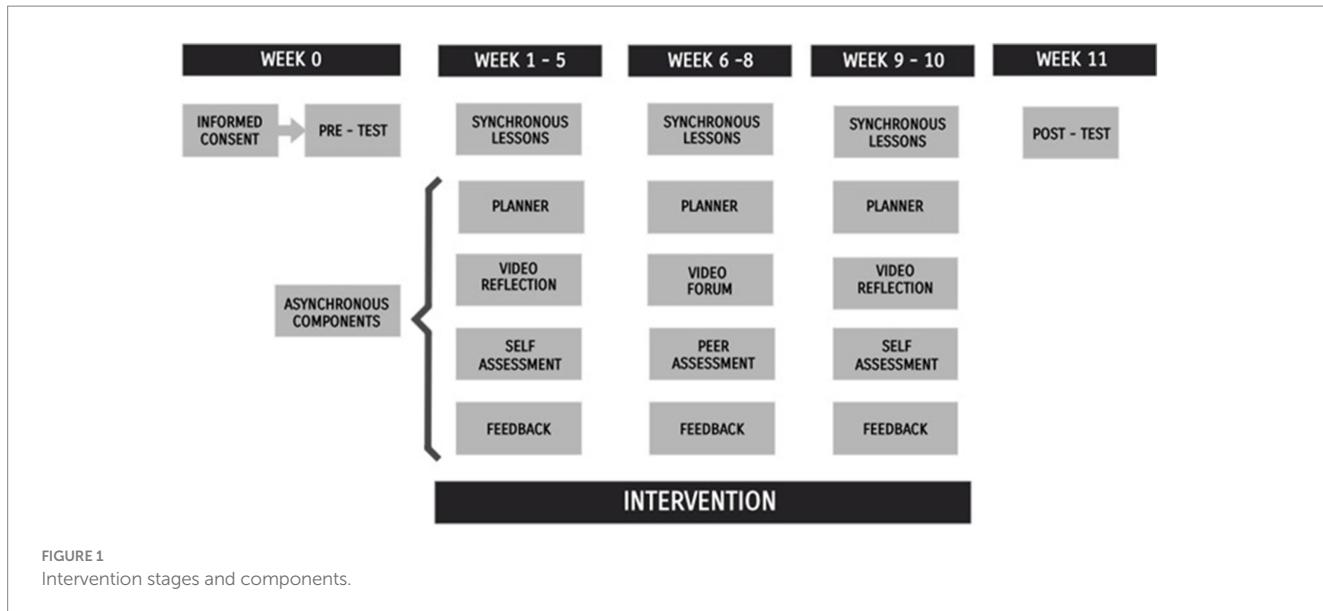
2   The Self-Regulated Learning Practices Scale assesses the level of self-regulation on university students in the teaching-learning process. This instrument is made up of 11 items with a 7-level Likert scale response format (1 = never, 7 = always) and was adapted for Chilean university students showing adequate psychometric properties for a one-factor model (Vergara-Morales et al., 2019).

3   The Self-Efficacy Questionnaire for self-regulation measures the degree of self-efficacy at being self-regulated in university contexts. This instrument consists of 9 items with a 7-level Likert scale response format (1 = Never; 7 = Always). The instrument was adapted for Chilean university students showing adequate psychometric properties for a one-factor model (Sáez et al., 2017)

3.4 Procedure

The instruments were administered to the intervention and control groups during one academic semester, before and after the intracurricular intervention was implemented, which took place between March 23th and June 30th. An informed consent was obtained from students according to the ethical protocols for working with human beings. Students who did not agree to participate were withdrawn from the study without any type of associated consequence.

3.5 Intervention

Integrated into the syllabus, the pedagogical intervention was planned and implemented with the aim of increasing primarily SRL, and more indirectly, engagement levels in EFL undergraduate students. This took the form of an intracurricular intervention that lasted for 10 weeks. It was aligned with the learning outcomes of a language course which is integral to the curriculum of the English Pedagogy program.

The learning outcome expected to benefit directly from this intervention focused on improving speaking skills at B2 level (CEFR), with a focus on asynchronous communication via the aural/oral and visual channels which virtual technology allowed. The digital tool Flip was employed, serving as the oral medium through which learners developed SRL strategies. This intervention was administered in the teaching modality of ERT resulting from the Covid-19 pandemic. Linguistic contents and objectives (grammar, vocabulary, linguistic functions, etc.) were maintained, though topics were replaced for SRL themes and awareness-raising activities, such as, setting goals, using a planner, creating beneficial study habits, diminishing bad habits, sleep health, procrastinating, managing time and tasks effectively, among others.

The SRL-aiming lessons were imparted synchronously through the default institutional platforms Canvas, Teams and Genially, as well as asynchronously, on the video-recording platform Flip. SRL elements were explicitly taught in real time, and off-line with instructional self-made videos prepared by professors, which included tasks requiring students to cognitively grasp, apply, incorporate and consolidate SRL concepts and strategies.

The teaching approach systematically integrated tasks and active methodologies, as those shown in Figure 1: (1) use of a planner in which students were able to schedule and organize daily and weekly academic work, (2) students' submissions of weekly video recordings whose aim was to engage them into reflection on their progress and usefulness of SRL tools, (3) video forum participation where students analysed and assessed their classmates' SRL declared progress with the use of rubrics, (4) positive and corrective feedback given by the professor and teaching assistants which supported and guided learners in the development of SRL, and (5) weekly self-assessment on Google forms, so that students could monitor specific SRL strategies and progress.

The intervention was carefully designed so that the three SRL-comprising phases were addressed; namely, forethought, performance, and self-reflection, where learners were not only expected to learn about what SRL was, but also to engage in

self-planned study scenarios. For instance, during the first phase they set goals for the course, reflected on strategies necessary to prepare for the different tasks, such as planning and scheduling study time. In a second stage they carried out the tasks while also being made aware of the relevance of the use and application of strategies and techniques, for example, planner use, the Pomodoro technique (Cahyaningrum and Indriani, 2023), distractor avoidance and reduction of procrastination time (e.g., time spent on social media), habit creation (adequate amount of sleeping time), etc. At this stage, awareness was also raised about how to apply SRL-related elements while attending synchronous classes, thus, they were required to attend, take notes, ask questions, make comments, and turn on their camera, among other activities. Additionally, they were asked to keep a record of those, which helped them estimate their progress regarding expected use of those actions. Finally, the last SRL-phase involved the production of their oral reflections video-recorded on Flip, and their self-assessment, instances that also served as an opportunity for participants to socialize and exchange ideas.

Similarly, researchers also ensured that students were offered a safe social context that supported them throughout the intervention. In this sense, interaction was key in promoting healthy relationships with teachers and peers. In addition, weekly positive feedback from their instructors, assistant and classmates, helped them build confidence and a timely sense of progress and achievement, leading to competence. Finally, the fact that students were using tools of their choice (see paragraph above) to organize time and tasks, chose strategies and techniques that were most appealing to their personality, and recorded self-made videos where they openly expressed their thoughts, emotions and ways in which they were becoming more competent, self-regulated learners, provided opportunities to become more autonomous (Furrer and Skinner, 2003; Chiu, 2021). The entire methodological design aimed to foster a supportive and motivating environment, which would arguably increase engagement.

Students in the control group participated in their compulsory EFL language course, which had the same level and the same learning outcome related to speaking skills development as the course for the intervention group. Lessons shared the same linguistic contents as in

the intervention group, but themes and activities did not incorporate any elements, such as the digital tool Flip or active methodologies aimed at SRL development, as those implemented in the intervention group. Lessons for the control group were delivered by one of the researchers who was also teaching an intervention group under the ERT modality during the sanitary crisis, in the same academic period as the intervention group.

3.6 Data analysis

To carry out the analysis, a Factorial Repeated Measures ANOVA was used (with an F test), after evaluating compliance with the assumptions associated with this test (Normality and Homoscedasticity test's). Subsequently, Bonferroni post-hoc test was used to identify significant effects in the specific comparisons.

4 Results

Descriptive statistics showed a small decrease in SRL for the second measurement for the control group, while for the intervention group, an increase in the post-intervention score was observed (Table 2).

Assumptions for Factorial Repeated Measures ANOVA were tested. Results showed non-compliance of normality assumptions. However, skewness and kurtosis were measured, and its results showed compliance with literature standards (each value was lower than ± [2]). For this reason, the research team relied on the robustness reported by ANOVA test in literature standards. Levene's test was also tested and showed compliance with homoscedasticity requirements (SRL pre-test group, $p = 0.247$; SRL post-test group, $p = 0.067$; Engagement pre-test group, $p = 0.896$; Engagement post-test group, $p = 0.145$).

Regarding SRL, analysis of intra- and inter-subject effects showed statistically significant differences in measurements before and after, and between groups (Tables 3, 4).

The analysis of the post-hoc comparisons regarding SRL showed statistically significant differences between the pre-test in the control group and post-test in the intervention group with a higher score in the post-test of the intervention group.

Also, statistically significant differences between the pre-test of the intervention group and post-test were found with a higher score in the post-test. Finally, statistically significant differences between the post-test of the control group and the post-test of the intervention group were observed with a higher score for the intervention group (Table 5). A clearer perspective is observed in Figure 2.

In relation to engagement, descriptive statistics showed a small decrease in the second measurement for the control group, while for the intervention group an increase in the post-intervention score was observed (Table 6).

TABLE 2 Descriptive statistics for SRL.

Self-regulated learning	Group	n	Mean	SE	Coefficient of variation
Pre-test	Control	16	95.875	5.118	0.214
	Intervention	54	101.450	2.010	0.171
Post-test	Control	16	92.875	6.094	0.262
	Intervention	54	105.001	2.300	0.134

TABLE 3 Intra-subject effects for SRL.

Cases	Sum of squares	df	Mean square	F	p	η^2	η^2_p
Self-regulated learning	209.761	1	209.761	1.558	0.206	0.004	0.020
Self-regulated learning group	885.189	1	885.189	6.577	0.014	0.014	0.076
Residuals	11053.257	68	131.656				

Analysis of intra- and inter-subject effects showed statistically significant differences in measurements of engagement before and after, and between groups (Table 7; Table 8).

The analysis of the post-hoc comparisons of engagement levels showed statistically significant differences between the pre and post-test in the control group, with a lower score in the post-test. Also, statistically significant differences between the pre-test in the intervention group and post-test in the control group were detected with a lower score in the post-test of the control group. Finally, the analysis showed statistically significant differences between the post-test in the control group and the post-test in the intervention group with higher scores for the intervention group (Table 9). A clearer perspective is observed in Figure 3.

5 Discussion

The complex circumstances of ERT, together with general students' profiles in Chilean higher education, forced the search for effective strategies aiming at equipping students with a

repertoire of elements and skills that they could employ to become more autonomous, competent and satisfied with their learning, and to feel connected with instructors and peers during times of social distancing. Specifically, in the present study, the participants, from Chilean EFL majors, had shown a decline in motivation during the first year of ERT in 2020. Based on attendance records and online analytics, which revealed limited participation in both synchronous and asynchronous activities, it had become evident that they lacked metacognitive strategies to effectively self-regulate their learning in 2021. The following discussion attempts to address the research questions that motivated the implementation of this study.

5.1 To what extent does self-regulation increase after the implementation of an intracurricular intervention aiming at SRL development?

The problem above was analysed and tackled within the framework of psychological models of engagement and self-regulation (Zimmerman, 2000b; Zimmerman et al., 2017). These models propose that enhancing those aspects could benefit students' overall autonomy, competence and relatedness. This study gives an account of the application of a curriculum-integrated pedagogical intervention to empower learners with essential SRL competencies, as found in similar studies (Fredricks et al., 2019). These competencies could help learners to efficiently manage academic work to potentially

TABLE 4 Between-subject effects for SRL.

Cases	Sum of squares	df	Mean square	F	p	η^2	η^2_p
Group	4700.594	1	4640.321	7.746	0.008	0.075	0.090
Residuals	49123.757	68	589.165				

TABLE 5 Post-hoc comparisons - group SRL.

		Mean difference	SE	t	Cohen's d	p_{bonf}
Control, Pre-test	Intervention, Pre-test	−7.638	5.243	−1.431	−0.401	0.928
	Control, Post-test	2.998	4.030	0.721	0.155	1.000
	Intervention, Post-test	−16.322	5.332	−3.075	−0.842	0.013*
Intervention, Pre-test	Control, Post-test	10.633	5.323	1.996	0.555	0.289
	Intervention, Post-test	−8.691	1.982	−4.355	−0.441	<0.001***
Control, Post-test	Intervention, Post-test	−19.301	5.302	−3.600	−0.998	0.004**

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

TABLE 6 Descriptive statistics for engagement.

Engagement	Group	N	Mean	SD	SE	Coefficient of variation
Pre-test	Control	16	79.188	10.778	2.694	0.136
	Intervention	54	82.290	11.347	1.3766	0.128
Post-test	Control	16	69.125	10.210	2.553	0.148
	Intervention	54	80.431	15.932	1.920	0.181

TABLE 7 Intra-subject effect for engagement.

Cases	Sum of squares	df	Mean square	F	p	η^2	η^2_p
Engagement	919.475	1	919.399	9.816	0.004	0.030	0.107
Engagement group	436.475	1	436.475	4.681	0.029	0.013	0.054
Residuals	7641.733	68	93.192				

foster their motivation by sustaining engagement and SRL levels, as suggested by Reid et al. (2005), Caruth (2018), and Aydin (2023), among others.

Results revealed that SRL increased significantly for the intervention group in the post-test compared to the pre-test in the same group and the post-test in the control group, with SRL levels in the control group even diminishing slightly in the post-test. This finding could be reflecting that the intervention efforts influenced the development of higher levels of SRL compared with their initial state, or with the control group, suggesting that a systematic and well-oriented teaching design focused on SRL, such as the intervention implemented in this study, can enhance SRL performance, and also promote students' permanent work in the designed tools. This is consistent with findings presented by Chen (2022) where interventions had similar instructional effects on students of different age groups and education levels, being duration and intensity of intervention significant factors that influenced the effectiveness of SRL interventions in the L2 context, especially for strategy use and self-efficacy.

An explanation for these results might relate to the systematic and comprehensive approach employed to deliver SRL components during the intervention. As closely as possible, its structure and sequencing followed the 3-stage cycle within the framework of Zimmerman (2000a,b), where the phases of forethought, performance and self-reflection are logically distinguished. This design seemed to favour the attainment of the findings above. Its cyclical nature seemed adequate to apply and organize the treatment in the case of specific tasks within lessons, as well as with the bigger linguistic aim of ensuring more practice and exposure time to the L2, and which would in turn enhance improvement of the students' speaking skill.

Firstly, students were expected to focus on its key elements by examining, through deep reflection, the likely benefits that adequate aspects of conduct, cognition and affect might bring to the fulfilment of academic goals, as similarly reported by Abello-Riquelme et al. (2022), and Cherng-Jyh et al. (2022). Secondly, the coverage of those elements incorporated students' performing actions whose aim was to apply them to their own conditions and preferences of learning

(Zhang and Zhang, 2019; Öztürk and Çakıroğlu, 2021). These centred around forethought, performance and self-reflection phases of the SRL cycle (Zimmerman, 2000a,b), which included the application of concepts aimed at academic success, such as planning short and long-term goals, ways of creating good habits and getting rid of detrimental ones, the neurobiological mechanism of procrastination, effective management of time and tasks, sleeping time, environment restructuring and reduction of distractors, identification of specific task-oriented strategies assigning achievement to one's own actions, among others (Zimmerman, 2013; Zimmerman et al., 2017). Thirdly, an important part of the intervention was carried out through video recordings on the online platform Flip, which, together with being a vehicle to convey content and strengthening English oral skills (Öztürk and Çakıroğlu, 2021), became a virtual space for interpersonal relationships and interaction under the safe environment of academic material, as also evidenced in studies by Cherng-Jyh et al. (2022), Maluenda-Albornoz et al. (2022), and Contreras et al. (2023).

According to the above, the intervention fostered SRL awareness, the application of SRL strategies in their discipline under ERT, and oral interaction with peers through video exchange. Consequently, oral practice, which arguably contributes to the development of speaking skills, was assured in terms of time and dedication from participants —an aspect that had been negatively affected the previous cohort because of COVID-19. In this way, the intervention mimicked normal classroom conditions of face-to-face communication, including the receptive skill of listening and the productive skill of speaking.
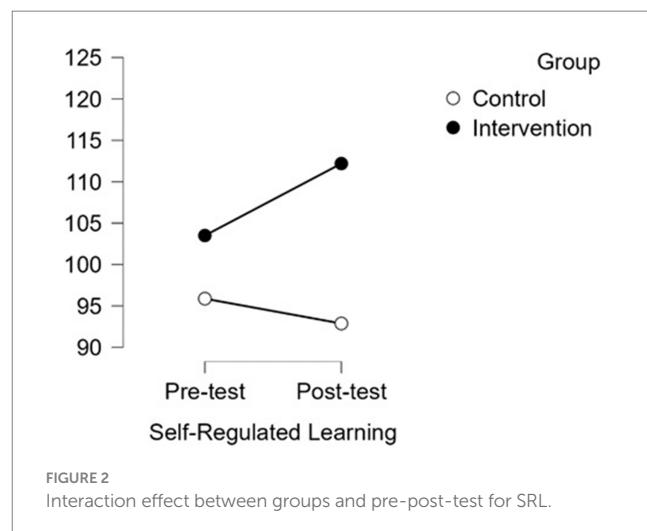
TABLE 8 Between-subject effects for engagement.

Cases	Sum of squares	df	Mean square	F	p	η^2	η^2_p
Group	1347.158	1	1347.131	5.179	0.027	0.044	0.058
Residuals	21297.336	68	259.732				

Interaction effect between groups and pre-post-test for SRL.

TABLE 9 Post-hoc comparisons: group engagement.

		Mean difference	SE	t	Cohen's d	p_{bonf}
Control, Pre-test	Intervention, Pre-test	−3.111	3.689	−0.839	−0.237	1.000
	Control, Post-test	10.067	3.411	2.949	0.761	0.025*
	Intervention, Post-test	−1.259	3.682	−0.344	−0.096	1.000
Intervention, Pre-test	Control, Post-test	13.155	3.690	3.565	0.989	0.003**
	Intervention, Post-test	1.855	1.652	1.116	0.141	1.000
Control, Post-test	Intervention, Post-test	−11.331	3.642	−3.059	−0.859	0.013*

*$p < 0.05$; **$p < 0.01$.
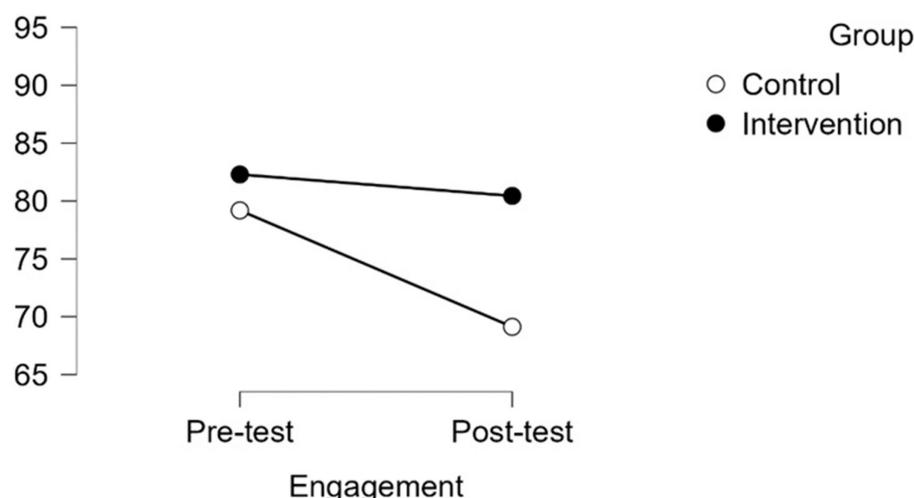
FIGURE 3
Interaction effect between groups and pre-post-test for engagement.

5.2 To what extent does engagement increase after the implementation of an intracurricular intervention aiming at SRL development?

Regarding engagement level, results showed a significant decrease in the control group, with it going down over the course of the academic term. While, on the other hand, even though the intervention group also decreased their engagement in the post-test compared to the pre-test, they did so only slightly since that difference was not significant (Fredricks and McColskey, 2012). These findings would be reflective of the intervention not being effective to improve engagement level, however, it could also be seemingly acting as a protective factor on motivation during the harsh conditions of ERT (Avila and Genio, 2020; Quang et al., 2022).

These results on engagement appear to be quite valuable. Though the pedagogical strategy was designed to improve SRL, the team of researchers also expected a motivational effect coming from the active-participative learning experiences involved in it; plus, the features associated to technology, which would raise enthusiasm and create connectedness among students, as found by Baber (2022) and Li et al. (2022). For this reason, even when the strategy failed to improve engagement, it succeeded in maintaining consistent motivational levels throughout the academic term (Avila et al., 2021). Since this decrease was modest, it might be argued that the pedagogical intervention served the said purpose, too. This becomes more apparent when we observe the dramatic decline in engagement level in the control group, as revealed in the post-test.

In addition, the intervention seemed to have a positive impact on attendance, actual class participation, and amount of asynchronous work effectively carried out by students, based on online analytics and monitored work by professors. These engagement indicators might be considered as evidence of behavioural change and might suggest a positive effect on motivation as well. These findings are in line with those reported in similar studies (Qutishat et al., 2022). The researchers could also experience firsthand learners' willingness to engage actively in lessons and tasks, as well as their positive evaluation towards the overall experience. In the same vein, self-assessment and content analysis of their entries from video submissions revealed that several elements from the intervention were positively perceived by learners, such as, the utility of a planner for effective time management, the significance of receiving timely positive and corrective feedback as a motivating factor to make progress and attain objectives, and the use of the oral medium as a vehicle to collectively reflect and strengthen SRL, while developing English speaking skills (Contreras et al., 2023).

It seems that the students' participation in a well-organized intervention, embedded in the course syllabus contents, was crucial to encourage them to take control of their learning and assume agency over their academic duties, which, in itself, was motivating for them. From the researchers' perspective, the intervention consisted of a series of activities that added varying degrees of complexity, demanding students to engage in elaboration at various levels. This could have had a negative effect on their motivation, however, this was not the case, as engagement was maintained throughout the course. Thus, the results suggest that this might be evidence of the protective effects of a well-designed and systematic teaching-learning strategy on students' motivational states, as the one applied in the study.

6 Conclusion

The challenging circumstances faced by undergraduate students in the context of ERT emphasized the need for effective strategies to enhance their autonomy, competence, and satisfaction with learning, as well as their sense of connection with instructors and peers. The curriculum-integrated intervention designed by the researchers effectively armed students with essential SRL competencies, which was reflected not only in the quantitative results of increased SRL levels, but also in learners' positive disposition towards academic work. This assertion comes from learners' active participation, attendance, completion of tasks and their own overall positive appraisal of the experience expressed through self-assessment and video reflections (Contreras et al., 2023).

It can be concluded that purposeful systematic training on SRL, such as the intervention framework presented in this study, results in positive outcomes in university students' academic life, and serves as crucial foundation to foster self-discipline and self-efficacy. EFL learners who are taught SRL strategies develop skills and acquire tools that are likely to enhance their performance and empower them to face complex challenges, to adapt to unusually demanding learning environments and to cultivate commitment to self-directed learning.

By examining the aspects above, this research attempts to contribute to the understanding of the impact of SRL instruction in higher education within a specific framework aimed at an EFL undergraduate level within the setting of confinement during the COVID-19 crisis.

6.1 Implications and limitations

Despite the limited number of participants, this research offers several insights about SFL instruction that can be applied to Chilean higher education. The chief aspect that stands out is the necessity for carefully planned methodologies that incorporate the development of SRL metacognitive skills as a foundational ground, particularly when students require an array of resources for autonomous work in the absence of traditional in-person instruction. Promoting SRL is a valuable teaching endeavour, as self-regulated learners are likely to apply these strategies across courses, enabling them to develop essential SRL tools to succeed academically and progress in contexts that demand initiative and continuous improvement in their learning path.

EFL learners could greatly benefit from this instructional approach since systematic practice in L2 requires the deployment of SRL-related strategies and skills for students to become competent language users. The communicative nature of language courses in EFL settings, where speaking skills represent the most visible aspect of proficiency (McDonough and Shaw, 2003), is a natural fit for the application of SRL features as explored in this study. With this model, SRL strategies and speaking competence became intertwined and mutually beneficial, as students could develop their ability to self-regulate their learning while simultaneously improving their speaking proficiency and, in turn, maintaining motivation and willingness to learn. This may be seen as a synergistic process where SRL instruction and the enhancement of speaking skills would mutually reinforce each other. Thus, EFL approaches could greatly benefit from this symbiotic relationship in course design where SRL becomes a backbone for language practice and acquisition.

Active methodologies and technological tools may have played a crucial role in gathering high participation and involvement in the study. Particularly, task completion and the promotion of metacognitive skills, such as progress monitoring and video-based self-reflection are noteworthy practices to make sense of learning experiences, and then take action (Li and Peng, 2018). In addition, when reflection is carried out in oral mode, immediately after students have been presented with new information, as was done in this intervention (Tochon, 2013; Cowan, 2019). For instructors, reflections expressed by learners may offer an eye-opening experience as students' insights on pedagogical matters not only foster a closer bond, but also serves as a stimulus for improving teaching practices.

One element that appeared somewhat redundant in the intervention design was the inclusion of open-ended questions in the weekly self-assessments, as some responses gathered through this instrument closely duplicated reflections submitted in the weekly videos. Overloading students with non-essential tasks could be discouraging and may hinder systematic record keeping. Additionally, collecting excessive data without the capacity to process it effectively can become an overwhelming activity for professors. Together with this, the repetitive nature of some tasks over a 10-week period may have resulted in reduced enthusiasm among students, which may help explain the maintenance in engagement level, rather than an increase. Also, when planning similar interventions is important to consider the idiosyncratic nature of students' engagement and self-regulation. Each learner may have different motivations and initial competencies which will influence their disposition towards the task interventions. Also, as this study was done in a ERT context, future endeavours should aim to replicate this design in face-to-face contexts.

Finally, regarding measurement, this research used a combined measure of two scales: the Self-Regulated Learning Practices Scale and the Self-Efficacy Questionnaire for self-regulation, without precedent. The reason for this combination was to include different indicators (items) in the same measure, considering both cognitive and behavioural components to obtain a better understanding of this variable. This implies a limitation because the new measure was not psychometrically tested before its use. Consequently, the analysis of the results must account for this limitation.

Data availability statement

The original contributions presented in the study are publicly available. This data can be found here: https://doi.org/10.6084/m9.figshare.26300194.v1.

Ethics statement

The studies involving humans were approved by Ethics, Bioethics and Biosafety committee, University of Concepción. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RO-T: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. YC-S: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. CS-C: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Supervision, Visualization,

Writing – original draft, Writing – review & editing. JM-A: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. CP-V: Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. AQ-E: Formal Analysis, Investigation, Writing – original draft, Writing – review & editing.

Funding

Acknowledgments

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The digital aspects of the wellbeing of university teachers

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Introduction: In the past few decades more and more studies have put the mental health and wellbeing of university lecturers in the limelight, especially considering the fact that lecturers' scope of responsibilities have been significantly transformed and expanded as a result of the massification and diversification of and structural changes in higher education. These changes intensified the workload, already rather high, thus negatively affecting lecturers' wellbeing. It is worth investigating how the increasingly marked presence of digital technologies affects the characteristics of teachers' workload. In this study, we intend to investigate the impact of digitization on the various areas of workload and work activities of university lecturers at a large university with many faculties, on the one hand, and teachers of institutions teaching in minority languages, on the other.

Methods: The online questionnaire compiled and based on the findings of our previous qualitative study was completed by teachers at one of Hungary's biggest universities, the University of Debrecen, and lecturers at other institutions of higher education providing for the Hungarian ethnic minority across borders and affiliated with the University of Debrecen, altogether 596 people. The database created obtaining the data was named Central and Eastern European Teachers in Higher Education (CEETHE, 2023), IBM SPSS 29 software was used to analyze the data.

Results: Digital technology plays a basic role in lecturers' work. Its importance is shown by the fact that the majority of respondents (54%) experiences significant or very severe stress in connection to technological problems. The majority of time spent with digital devices is included in working hours, so these technologies play a prominent role in dissolving the boundaries between professional and private life. Furthermore, many people find their use more exhausting than mental work performed without relying on them.

Conclusion: By continuously developing the digital competency of university lecturers it is possible to mitigate the stress triggered by technological problems as well as reduce screen time. It is necessary to ensure that institutions of higher education introduce policies that ensure work-life balance for teachers.

KEYWORDS

wellbeing, university instructors, digital technology, comparative research, online survey

1 Introduction

People have always worked hard to live well, to live happier. How to make this a reality, however, the answer is unclear, since one can think about happiness in many ways, it has just as many definitions. In order to define the term, various authors multiple times stretched back all the way to Aristotle, who had already differentiated between two definitions of happiness –hedon and eudaimonia (Aristotle, 1975). Since then, the concept of happiness has generated many debates (Besser, 2020; Greve, 2023) and can be classified as "chaotic concepts" (Renz, 2021), the only consensus being that it is a multidimensional concept. However, the number and content of the dimensions vary greatly between authors (see Haybron, 2000; Seligman, 2011), sometimes with conspicuous differences.

Such diversity might also be owing to the fact that the number of surveys and studies on happiness has increased by leaps in past decades. The concept and interpretation of happiness has become even more diverse in the professional literature, further complicating the traditional view; for instance, some authors often identify happiness with subjective wellbeing (Veenhoven, 2004; Jayawickreme et al., 2012), despite the fact that they are two different concepts. Nonetheless, this link already shows that wellbeing – just like happiness – does not have a widely accepted definition. According to authors Kun and Szabó, wellbeing is a complex umbrella concept, which has many measurable elements. "Each of these elements is a component of wellbeing, but none of them can define it alone" (Kun and Szabó, 2017, p. 282). The confusion is further exacerbated by the fact that the authors use the terms wellbeing, quality of life and welfare as synonyms on more than one occasion (Weijers, 2020; Ciziceno, 2022). It is no surprise therefore that studies investigating the quality of life resulted in more than 1,200 measurement tools by the mid-1990s (Stone et al., 2020). This relatively high number is in part attributable to fact that many of these researchers had not developed their own theoretical or empirical frameworks for their research (Claes et al., 2012), but only reinterpreted a previous approach. As a result of all this, Schalock and Alonso already identified more than 200 definitions related to wellbeing and quality of life in 2002 (Schalock and Alonso, 2002), and the number has increased significantly since then.

Perhaps the most renowned definition of subjective wellbeing is attributed to Diener (1984), who defines the concept of wellbeing by three factors: life satisfaction (LS), positive affect (PA), and negative affect (NA). In this sense, in addition to a general satisfaction with life, wellbeing requires a high level of positive emotions and a low level of negative emotions. Based on this approach, several measurement tools were created (e.g., The Satisfaction With Life Scale – Diener et al., 1985; The Scale of Positive and Negative Experience, The Flourishing Scale – Diener et al., 2010) that mark various components of subjective wellbeing. Measures with good psychometric properties related to the scales are mostly based on the frequency of the different emotions experienced. In our ever-accelerating world, these feelings often alternate at the speed of light, and the concept of wellbeing is less and less linked to a single specific situation (Wright and Cropanzano, 2000), but is rather characterized by a dynamic, fluid state (Robertson and Flint-Taylor, 2008). Digital technologies play a crucial role in these rapid changes, as they can trigger very high and very negative emotions almost at the same time. That is why in this study we provide a very broad interpretation of the concept of wellbeing. Starting out from Dodge et al.'s definition, according to which wellbeing is "the balance point between an individual's resource pool and the challenges faced" (Dodge et al., 2012, p. 230). Based on this, a state can be considered a stable state of wellbeing where the individual has the psychological, social and physical resources they need to meet a given challenge, so resources and challenges are in balance.

1.1 Teacher wellbeing

One of the most quintessential parts of wellbeing studies is looking into workplace wellbeing. Not only is this because employees spend approximately one third of their day at their workplace, but also the emotional and social experiences they collect while on the job later have an effect on them (Kun and Gadanecz, 2022). It is for this reason that we must get to know the characteristics of workplace wellbeing, for it helps us understand the ingredients that influence their health, job execution and work performance.

Every employer must be aware of the fact that their employees' mental health and wellbeing are integral factors in the performance and success of the institution (Page and Vella-Brodrick, 2012). Workers with lower wellbeing level are less productive, they more often make bad decisions, are more often absent from work, and they contribute to the institution's performance in a decreasing amount (Price and Hooijberg, 1992). Those with higher wellbeing better handle the stressful results (Wood and Joseph, 2010), are more easily motivated, have more positive workplace relationships, and are more satisfied with their work (Salas-Vallina et al., 2021). Beyond this, there is a clear tie between workplace wellbeing and performance, which is particularly true of such complex, demanding, and creative work, like teaching and researching (Krekel et al., 2019).

Empirical evidence shows that in school teachers are the most important factors that help along student success, satisfaction, and performance (Stronge et al., 2004; Barber and Mourshed, 2007). Therefore, teachers' workplace happiness and wellbeing are critical factors for a positive classroom environment and successful instruction. We read in the 24th point of the Council of the European Union's document regarding Europe's future teachers that: "The wellbeing of teachers and trainers influences their job satisfaction and enthusiasm for their work, and has an impact on the attractiveness of their profession, and subsequently on their retention in the profession. It is an important factor in quality and performance, correlating with their own motivation and with the motivation and achievements of their learners." (Council of the European Union, 2020, p. 16).

Appropriate to the significance of the topic, the wellbeing of teachers is set at the center of researchers' tests at an ever-increasing rate, where these researchers, in a multitude of ways, focus on teachers' personal, environmental, and relational factors (Brouskeli et al., 2018). The varied approaches almost naturally entail diverse definitions of teacher wellbeing. In the interest of harmonizing these definitions and being able to execute international studies on the topic, the OECD took up the task of forming an overarching model and concept framework about teacher wellbeing. In the document published in 2020, teacher wellbeing was defined as "teachers' responses to the cognitive, emotional, health, and social conditions pertaining to their work and their profession" (Viac and Fraser, 2020, p. 18). In this paper, we start from this definition.

The framework of teacher wellbeing formed in the course of the work laid out four critical areas: (1) cognitive wellbeing, (2) subjective wellbeing, (3) physical and mental wellbeing, and (4) social wellbeing (Viac and Fraser, 2020). Cognitive wellbeing refers to the set of skills and abilities that teachers need to work efficiently. Included in this is a particularly important factor: the extent to which teachers are able to learn new information and the extent of their self-efficacy and belief in their performance abilities. These beliefs influence how much energy they invest in their work, how persistent they are, and how much stress they take up. All of these have an impact on their educational practice, enthusiasm and commitment (Dreer, 2021; Bardach et al., 2022; Shu, 2022). OECD defined subjective wellbeing based on Diener's work as follows: "Good mental states, including all of the various evaluations, positive and negative, that people make of their lives and the affective reactions of people to their experiences" (OECD, 2013, p. 10). Teachers make contact with other persons on countless occasions: their students, the parents of those, their colleagues, the school management, different professionals, etc. Social wellbeing refers to the frequency, quality and depth of these interactions. The characteristics of keeping contact with others can have positive and negative impacts on the wellbeing of teachers. The conduct of students, an enjoyable session of further education, the support of colleagues and the management or, conversely, the lack of those things, have great influence on the practice of teachers and their work satisfaction (McCallum et al., 2017).

Of the four areas, the physical and mental wellbeing are where most of the problems lie, particularly that teachers suffer from more psychosomatic disorders than other groups (e.g., sleep-or memory impairment) (Scheuch et al., 2015), and stress caused by school was also measured to be high. The former is in no way a surprise, after all, teaching has been for a long time been counted among the most stressful professions (e.g., Travers and Cooper, 1993; Johnson et al., 2005). What is more, the stress factors hardly change, among the most substantial problems were and still are great workloads, lack of balance between work and private life, restricted autonomy, and excessive administrative commitments (Mercer and Gregersen, 2020). Based on the Wray and Kinman (2021) study carried out in higher educational institutions, the fact that the majority of those asked (71%) held that the wellbeing of the staff is not a priority for the university (71%) could play a role in mental overloaded-ness, what is more, three quarters of respondents thought that asking for help as a result of stress or mental health problems would directly impact their careers in a negative way (Wray and Kinman, 2021). In light of all this, it comes as so surprise, the stress level of teachers is continuously rising. According to one study, 72% of respondents said that they have experienced some sort of mental health problem in the past year (Savill-Smith, 2019).

The outbreak of the COVID-19 pandemic at the start of 2020 caused the situation to further deteriorate, the transition to the emergency distance learning practically caused the stress-and anxiety of teachers to drastically rise (Besser et al., 2020; Li et al., 2020). The pandemic completely changed the relationship teachers had with digital technology as well. Independent of prior attitudes and individual practices, this blight made the intensive application of technology mandatory for everyone. With the cessations of closing schools, the need to use tech stopped, but the expectation to use digital solutions in in-class (contact) teaching rose to a level beyond that of earlier. The effects of this process of change on teachers' wellbeing are

not yet known, but it seems doubtless that digitization has a double impact on mental, physical, social and emotional health (Passey, 2021).

In the past decades more and more studies focused on the mental health and wellbeing of university lecturers, especially since the responsibilities of teachers have changed due to the massification of higher education and its shift toward the service industries (Kinman, 2014). The development of new training curricula as well as the related assessment systems, including the new challenges involved in lecturers' performance evaluation, increased teachers' already high workload. This is a significant problem because, as former investigations into university lecturers' overload have shown, overload at the workplace has several deteriorating effects (Kinman and Johnson, 2019). For instance, it has a negative connection to teachers' performance (Janib et al., 2021), it is a significant risk factor for psychological health (Hobson and Beach, 2000), has a negative impact on work-life balance (Franco et al., 2021) and is a predisposing factor for a negative perception of wellbeing (Pace et al., 2021).

The appearance and swift spread of digital technologies presented teachers with new challenges. Many forecasted that new technologies will alleviate teachers' workload because they will facilitate a quicker completion of repetitive, time-consuming tasks and fasten communication and cooperation (Potter et al., 2022). However, today we have accumulated empirical evidence to show that rather than alleviating workload digital technologies are prone to increase them (Facer and Selwyn, 2021). On the one hand, they extend the timeframe of work, thereby increasing the amount of work to be done (Pollock and Hauseman, 2018). On the other hand, the deployment of new devices and programs continuously require teachers to acquire new knowledge and skills, which also increases workload (Haleem et al., 2022). To sum up, the continuous spread of digital technologies plays a role in both decreasing and increasing teachers' workload (McCallum et al., 2017).

As researchers of the Centre for Higher Education Research and Development (CHERD-H) at the University of Debrecen, we set ourselves the goal of getting to know the characteristics of the wellbeing, working conditions and productivity of university lecturers. Since the balance point between an individual's resource pool and challenges faced (Dodge et al., 2012) easily tilts, in our study we examined many factors related to the wellbeing of teachers, from sports habits to cultural consumption, from issues of higher education and pedagogy to stress factors. In this study, we intend to investigate the impact of digitization on the various areas of workload and work activities of university lecturers at a large university with many faculties, on the one hand, and teachers of institutions teaching in minority languages, on the other. Differences between genders and age groups are also mapped, because the findings related to groups formed according to these criteria are often contradictory. Certain studies (e.g., Guillén-Gámez et al., 2021) prove that there are no differences between the use of digital technology by male and female university lecturers, but other studies (e.g., Bandrés et al., 2021) identify several deviations. Findings based on respondents' age groups are also not clear, because in some previous research projects no differences were found between younger and older respondents (e.g., Inamorato dos Santos et al., 2023); however, other studies (e.g., Mora-Cantallops et al., 2022) measured a significant difference between the characteristics of teachers of different age groups.

We asked questions regarding each of the four areas of teacher wellbeing (Viac and Fraser, 2020). For the most problematic area,

physical and mental wellbeing, we examined workload and work-life balance. In terms of cognitive wellbeing, we inquired about methodological development. Regarding subjective wellbeing, we examined the perception of activities performed with digital tools. In terms of social wellbeing, we investigated different aspects of digital communication.

2 Methodology

2.1 Data and procedure

In the first phase of our research, in 2022, we conducted seven focus group interviews online with Hungarian-speaking teachers from higher educational institutions in Hungary, Transylvania, the Partium, Transcarpathia, the Uplands and Vojvodina ($N = 41$). The interviews investigated a broad scope of factors influencing the work of the lecturers, the various stressors and the available resources. Among the findings, it stands out that the institutional environment, appropriate infrastructure, including functioning technology, and continuous and efficient communication are key factors in terms of teachers' productive work and wellbeing (Kovács et al., 2024). In order to investigate the various factors more keenly using a broader sample, after analyzing and processing the interviews we compiled the online questionnaire that forms the basis of this research[1].

Basically, the questionnaire formulated closed questions, primarily 4- or 5-point Likert scale questions, but we also used nominal or ordinal scale questions. We created different question groups, examining the workload of the lecturers (5 questions, Chronbach's $\alpha = 0.723$), and how much they consider different activities (e.g., research, publishing) as their responsibilities in addition to teaching (14 questions, Chronbach's $\alpha = 0.803$). The wide scope of activities also raises the question of how it is possible to establish and maintain the a work-life balance, which was also examined through several questions (10 questions, Chronbach's $\alpha = 0.883$). The performance of various tasks very often requires digital communication (3 questions, Chronbach $\alpha = 0.704$) and an increasingly intensive use of digital tools (7 questions, Chronbach $\alpha = 0.737$). Therefore, we investigated these areas, too.

The research focused on teachers at one of the biggest universities in Hungary, situated in a disadvantaged region, the University of Debrecen, on the other hand, we intended to examine the teachers of minority Hungarian higher education institutions across borders linked to the University of Debrecen, too. The idea behind this was to map any differences that might be detected in the characteristics of target groups despite the common basis of the mother tongue.

In order to ensure that the study yields representative data, we strove for a sampling rate of at least 10% per institution, but in the case of the University of Debrecen, the target was the same value per faculty. We sent the link to the online questionnaire to all lecturers of the institutions under survey in the spring of 2023 after obtaining permissions from the heads of the institutions, thus ensuring probability sampling. Each institution was sent two letters of invitation, but institutions with a proportion of respondents under

10%, a third letter was sent out to the lecturers of the relevant faculties. Such a letter was only necessary in the case of two faculties at the University of Debrecen, but in the end here as well the target percentage was reached, and final completion rate for the entire institution amounted to 16%. We achieved much higher rates in the minority higher education institutions across the border, which was primarily due to the fact that the staff of certain institutions was rather low, in several cases under less than 50 people. The database created obtaining the data was named Central and Eastern European Teachers in Higher Education (CEETHE 2023). IBM SPSS 29 software was used to analyze the data, employing Chi-Squared test, Mann Whitney test, Wilcoxon test and One-way ANOVA test.

2.2 Participants

After completing the questionnaires, the responses of 596 respondents were included in the database created for data cleaning. The greatest amount of responses ($n = 356$) came from the largest institution, the University of Debrecen. In the case of Hungarian minority higher educational institutions across the border, the numbers and institutions were as follows: Romania's Babes-Bolyai University, Emanuel University, Nagyvárad State University, Partium Christian University and Sapientia Transylvanian Hungarian University ($n = 113$); Serbia's Technical College of Subotica and the University of Novi Sad ($n = 40$); Slovakia's University of Eperjes and János Selye University ($n = 35$); and Ukraine's Ferenc Rákóczi II Transcarpathian Hungarian College and Ungvár National University ($n = 52$).

Throughout the course of the data processing, not only in area did we divide our respondent pool into two subgroups (those from Hungary and those across the border), but also we took into account gender and age. At the University of Debrecen and the cross-border institutions, the gender division of teachers was quite varied. Among respondents from Debrecen, the ratio of the two genders was practically identical (50.1% men; 49.9% women), while, among foreigners, women were significantly overrepresented (39.6% men, 60.4% women). This disproportion is first of all due to the fact that the cross-border institutions involved in the study were usually engaged in some level of teacher training program, which based on the type of training (similar to public education) had markedly more women participating as teachers. Our respondents were separated into three subgroups according to age (average age 45.25 years; SD = 10.25), since it was often possible to show generational differences regarding the use of digital technology. These three age groups were as follows: younger than 40: (187 persons- 32%), 40–49 year olds (206 persons – 35.2%), and older than 49 years (192 persons – 32.8%).

3 Results

First, we examined the workload of university teachers (Table 1), which, based on more research, belongs among the basic sources of stress. During our study, based on the answers of the respondents, they are undoubtedly overburdened, with only 25% of them stating that on an average week they work for about 40 h of work (the official amount of hours to be worked). Everyone else testified of higher working hours than this, a quarter of respondents saying that they

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1 https://evasys.unideb.hu/evasys/online.php?p=5EZUT

TABLE 1 The weekly workload of respondents.

Hours		University of Debrecen	Foreign	Man	Woman	Total sample
36–40	Person	70	78	48	96	148
	%	19.7%	32.9%	17.7%	30.5%	25.0%
41–45	Person	82	72	73	80	154
	%	23.1%	30.4%	26.9%	25.4%	26.0%
46–50	Person	93	41	61	73	134
	%	26.2%	17.3%	22.5%	23.2%	22.6%
51–55	Person	51	30	52	29	81
	%	14.4%	12.7%	19.2%	9.2%	13.7%
56–60	Person	38	9	19	27	47
	%	10.7%	3.8%	7.0%	8.6%	7.9%
>60	Person	21	7	18	10	28
	%	5.9%	3.0%	6.6%	3.2%	4.7%
Total	Person	355	237	271	315	592
	%	100%	100%	100%	100%	100%

Source: CEETHE 2023 database.

work 50 h a week. Men respondents work significantly ($p < 0.001$, Cramer's $V = 0.224$) more (mean = 47.3 h at mean intervals) than women (mean = 45.4), and teachers at the University of Debrecen (mean = 47.4) are more burdened with workload ($p < 0.001$, Cramer's $V = 0.222$) than their colleagues across borders (mean = 44.6). At the same time, among the various age groups, there is no difference in this regard.

One of the important jobs of teachers in higher education is teaching. Due to changing expectations and circumstances, it is needed to continuously try and implement new and innovative teaching methods. Our respondents understand these expectations, the majority (85.9%) completely or for the most part see this development as their job. Women identify with this task far more (89.9%) than men (80.1%) ($p < 0.001$, Cramer's $V = 0.226$), and it is also a noticeable difference among the age groups ($p < 0.003$, Cramer's $V = 0.130$): in contrast to the general assumption, the oldest age group (those above 50) consider it their job to try out the new teaching methods (90.5%).

In this renewable process, digital devices and solutions play an ever-increasing role which can appear in every type of class. The majority of our respondents use digital devices in every or almost every class they hold. After examining the subgroups, it was only among the Debrecen and cross-border respondents that we found the question significant ($p = 0.005$, Cramer's $V = 0.264$), and difference (Table 2), more frequent than the Debrecen teachers' use of devices during lectures. In other types of classes, the level of technology use was already lower, but, almost a quarter of teachers doing field training (24.2%) utilize digital devices in every class type.

The problems connected to digital devices that appear during teaching can cause quite unpleasant moments for the teacher, especially, if these devices play an integral role in the make-up and the execution of the class. It is for this reason that we asked our respondents, to what extent they consider the moment stressful when their devices do not work as expected? Most of those who filled out the survey (54%) considered such times significantly or very heavily

TABLE 2 How often do they use digital devices during lectures?

		University of Debrecen	Foreign	Total
I do not use digital devices at all	Person	4	3	7
	%	1.2%	1.3%	1.2%
Rarely	Person	7	17	24
	%	2.1%	7.3%	4.3%
In half the classes	Person	9	13	22
	%	2.7%	5.6%	3.9%
In most classes	Person	57	48	105
	%	17.2%	20.7%	18.7%
All the time	Person	254	151	405
	%	76.7%	65.1%	71.9%
Total	Person	331	232	563
	%	100%	100%	100%

Source: CEETHE 2023 database.

stressful. Of the subgroups, only the men and women gave differing statements ($p = 0.037$, Cramer's $V = 0.233$), the total of women experienced these happenings in a more negative way (Table 3.).

One of the special modes of the teaching application of digital solutions and of information and communication technologies (ICT) is online teaching. Near two thirds (64.2%) of respondents view the planning and creation of a learning-teaching environment as their job, though it is possible to see significant difference between the subgroups ($p < 0.001$). The cross-border teachers (73.1%, Cramer's $V = 0.223$), as well as the women (69.8%, Cramer's $V = 0.221$) consider this task more to be their own, than the teachers of the University of Debrecen (58.2%), and the men (56.9%). Among the three age groups,

TABLE 3 To what extent do you consider stressful the situation when digital devices do not work in class?

		Man	Woman	Total sample
It does not stress me at all	Person	21	17	38
	%	8.0%	5.4%	6.6%
It does not stress me so much	Person	50	38	88
	%	18.9%	12.0%	15.2%
It does and does not stress me	Person	65	76	141
	%	24.6%	24.1%	24.3%
It stresses me	Person	105	141	246
	%	39.8%	44.6%	42.4%
It is very distressing	Person	23	44	67
	%	8.7%	13.9%	11.6%
Total	Person	264	316	580
	%	100%	100%	100%

Source: CEETHE 2023 database.

however, the middle group (40 year-olds) members identify most (68.2%) with the task. It is worth highlighting that at our respondents' workplaces their full-value work in distance learning with digital support is only recognized to a small extent (35.5%), thus, these percentages can be seen as expressly high.

Digital devices are naturally not only used in the classroom by respondents, but for other purposes as well. As a result, this is a rather frequent activity for 75.2% of respondents to use their devices for at least 5 h a day on average. Furthermore, 22.8% of those who filled out the survey partake in this activity for more than 8 h per day. Thus, the average time spent using technology is 5.9 h. In fact, there is no difference in the length of time of usage for employees in other countries, neither among men and women, nor among age groups. This value is equally high for all subgroups. Regarding using technology during the week, difference only appears between Debrecen and cross-border respondents in that the time spent in front of a screen for work is far higher in the previous group. Altogether 53.4% of people from Debrecen, 43.2% of respondent cross-border citizens stated that ($p = 0.013$, Cramer's $V = 0.257$) three quarters of the time spent with digital devices was used to carry out tasks for work. This changes when it comes to the weekend, and not just in the fact that our respondents spend a good 2 h less (3.8 h) in front of the computer. The screen time of men on the weekend (4.1 h) is on average a half hour more than that of the women ($p = 0.041$, Cramer's $V = 0.241$), while the women sit down to the computer for work in a greater ratio than the men ($p = 0.044$, Cramer's $V = 0.140$). Among the three age groups variation was also found: on the weekend, the oldest group spends far more time with digital technology for work, than with the younger group ($p = 0.004$, Cramer's $V = 0.150$). While 34.3% of those above 49 years of age spend three quarters of their screen time with work, this ratio of doing work is typical of only 16.2% of the younger group (younger than 40).

For university teachers, doing work not only refers to teaching. An equally important expectation of them is publishing in ever-increasingly prestigious journals and with highly listed publishers. The

youngest group ($p = 0.04$, Cramer's $V = 0.106$) feels that this is a rather overwhelming expectation (51.1%), the same, for the older generation, is not such a frustrating feat (37.7%). The difference between the genders, however, shows that more teachers from the University of Debrecen (46.2%) feel greater pressure ($p = 0.007$, Cramer's $V = 0.187$) to publish than the cross-border teachers (42.6%). The interiorization of external expectations, however, varies in amount and direction in these two groups. The Debrecenians (59.9%) consider it more their job than the cross-border teachers (43.5%, $p < 0.001$, Cramer's $V = 0.211$) to publish in Q/D-level journals and in international foreign language volumes. Regarding publishing in the mother or state tongue, however, the situation is flipped ($p < 0.001$), with the foreign teachers identifying in greater number (49.4%) with the task than Hungarians (39.8%).

Digital technology also has an impact in this area. Our respondents in large part (57.2%) or fully agree with the statement that with the help of digital technology they can more easily meet scientometric expectations. Of the 596 respondents only 19 (3.2%) disagree with this postulate, the majority of whom work in the natural sciences or medical departments.

Using digital technology for work (as we previously saw with the majority of our respondents) has advantages, first, if the work done with the help of technology is less cumbersome than its traditional form. A third of our respondents (34.6%) think this, and many (39.5%) cannot decide if there really are any positive impacts on work. However, 30.7% of cross-border teachers hold that activities conducted through technological tools is more exhausting than doing the intellectual work without them. In contrast, among the Debrecen respondents significantly fewer ($p = 0.015$) teachers share this opinion (22.6%).

The amount of time spent working and using devices shows that the work and private lives of our respondents have to some extent blurred together. And we examined what role, according to opinion and testimony, tech devices have to play in this. According to a third of the teachers (32.7%), there is no such relationship, or the effect is only minute. Another (neigh) third (30.6%) said that the tie is doubled, that is unclear. The third of respondents (36.7%), however, stated that digital devices play a significant role in the amalgamation of work and private life. It may come as somewhat of a surprise, but among the subgroups formed by gender or age there is no difference in the judgment of the examined effect. Yet, the foreign respondents, more than the employees of the University of Debrecen, consider the role of devices in the blurring of work and private life more significant ($p = 0.012$, Cramer's $V = 0.248$) (Table 4).

Taking into consideration the long screen time and the aforementioned analyzed role of digital technology, the question arises, to what extent can our respondents easily find the balance between offline and online activities? Nearly a quarter of interviewees (26.8%) think that this is not too difficult a task, a third (34.2%) say that it is not at all or not very easy. Though there is no difference between the age groups as regards the amount of time devices are used, for the oldest group creating a balance is somewhat easier ($p = 0.036$, Cramer's $V = 0.219$), among them 32.4% either completely agree or simply agree with the statement.

Using these devices greatly sped up and intensified communication. There is no need to wait for days or even weeks for a reply letter to be sent by post, as was the custom several decades ago. What is more, there is no need to wait for in-person meetings, any thoughts and happenings can be shared with friends through a chat

or short text message. It is not entirely necessary to respond to these messages or received emails right away, especially in a very stressful situation, where it would be better to respond more thoughtfully and calmly at a later date. For our respondents, however, only 31.9% agree with the statement that digital technology's asynchronous communication makes solving the problem more thoughtful, thus decreasing stress levels. Though the cross-border teachers and those over 50, in considerably greater numbers, think this way (35.1%, $p = 0.04$, Cramer's $V = 0.230$; also 37.6%, $p = 0.032$, Cramer's $V = 0.221$), altogether this does still mean that the interviewees do not feel the stress-lowering effect in connection with asynchronized digital communication.

During the course of our previous interview test, many vocalized, regarding the communication effect of digital technology, that multiple times they receive emails that are content-wise incomplete, and stylistically inappropriate. In contrast, our respondents' majority

(47.2%) said that students are able to communicate digitally with teachers in the appropriate manner. Almost a third of those asked (30%) could not clearly convey their opinions on the question, and only a fifth (22.8%) think that student communication is inappropriate. What is surprising is that while 30.8% of the youngest respondent age group (those under 40) are dissatisfied with student digital communication, 21.9% of 40 year-olds and 15.9% of 50 year-olds share this feeling ($p = 0.003$).

Among the effects of digital communication is the phenomenon that not only students, but also colleagues and leaders can more easily and more quickly reach teachers in higher educational institutions. However, this continuous availability can be bothersome to them, 49%, almost half, of respondents considered this irritating, and only a few (5.8%) viewed it as no problem at all.

Finally, we posed an overarching question to the teachers regarding using digital technology in higher education. Almost all of those asked thought that they could not imagine higher education without digital technology. However, interestingly, four persons (from separate fields) completely rejected the statement. Their answer was especially surprising because they personally used this technology several hours a day, while, with the exception of one colleague (from the music faculty), most also used it in their classes. Regarding the subgroups (Table 5), it can be said that the teachers of the University of Debrecen ($p < 0.001$, Cramer's $V = 0.277$), and men ($p < 0.013$, Cramer's $V = 0.148$) agreed with the tested statement in greater numbers than the cross-border teachers and women.

4 Discussion

Using digital tools and solutions is not only an opportunity for teachers but also somewhat of a requirement, a compulsion even. As a result, they have to transform and modernize their previous solutions and methods, on the one hand, and on the other, they have to launch a permanent learning process, given that digital tools are constantly changing, developing, and new inventions and programs appear, while knowledge of these can only be achieved through continuous self-education. Many people tend to forget that even though these new tools provide their users with countless new

TABLE 4 The amount of agreement with the statement: "the blurring of work and private life is decidedly thanks to digital devices."

		University of Debrecen	Foreign	Total
I completely disagree	Person	64	28	92
	%	18.1%	11.9%	15.6%
I disagree	Person	67	34	101
	%	19.0%	14.4%	17.1%
I neither agree nor disagree	Person	106	74	180
	%	30.0%	31.4%	30.6%
I agree	Person	83	83	166
	%	23.5%	35.2%	28.2%
I completely agree	Person	33	17	50
	%	9.3%	7.2%	8.5%
Total	Person	353	236	589
	%	100%	100%	100%

Source: CEETHE 2023 database.

TABLE 5 The amount of agreement with the statement: "I cannot imagine higher education without digital technology."

		University of Debrecen	Foreign	Man	Woman	Total sample
I completely disagree	Person	0	4	3	1	4
	%	0.0%	1.7%	1.1%	0.3%	0.7%
I disagree	Person	7	6	7	6	13
	%	2.0%	2.5%	2.6%	1.9%	2.2%
I neither agree nor disagree	Person	31	31	31	31	62
	%	8.8%	13.1%	11.6%	9.8%	10.5%
I agree	Person	77	72	49	97	149
	%	21.8%	30.5%	18.4%	30.6%	25.3%
I completely agree	Person	239	123	177	182	362
	%	67.5%	52.1%	66.3%	57.4%	61.4%
Total	Person	354	236	267	317	590

Source: CEETHE 2023 database.

opportunities, their use can have not only benefits, but also negative consequences, as much as to threaten the wellbeing of users (Viac and Fraser, 2020). In our research, we wanted to examine the impact of digitization on the various aspects of university lecturers' workload and work activities.

Previously more studies proved that for teachers one of the most severe stress factors was a large workload (Garland et al., 2020; Iyaji et al., 2020; Mercer and Gregersen, 2020). The university instructors we examined also testified of this high workload and from their answers it was also found that digital technology plays a big part in doing their work. When starting from generational theories, we examined the data from the direction of various age groups. Neither were we able to show generational differences in frequency of use, nor in the stress-generating effects of technical issues [in contrast to the Mercader and Gairín (2020) pair]. We were, however, able to discover that our respondents use digital tools in class rather often, especially for lectures. The lower usage value regarding all the other class types, along with the results of other studies (e.g., Marín-Díaz et al., 2020) it has become clear that in lectures it is only the demonstration portion that restricts the use of ICT. Due to its basic function, it is particularly critical that during these classes the tools for demonstration work well, thus, it is no surprise that for our respondents technical problems that occur mean substantial (techno)stress situations (Brod, 1984), for women in particular. Apart from this area, however, in the in-class use of ICT itself and the frequency thereof, we found such gender differences as Bandrés et al. (2021), who found multiple variations between men and women, specifically regarding stance and attitude. According to their results, female teachers see greater potential in using and applying ICT in teaching, but we did not address this question in this study.

Another serious stress factor for teachers was the blurring of work and private life (Garland et al., 2020; Fetherston et al., 2021), and according to our respondents digital technology weighs in very heavily in this process. On one hand, technology makes it possible to work from anywhere, thus some of those working hours are spent within the four ways of the home. Often the teachers themselves encourage this, because one's own personal space is calmer, more comfortable for certain tasks (for instance, the majority of publications are born out of the studies and offices in the home). On the other hand, digital technology changes not only the places of doing work, but also the time as well, in short, a new task can be sent out or given at any time. Continuous availability truly is one of the greater negative aspects of digital communication (Bordi et al., 2018; Potter et al., 2022), which bothers a significant number of our respondents, what is more, it irritates them. In this regard, in particular, the boss or supervisor at the workplace is greatly responsible. If they would not send urgent emails demanding immediate response, not only once but many times, and if the teachers' mobile phones would not ring because of question from the workplace, then peaceful rest and regenerating process would not cease. These results ring true for Czerniak-Swędzioł et al.'s findings as well, according to which teachers feel that digital technology is useful in their work, but their private life pays the price (Czerniak-Swędzioł et al., 2021). It is not surprising that various companies have now in policy regulated after-work emailing, that they might promote the switch to offline mode and to rest. On the other hand, no such example could be found in the field of higher education, in spite of the fact that as early as 2007 Grawitch et al. proposed the

need to include restrictions ensuring teachers' work-life balance in deeds of higher educational institutions (Grawitch et al., 2007).

Other significant stressors in the lives of university lecturers include the pressure to publish (Barton et al., 2023). This is a particularly severe factor for anxiety, since the failure to meet publication expectations often results in the loss of one's job (Urbina-Garcia, 2020). From among our respondents the young and the University of Debrecen instructors feel that the pressure on them to publish is ever-increasing. The respondents understand that it is one of their tasks, but their answers varied regarding this expectation. The Debrecenians, in step with the international trend (Nicholls et al., 2022), see publishing in Q/D-level journals and international foreign language volumes as their job, while cross-border teachers view publishing in their mother tongue (or the state language) to be their priority. The difference springs from the fact that cross-border respondents are the teachers of Hungarian-speaking, minority institutions. Their mother tongue is not the same as the state language, therefore, they need to ensure that their proficiency in the state language is high as well, for this is the only way that they would be able to organically integrate into the professional life of their country.

In order to convey academic results one must already have many thousands of professional journals at his disposal, likewise, these without exception must be available in digital format (as well) and in most cases the publishing process itself must be manageable online (Demeter and Istratii, 2020). Certainly these play a part in the majority of our respondents thinking that, with the help of digital technology, the scientometric expectations are more easily fulfilled. The ease not only means an increase in opportunities due to simpler access, but also it points out that work done with the help of technology is less straining than its traditional form. In summary, a little more than a third of our respondents think this, but almost one third of cross-border teachers think that this type of activity is more exhausting than conducting intellectual work without the use of digital tools. Those who think this, when they can afford to, clearly excuse themselves from work using ICT.

5 Conclusion

The wellbeing of the individual is today indisputably connected to the world of online information, and with those digital tools and technologies that create interface with that world (Burr et al., 2020). However, the expectations coming from the digital world are continually changing, increasingly new technical tools and software appear, thus the scale of challenge-resource (Dodge et al., 2012) is repeatedly tipped out of balance. In order to overcome a new challenge, an individual tries to mobilize new assets, and, if successful, a new balance can be achieved. Nevertheless, this new state will still differ from the previous place of rest. The state of wellbeing, therefore, is not static but dynamic, able to maintain with intervention, some small, some great. The online sphere that sprung up beside the offline world and has an ever-growing role made it necessary to intervene, for, digital technologies constantly generate new challenges. The shifting power field transforms the work and activities of the university teachers, so, the characteristics of their wellbeing constantly change. In our study, we attempted to get a grasp on these characteristics.

There is no question that newer significant waves will upset the balance of wellbeing, after all, the post-COVID new norms have not even formed, and artificial intelligence (A.I.), for example, is already

here, the arrival of which has already brought on quite a few new challenges. Despite all the arguments and uncertainty, however, the applicability of A.I. in the teaching process is unquestionable. Applied directly to teaching, it can be used in at least 10 different ways (Yufei et al., 2020). Since the limits of applying artificial intelligence cannot be predicted in either the school, work, or private life, it necessary to give the youth in today's education system such dynamic, improvable knowledge which, once in their possession, will make them able to compete, and collaborate with A.I.

All of this must, of course, be actualized without having digital technology rule both the teachers' and the students' every day, because, if it is technology dominated, their wellbeing will most certainly swing out of balance. In our modern, ICT tool-networked world, one of teachers' important jobs should be to provide and help students in forming and maintaining the balance in their wellbeing. For this, they must first start a „digital detox" (Syvertsen and Enli, 2020), they must learn the conscious use of ICT tools and their resources in such a way that they can form the balance between their online and offline lives. In order that this may be realized, institutions of higher education need to develop training programs in two directions rather urgently. One direction aims at the continuous development of digital competencies, because with suitable preparation instructors can save a lot of time and energy, and their confidence in the use of tools can also reduce their anxiety about technological problems. The other group of training programs wishes to support a more conscious device use and provide assistance in finding a healthy work-life balance.

6 Limitations and suggestions for future research

Our research has certain limits due to its analytical nature. The questionnaire covered several partial areas, so completing the entire material was quite time-consuming. This may have reduced the number of respondents, but at the same time it created a framework for drawing a complex picture, which still needs to be carried out. To do so, another brief questionnaire should be compiled - in addition to background questions -, which is specifically related to the use of digital technology, and which could cover specific digital options available to and also needs of the individual fields. For example, there can be a significant differences between the characteristics of a university instructor who teaches the use of some notation or composition software for music and another one that teaches the design of a smart home control system.

Differences resulting from the various sizes and organizational cultures of the different institutions (the University of Debrecen and minority Hungarian higher education institutions not based in Hungary) may have had an impact on the responses of the lecturers. In a new study it would become possible to compare the characteristics of institutions of similar sizes and a similar range of training programs. For the comparison to be made, researchers need to disclose the characteristics of organizational cultures, house rules and procedures related to the use of digital technologies, and all available internal training programs.

Another limitation is that current experiences with digital technology can distort the picture. Respondents are more prone to mark negative values if they have had a major technical problem with a device or program in the period immediately prior to completing the questionnaire. The answers may also be influenced by the individual level of digital competencies, but the size and length of the questionnaire did not accommodate other questions related to this. In a more recent study, however, educators' digital competencies might be explored, for example, by using the European framework for the digital competence of educators (DigCompEdu).

Data availability statement

The data that support the findings of this study are available from the corresponding authors, but restrictions apply to their availability. These were used under license for the current study, and, so, are not accessible by the public. Data are however available from the corresponding authors upon reasonable request and with permission of the School Ethics Committee of Doctoral Program on Educational Sciences at the University of Debrecen.

Author contributions

AB: Writing – original draft, Writing – review & editing. KK: Writing – original draft, Writing – review & editing.

Funding

Acknowledgments

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Changes in perception of gender differences in university male students after a self-determination program

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The aim of this study is to explore the outcomes of an intervention program to promote prosocial behavior, foster personal responsibility and overcome gender stereotypes in sports. This is a mixed (qualitative-quantitative) quasi-experimental study using a single group. The sample consisted of 72 male university students (21.9 ± 8.85 years) enrolled in Spanish university. The program is based on the Self-determination Theory and consisted of 26 sessions. A teaching guide for gender equality in physical education, the "It Grows" program. The results of the study indicate that, firstly, the program is effective in significantly raising scores for the variable Personal Responsibility, improving decision-making and commitment to one's own goals. Secondly, there was an increase in Prosocial Behavior, indicating greater degrees of empathy. Third, processes of intrinsic motivation also improved, with significantly higher scores in Basic Psychological Needs. Fourth, there was a decrease in the prevalence of gender stereotypes and sexist attitudes. An analysis of the pre-intervention correlations between variables indicated a positive and significant correlation between Personal Responsibility and Basic Psychological Needs ($p < 0.001$; $r = 0.700$), and between Responsibility and Prosocial Behavior ($p < 0.001$; $r = 0.504$). After the intervention program, a positive correlation was found between scores for Personal Responsibility and Basic Psychological Needs ($p < 0.001$; $r = 0.839$) and between Personal Responsibility and Prosocial Behavior ($p < 0.001$; $r = 0.624$). After the intervention program a negative correlation was also found between scores for Personal Responsibility and Gender Stereotypes ($p < 0.001$; $r = -0.281$).

KEYWORDS

equality, gender, sports, education, program

Introduction

Perception of the difficulties in the practice of women's sports

There is an evident need for Physical Education (PhysEd) programs that foster the positive growth and development of young people (Rosado et al., 2022). Programs for Personal and Social Responsibility have proven effective in developing greater empathy, motivation and emotional intelligence, demonstrating that PhysEd is important not only in terms of physical fitness and motor skills but as an essential element in any educational program (Ambrós, 2023).

The World Health Organisation (WHO) has raised the alarm on the growing physical inactivity of people of all ages and especially young people throughout the world (Chaput et al., 2020). In this context, Physical Education (PhysEd) plays an essential role is promoting physical activity and the acquisition of healthy habits (Fairclough et al., 2018). Research has shown that, in the case of PhysEd, the time dedicated to physical activity is highly unequal in terms of gender (Kirkham-King et al., 2017; Mayorga-Vega et al., 2019), where male students generally show much higher levels of physical activity than female students. This has been observed at both the Primary and Secondary Education levels.

A number of studies have also noted that the motivational predisposition of students is the key to their engagement in physical activity and interest in Physical Education (Stelzer et al., 2004; Moreno et al., 2006; Herrmann et al., 2024). Unfortunately, as students advance through their school years the levels of motivation, satisfaction and perceived utility of physical education tend to decrease, and especially among girls (Lago-Ballesteros et al., 2018).

Authors such as Rink and Hall (2008) have found that the negative perception of Physed among girls is due to the incongruence between the difficulty of the tasks assigned in class and their actual motor skills. Thus, it seems that the methodology used in PhysEd are more tailored towards male students and fail to motivate and interest female students.

Development of personal responsibility

One important model that has been implemented in Physical Education and Sports in the last decades has been that of Personal and Social Responsibility (Hellison, 1985), created to harness physical activity and sports to foment positive values and develop personal responsibility among young people at risk of social exclusion. The primary aim of Personal and Social Responsibility, is to develop the personal skills and competences for these students to successfully meet the challenges in their daily lives. And they can respond effectively to difficult situations. The key elements of the program are: (a) self-directed learning; (b) strengthen the teacher-participant relationship; and (c) transferring difficult situations from sport to life. Both the content and methodology of the Personal and Social Responsibility program are related to Bandura (1997) Social Learning Theory and the Positive Development Theory (Shek et al., 2019; Carreres-Ponsoda et al., 2021; García et al., 2021). The goals of the program are to (1) improve students' social skills; (2) fostering a sense of responsibility both for oneself and for others; and (3) develop personal control strategies. As stated by Kohlberg and López (1982) and Piaget (1996), the development of personal responsibility focuses on personal commitment and taking on the challenge of life to achieve personal and professional success.

Development of prosocial behavior

For Yao and Enright (2022), Prosocial Behaviour can be defined as a willingness to help others, involving emotional awareness, altruism and cooperation. For Caamaño and Leiva (2024), prosocial behavior goes beyond correct behavior, it is having the initiative to go out in situations of inequalities or social disadvantages. Prosocial Behavior refers to behavior that involves sharing, supporting and

protecting others. The principal factors which facilitate Prosocial Behavior are empathy, moral judgment and positive emotions. Empathy is thus an important factor in the development of effective interpersonal skills such as problem solving (Saltos et al., 2020). For authors such as Aguirre-Loaiza et al. (2020), empathy also includes the capacity to commit to others and put oneself in their position. The practice of sport encourages the acquisition of moral values and positive patterns of behavior, boosting social skills such as mutual respect, cooperation, fair play and tolerance. All of these issues may be considered as Prosocial Behavior (Smith-Palacio et al., 2021; Piñeiro López et al., 2022; Figueroa et al., 2024).

A number of authors (Parise et al., 2015; Elizalde et al., 2024) maintain that sports programs enhance pro-sociability and improve moral reasoning, mitigating antisocial behavior. The term antisocial behavior refers to actions which are intended to harm, prejudice or denigrate others. Antisocial behavior in sport is manifested in cheating, faked falls or injury (Kavussanu and Stanger, 2017). Other authors (Escobar et al., 2024) highlight the importance of evaluating models of pro-sociability through sports, noting that not all sports equally discourage aggressive behavior and that the key to any prosocial sports program must be fostering moral behavior. Thus, programs that both encourage and facilitate the evaluation of moral behavior in sports are an essential element of Physical Education.

Similarly, Sari et al. (2024) consider sports to be the ideal means to promote positive values among young people. The concept of Positive Youth Development (PYD) is an effective approach in the development of these values ad behaviors and there is a great deal of literature dealing with the relation between sports and the development of reasoning skills among young people (Camiré and Santos, 2019; Kendellen and Camiré, 2019; Strachan et al., 2020).

Basic psychological needs

According to Ortiz and López-Walle (2022), motivation is a psychological mechanism that governs the direction or intensity of behavior and is therefore an essential element in any commitment and engagement and can be transferred from the academic sphere to one's personal life. An understanding of the Basic Psychological Needs of students is provided by the Self-determination theory by Ryan and Deci (2017). The focal point of this theory is to determine contexts which facilitate or hinder the development of intrinsic motivation and healthy psychological habits (Ryan and Deci, 2000; Huhtiniemi et al., 2019; Martínez Heredia et al., 2020). Furthermore, motivational regulation, driven by processes of self-determination are essential to the notion of autonomy. In this line, Mosqueda et al. (2019) propose certain types of motivation: intrinsic motivation (referring to an orientation towards autonomy and informed interpretation of circumstances); extrinsic motivation (referring to actions subject to external pressures rather than independent choice) and demotivation (referring to involuntary actions lacking clear purpose and the perception that outcomes do not depend on one's actions).

Ryan and Deci (2017) describe Basic Psychological Needs (BPN) as the psychological nutrients necessary for personal growth, integrity and wellbeing. They also argue that BPN are drivers of personal satisfaction and wellbeing and the failure to meet these needs can

contribute to the appearance of certain pathologies. These authors highlight three key BPNs: Autonomy, referring to the perceived ability to direct one's own life; Competence, referring to the perceived effectiveness and mastery of tasks; and Relation, the feeling of meaningful interaction with others.

Gender stereotypes in sports and physical activity

The influence of the media can have a direct impact, consciously or unconsciously, on students, often limiting the motivation of girls and leading them to assume predetermined social roles (Mateo-Orcajada et al., 2021; Chihuailaf-Vera et al., 2024). This can also the case with textbooks which employ sexist language or stereotypes and which may be subtly reinforced by teachers (Alvariñas-Villaverde and Pazos-González, 2018). The problem is accentuated when girls lack positive role models and contemporary society assigns predetermined roles through toys, games sexist films, etc. There is a failure to recognize the achievements of women in sport, as well as in science and politics, all of which contribute to the notion that sports is a masculine pursuit. Stereotypes are understood as a set of preconceived values, roles or beliefs inculcated in men and women and generally accepted by society (Navarro-Patón et al., 2020; Soberanis and Pech, 2023). It may be said, in line with Amurrio Vélez et al. (2012), that gender stereotypes are characteristics and traits attributed to an individual based on their gender. These characteristics are assigned according to the roles and identities traditionally ascribed to men and women. García Pérez et al. (2016) explain that gender stereotypes are assimilated through cultural and social contexts and that, just as they are learned, they can be modified or overcome through learning. For Ferree and Hall (1996), the concept of gender socialization is directly related to the social expectations, social control and struggles which sustain traditional roles and behavior among men and women.

Currently, physical education plays an important role in overcoming these gender stereotypes. A wide range of programs have been implemented aimed at different populations with different themes and orientations (Mateo-Orcajada et al., 2021; Tyarakanita et al., 2021). It is necessary to overcome gender stereotypes that present girls as less physically active than boys (Arrebola et al., 2019; Monforte and Colomer, 2019).

Considering this, we will explore the effect of a program which promotes (1) Personal Responsibility and, consequently, the taking of personal decisions and commitments based on personal goals; (2) Prosocial Attitudes as a consequence of empathy with others; (3) the influence of motivational processes among students in the development of Basic Psychological Needs; and (4) the overcoming of Gender Stereotypes in sport, leading to greater recognition, integration and engagement of women with sports.

Objectives and research questions

The aim of this study is to explore the impact of a program to promote equal opportunity in university education in terms of Personal and Social Responsibility, Prosocial Behavior, Gender Stereotypes and the Basic Psychological Needs of students of Physical Activity and Sports Sciences.

Method

The research used a mixed quantitative-qualitative methodology through narrative analysis. This methodology follows the essential elements of the interpretive paradigm, prioritizing the explanation and comprehension of experiences related to social life and its meaning to individuals (Coffey and Atkinson, 2003). Unlike qualitative methodology, in mixed methodology, concepts of triangulation and multiple operationalism are included in order to validate more than one method as part of the analysis process. In this way, the findings found from two or more methods reinforce the belief in the results (Ballesteros et al., 2024).

This research adhered to the principles of the Declaration of Helsinki De la WMA (De La WMA, 2013) and the ethical guidelines of the American Psychological Association (2016). It was approved by the ethics committee of the Francisco de Vitoria University, registration number 5/2024. All participants at the university gave informed consent prior to their participation in the study.

Participants

A total of 72 male students, between the ages of 19 and 24 (21.0 ± 7.9 years), participated in the study. All were Spanish university students in the second year of the Degree in Physical Activity and Sport Sciences. A non-probability convenience sampling method was used.

Procedure

The intervention consisted of 28 sessions. In the first session, students were informed of the procedure of the research, the scales to be completed and the pre-intervention data was collected. In the subsequent 26 sessions the 'It Grows' program was implemented for the promotion of gender equality among students. The order of the intervention was as follows: During the first 3 weeks (6 sessions) dynamics were conducted during warm-up period; the following 2 weeks (4 sessions) were dedicated to the resolution of case studies using the Wooclap platform; the following 7 weeks (14 sessions) involved practices in equality, course content and the development of the program; the final 2 sessions were dedicated to debate on videos. Finally, in the last session of the program students again completed the questionnaires on Personal Responsibility, Prosocial Behavior, Basic Psychological Needs and Gender Stereotypes in Sport and gave their feedback on the program, the changes in their way of thinking and the utility of the 'It Grows' program in the training of athletes.

'It grows – women and sport' program

The 'It Grows' program (Lamoneda Prieto et al., 2023) incorporates a series of activities designed to promote social equality, break gender stereotypes in sport, improve Prosocial Behavior and increase levels of Personal Responsibility among university students (Annex 1). The program was implemented between January and May of the 2021-2022 academic year and serves as a guide and framework to raise awareness of the achievements of women in sport, promote

attitudes of equality and to contribute to the development of Prosocial Behavior and Responsibility. The program works in two ways: through directed activities and interactive activities. Our intervention consisted of 5 phases, gradually reducing the role of teachers and giving increasing protagonism to students. In the first sessions, directed by teachers, students experienced habitual situations involving commonplace gender stereotypes and about which students were asked to give their opinion and course of action. With the help of the online tool Wooclap, students responded to virtual situations and contexts, with themes such as "Women and Sport." The questions were principally related to Prosocial Behavior and presented as open questions. At the end of this process students watched educational videos contextualizing the questions followed by an evaluation of their responses (Table 1).

Instruments

Personal responsibility

The validated Spanish version (Escartí et al., 2011) of the Personal and Social Responsibility Questionnaire (PSRQ) by Li et al. (2008) was used to evaluate the impact of the p8rogram on Personal Responsibility. This tool consists of 14 items divided into two factors of seven items each: social responsibility (Items 1 to 7) and Personal Responsibility (items 8–14). Participants responded using a 6-point Likert-type scale from 1 (totally disagree) to 6 (Totally agree).

Prosocial behavior

The Prosocial Behavior Questionnaire (Martorell et al., 1995) for children and adolescents was used to evaluate collaborative behavior, such as sharing, encouragement and understanding. This tool has no time limit for completion consists of 55 items with six possible responses, from 1 (Totally disagree) to 6 (Totally agree).

Basic psychological needs

To explore the area of Basic Psychological Needs, the study made use of the Spanish version (Lozano et al., 2024) of the Basic Psychological Needs in Exercise Scale (BPNES: Vlachopoulos and Michailidou, 2006). The instrument begins with the phrase "In my Physical Education classes… "followed by 12 items that measure the perception of autonomy (4 items, e.g.: "The way I exercise is in agreement with my choices and interests"), perception of competence (4 items, e.g.: "I feel I have made a lot of progress in relation to the goal I want to achieve"), and social relation (4 items,

e.g.: "I feel comfortable with the people I exercise with"). The tool uses a 5-item Likert-type response scale from 1 ("Totally disagree") to 5 (Totally agree).

Gender stereotypes in sports

The instrument Gender Stereotypes in Sports among Spanish Children and Adolescents (CEGAFD) (Granda et al., 2018) was used, consisting of 24 items with a 5-point Likert-type response scale (1 = Totally disagree; 5 = Totally agree) that addresses the following four dimensions or factors: Gender differences and their relation to sports (for example: "*In general, boys are better at sports than girls*"); Sports and gender (for example: "*It is more difficult for female athletes to make it in sports*"), Gender stereotypes associated with sports and physical activity (for example: "*Some sports are for women and others are for men*"), Beliefs about sports and gender (for example: "*Girls can develop their physical abilities as much as boys*") and Physical Education classes and gender (for example: "*In PhysEd, the teacher normally demands more from boys than girls*").

Evaluation of the program

Open questions were posed at the end of every resolution of the case (Case 1: On Gender and Sport; Case 2: Empathy, gender stereotypes; Case 3: Disadvantages due to technical skills). How does the player feel when their teammates do not collaborate with them? How should a player react when they feel excluded from a sports activity? What would you say to classmates who want to win at any price? What would your family think of this situation? What social commitment does these cases involve?

Wooclap tool

The Wooclap tool is an online, self-report educational platform. Researchers provide the participants with a password to access a series of cases to be resolved, learning videos and open questions on Prosocial Behaviour. Participants completed these assignments using their own criteria and reasoning. The Wooclap tool then generates a report of the responses.

Individual reflections of the sample

During the intervention program, students analyzed an article entitled "*Perceived difficulties in the practice of Sports and Physical Activities among adolescent girls and their change over time*" (de Quel Pérez et al., 2010). Subsequently, outside class time, students were asked to write a 2,400 words summary of the article, describing its principal contents and their personal impressions and opinion.

TABLE 1 Design of the program 'It Grows − Women and Sport' − Self-Determination Theory by Ryan and Deci (2000).

Program 'It Grows − Women and Sport'			
Objectives	Means	Activities	Self-Determination Theory (BPN)
Analyze the results in terms of Gender differences	The Wooclap educational tool	Group dynamics, debates, etc.	Autonomy, the perceived ability to direct one's own life
Analyze the benefits in terms of prosocial behavior	Portfolios	Video-analysis	Competence, the perceived effectiveness and mastery of tasks
Analyze the benefits in terms of Responsibility among university students	Wooclap statistics	Problem solving	Relation, the feeling of meaningful interaction with others

Data analysis

The normality of the variables were analyzed by means of the Shapiro Wilk test. Assuming all variables had a normal distribution ($p > 0.05$), the pre- and post-intervention results were analyzed using a Student's t-test for related samples. The effect size was calculated using the Cohen (1988) scale: an effect size below 0.2 is considered small, proximate to 0.5 is considered moderate and over 0.8 is considered large. Furthermore, the relation between the different variables was studied using the Pearson's r. The confidence interval was established as 95%. The reliability of the questionnaires was calculated using Cronbach's alpha.

A qualitative analysis was conducted for a deeper exploration of the thinking of students about the educational intervention program. Using the Wooclap platform, the personal contributions and criteria of participants was analyzed based on their work and final evaluations in the open questions. The research has an interpretive approach to existing interactions before the same object of study, triangulating the information collected in different instruments (Richards and Hemphill, 2018).

To certify the reliability, transferability and credibility of the results, coinciding text patterns were coded to permit the analysis of text extracts (Salmona and Kaczynski, 2024). Text and ideas saturation techniques were also used to establish thematic areas. After deliberation, the documents were organized and grouped into categories and sub-categories in line with the aims of the study and the specificity and coherence criteria (Trainor and Graue, 2014).

Results

Reliability of the questionnaires

For the sub-scale social responsibility, the α values were 0.805 and 0.705 for personal responsibility. In prosocial behavior, the Cronbach's alpha for reliability was between 0.724 and 0.814. The α values for the three sub-scales evaluating Basic Psychological Needs (perceived autonomy, perceived competence and social relations) were: 0.797, 0.860 and 0.906, respectively. The reliability, according to Cronbach's alpha for each of the subscales of Gender Stereotypes in sports were between 0.675 and 0.805 for all the sub-scales with the exception of 'Beliefs', which scored 0.310.

Quantitative analysis

Participants in the program showed significant improvement in all variables of the study: responsibility in PhysEd, satisfaction of Basic Psychological Needs, Prosocial Behaviour and Gender Stereotypes ($p < 0.05$). No significant differences were found in the sub-scales n° 2, sport and gender, n° 4, beliefs, and n° 5, PhysEd classes referring to "Gender Stereotypes" (Table 2).

Qualitative analysis

A total of 513 text fragments were extracted, the majority positive comments (486 versus 27) Figure 1, firstly referring to Personal Responsibility (139 positive fragments and 18 negatives; for example: '*hit them*'). The second most common theme was related to prosocial behaviour (153 positive fragments and 18 negatives; for example: '*I only know I do not know anything*'). The third most common referred to Basic Psychological Needs (BPN) (100 positive fragments and 32 negative fragments; for example: 'buy a piñata) and finally, the fourth most common theme was in relation with Gender Stereotypes (76 positive fragments and 4 negative fragments; for example: 'a good slap is always a win but a little talking can also work'). The distribution of the responses is shown in Figures 2, 3.

Responsibility (146 fragments)

The Wooclap tool was used to extract the opinions of the participants regarding social skills such as empathy, solidarity or assertiveness. These comments also highlighted the need for players to feel supported by their coaches and trainers.

> The female students does not feel supported by their coach, since they don't offer opportunities to play and also don't help them in training. They feel excluded from the team (A 11 male).

> The person feels that they aren't given the chance that everybody deserves, and so they feel sad and excluded (A 14 male).

> We can help her by showing support/empathizing with her. Being assertive (A 8 male).

Prosocial behavior (171 fragments)

The most frequent comments extracted from the final document (portfolio) refer to prosocial behavior, arguing about the importance of incorporating into sports behavior such as: helping an injured player, respect towards the losing team, being cordial at the start of the match and respecting the referee.

> When a player is injured during a game. The game stops until the player is helped off the pitch/Because there are a lot of followers and that may serve as an example in daily life. What happens in sports is a reflection of reality (A 19 male)

> For the good of all and for the sport to be enjoyable/Because it helps you to develop essential values for life (A 20 male)

> Shake hands with the rial after losing a match (A 3 male)

> Set goals, both for sports and in social life so everyone can see the positive values for society (fellowship, effort and dedication) (A 7 male)

> Because sports should be a source of positive values and beliefs for everyone and especially for kids beginning to practice sports (A 10 male)

> When the referee calls a penalty that is totally unfair and the player complains because it wasn't really a penalty (A 10 male)

Gender equality (132 fragments)

Many participants believe that the abandonment of sports and physical activity by girls is due to the limited motivation provided by

TABLE 2 Responsibility, pro-sociability, BPN and gender stereotypes before and after the it grows program [Mean (standard deviation)].

	Pre-test	Post-test	Diff	z	d	p
Responsibility in PhysEd						
1. R. Social	2.67 (1.05)	4.21 (0.39)	1.54 (1.04)	−11.625	1.4	**<0.001**
2. R. Personal	2.77 (0.82)	3.76 (0.50)	0.99 (0.88)	−8.814	1.1	**<0.001**
Prosocial behavior						
1. Empathy	2.86 (0.66)	3.84 (0.30)	0.98 (0.70)	−11.007	1.4	**<0.001**
2. Respect	2.93 (0.58)	3.67 (0.23)	0.74 (0.63)	−9.172	1.2	**<0.001**
3. Sociability	2.94 (0.70)	3.90 (0.26)	0.95 (0.68)	−11.017	1.4	**<0.001**
4. Leadership	3.00 (0.74)	3.85 (0.32)	0.85 (0.76)	−8.749	1.1	**<0.001**
BPN satisfaction						
1. Autonomy	2.95 (0.99)	3.81 (0.76)	0.85 (1.19)	−5.634	0.7	**<0.001**
2. Competence	2.93 (1.13)	4.03 (0.59)	1.09 (1.14)	−7.494	0.9	**<0.001**
3. Relation	2.87 (1.20)	4.07 (0.53)	1.19 (1.29)	−7.344	1.0	**<0.001**
Gender stereotypes						
1. Diff. associated with gender	3.28 (0.55)	2.41 (0.92)	−0.87 (1.06)	6.439	0.8	**<0.001**
2. Sport and gender	2.99 (0.73)	2.82 (1.00)	−0.17 (1.25)	1.060	0.1	**0.293**
3. Stereotypes	3.22 (0.65)	2.50 (0.85)	−0.72 (1.07)	5.298	0.6	**<0.001**
4. Beliefs	2.93 (0.80)	3.04 (0.79)	0.10 (1.17)	−0.730	0.9	**0.468**
5. PhysEd Class	2.97 (0.83)	2.81 (0.90)	−0.15 (1.16)	1.402	0.1	**0.164**

An analysis of pre-intervention correlations shows a positive and significant relation between scores for Personal Responsibility and Basic Psychological Needs ($p < 0.001$; $r = 0.700$), and between Responsibility and Prosocial Behavior ($p < 0.001$; $r = 0.504$). The correlations after the intervention reveal a positive relation between scores for Personal Responsibility and Basic Psychological Needs ($p < 0.001$; $r = 0.839$), and between Personal Responsibility and Prosocial Behavior ($p < 0.001$; $r = 0.624$). Furthermore, after the intervention a negative relation was observed between scores for Personal Responsibility and Gender Stereotypes ($p < 0.001$; $r = −0.281$). Among the results of the subscale of Gender Stereotypes in Sport, there was a significant improvement in the variables of Differences Associated with Gender and, Stereotypes ($p < 0.000$). No significant differences were found in the variables Beliefs ($p = 0.372$) and Physical Education Class ($p = 0.204$) after the intervention.
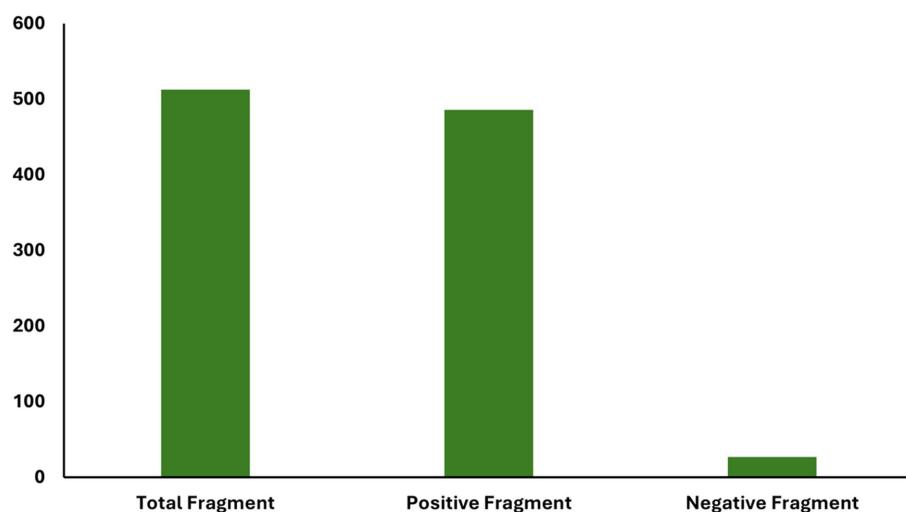
FIGURE 1
Distribution of total fragments.

Physical Education classes. Others confirmed that girls often provide excuses for not doing more sport. For example:

> Honestly, from my point of view, and with all due respect, I think a lot of excuses are given that may lead women to avoid sports in many cases. I understand that it may be unusual to see a young girl kicking the ball around and maybe some little boy makes some stupid comment but, you have to be strong, and with practice anyone can learn to kick a ball one way or another. Things have changed and are much more controlled now, and that's good, since everyone has the same rights, men, women, tall, short, etc. (A10 male)
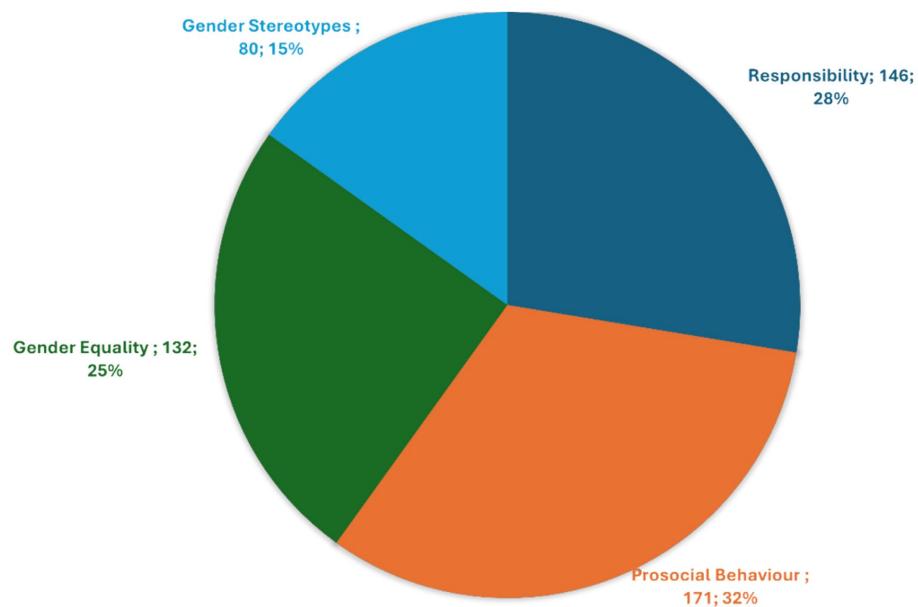
FIGURE 2
Fragments by variables.
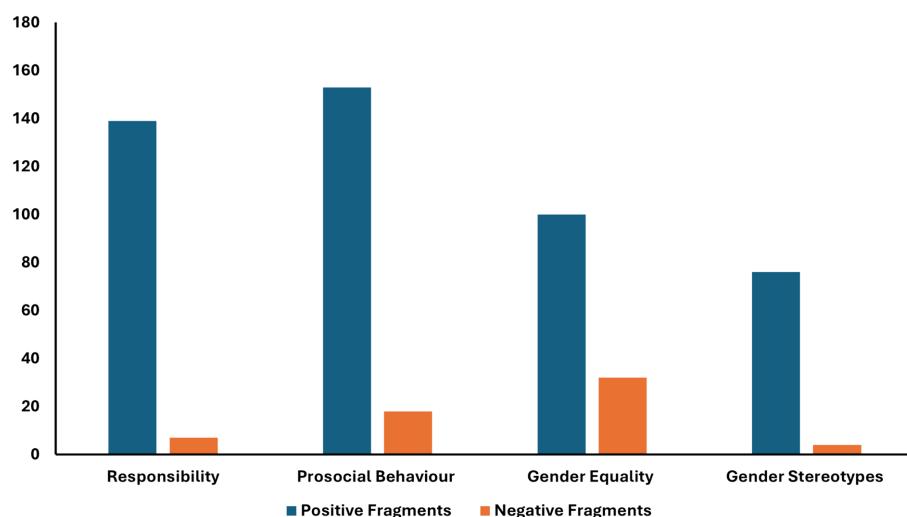
FIGURE 3
Distribution of fragments according to the opinions of the participants.

The growth of women's sports has been so spectacular in recent years that you could think that it barely existed before. It is surprising to learn about how famous some women athletes were in the early XX century. (Individual work. male)

It's interesting to know that, internationally, the biggest change happened in 1912 when the Swedish Olympic Committee included water sports in the official program, and so swimming become the first female Olympic sport. This caused a backlash by the founders of the modern Olympic Games. In response, the French athlete Alice Milliat founded the Female Sports Federation of France in 1917. (A2 male).

Gender stereotypes (80 fragments)

The contributions were aimed at empathising with the situation experienced by the female student and the proposals of dynamics that empowered the female players, promoted group cohesion and the search for solutions in the face of conflicts. The responses largely rejected the abandonment of sports. An example of a negative comment: "*Buy her a piñata*"; an example of a positive comment: "*Tell the coach to speak to my teammates.*"

"I would tell them not to put up with any abuse, to be brave, and to tell their teammates what they think and if things don't change then speak to the coach to deal with the situation or else kick the problematic

ones off the team to avoid uncomfortable situations in the club with very firm values against abuse. Stop violence" (A2 male)

A number of proposals were made for initiatives such as dynamics for conflict resolution in response to the situation of the player. These dynamics focused on role changes, changing the rules of the game and analyzing the problems.

"I'd give them good boost (motivational) to encourage them to continue with sports" (A23 male)

Some participants believed, in this case, it was essential to work on motivation and self-esteem to continue practicing sports.

"Talk to my parents and with the coaches to reach a solution / face up to my teammates and make my feelings clear" (A2 male)

One group of participants supported the idea of a family intervention in these cases, not limited only to the sports club or the team of the player.

"Talk to my teammates to reach a solution because I can improve, and they can also change their behavior" (A3 male)

"Speak with her and with the rest of the team so they know how Alicia feels and so get over the situation with the help of teammates" (A2 male)

"Speak to her in a constructive way, not a destructive way, support her and help her to improve and to see that its not true its her fault the team lost. We are a team and we are all responsible for what happens in the match" (A18 female)

Discussion

The aim of this study was to analyze the effects of a program to promote equality in university education, focusing on the variables of Personal Responsibility, Prosocial Behavior, Gender Stereotypes and Basic Psychological Needs. The results after the implementation of the intervention program indicate significant changes in the majority of the variables and a positive correlation between Personal Responsibility and Prosocial Behavior and Basic Psychological Needs as well as a negative correlation between Personal Responsibility and Gender Stereotypes.

Regarding Personal Responsibility, the study found a 43% increase in this variable after the intervention, which may be related to the exposition of criteria and analysis between equals guided by researchers. This hypothesis is in line with the previous findings; participants of a study evaluating the effects of an intervention program based on a hybrid model (Sport Education - Personal and Social Responsibility) showed significant improvement in their levels of Personal Responsibility (Menéndez-Santurio and Fernández-Río, 2016). This suggests the effectiveness of novel approaches in improving behavior and attitudes. Another study aimed at furthering the development of Personal Responsibility, confirmed that improvements in this area also enhance general quality of life (Sánchez-Alcaraz et al., 2012). A number of authors, including Sánchez-Alcaraz et al. (2014), have noted that satisfactory levels of

Personal Responsibility also correspond to greater sportsmanship and lower levels of aggression. Thus, this research identifies three directions of opinion of the students. Firstly, opinions on the need to improve relation between equals. For example, the vulnerability of the protagonist in the case opened a debate between students and an analysis of the best means of intervention. Secondly, opinions on the need to enhance the teacher-student relation, especially in terms of the teacher listening and creating a feeling of group belonging. This notion of belonging is very important given its effective transference to other areas of life, family, school and society. Finally, another line of opinion focused on the work to develop positive values using educational tools combined with athletic activities for social learning. These results are in line with those of other studies (Wright et al., 2018; Carreres-Ponsoda et al., 2021) which found notable improvements in the scores for Personal Responsibility after the implementation of an education intervention program in this area.

The study confirmed an increase of 25.9% in the values corresponding to Prosocial Behavior, which may be associated with the capacity for empathy in the situations analyzed in the classes. Similarly, studies such as that by Del Carmen Rivera-Mancebo et al. (2020), found significant improvements in Prosocial Behavior in all subscales: social withdrawal, social timidity, leadership and social relations after the implementation of a program using the Sport Education Model (SEM). These results confirm the effectiveness of educational programs in improving behavior. Furthermore, the results regarding Prosocial Behavior in another study (Calderón et al., 2016) confirm the development of shared common objectives, putting aside personal interests in favor of inclusion, participation and collaborative work. Other studies (Goudas and Magotsiou, 2009; Prieto et al., 2024) into improving Prosocial Behavior, affirm that the development of cooperative attitudes has a positive impact on social relations, reducing disruptive behavior. Among the most common opinions of students participating in this study were the importance of fair play above winning at all costs, respect for rivals and teammates. The participants analyzed the decisions of the referee and the willingness of the players to accept them without aggression or violence. These are interesting debates through which participants engage in the principles of the Sport Education Model (Siedentop, 1994). This model proposes six elements to foster Prosocial Behavior: seasons, affiliation, recording keeping, formal competitions, festivity and culminating event. Specifically, the model aims to improve student motivation by assigning roles and tasks.

Regarding Basic Psychological Needs, the results confirm a significant improvement of 33%, which may be related to the development of personal competences throughout the intervention program. Other similar studies (e.g., Mosqueda et al., 2022) showed different results, finding no significant changes in the development of Basic Psychological Needs through the motivation program. However, a study by Sánchez (2022) showed significant results in the relation between Personal Responsibility and Basic Psychological Needs, in line with the findings of our research. This variable assumes greater importance as the students improve their performance, experience feelings of greater personal and group achievement and improve relations with others.

This study also analyzed the opinions of participants regarding the abandonment of physical activity and sports by girls. Student comments in this regard were generally oriented towards the importance of motivation and the adaptation of PhysEd class content for girls. These opinions are in line with the Self-determination Theory

by Deci and Ryan (1995) which focusses on motivation, person growth and the satisfaction of Basic Psychological Needs (BPN) (competence, autonomy or novelty and relation). Regarding BPN, the majority of comments by participants referred to the areas of personal competence and autonomy. A study by Knowles et al. (2018) found improvements in all BPN and student participation after conducting a 20-session sport education program. Similarly, Wallhead et al. (2014) implemented a program that included handball, volleyball, basketball and floorball, which showed positive results for BPN and autonomous motivation. The results of the present study have been fundamentally positive, especially in terms of enhancing competence and autonomy; this may be due to the structure of the 'It Grows' program itself aimed at improving the direction, execution and corrections within the sessions. A study by Cantú-Berrueto et al. (2016) also found positive results in terms of the satisfaction of BPN among sports trainers. The results show that the perception of support for autonomy from the trainer/coach is positively correlated with the satisfaction of Basic Psychological Needs, particularly relation and autonomy.

After the intervention program, there was a significant reduction in the values of two subscales of the Gender Stereotypes in sports (Diff. Associated with gender and stereotypes), which may be related to the reflection activities incorporated into the program. Similarly, a study by Martínez-González et al. (2021) into Gender Stereotypes in sports using a sample of 1,147 participants found that an individual's actions can have a large impact on others and that the family environment is the key to eliminating Gender Stereotypes through programs aimed to eliminate this phenomenon. For Solmon (2014), educators play a decisive role in the design of educational sessions aimed at eliminating Gender Stereotypes and boosting the motivation of girls to practice sports and physical activity.

Another aim of the program is to analyze perceived gender differences. The opinions of participants confirmed the effectiveness of the program and students clearly acknowledged inequalities in treatment and opportunity due to gender. Thus, the program included dynamics to ensure equal opportunities were offered regardless of gender, diversifying roles and strategies for conflict resolution. Participants also considered debates to be an effective educational tool with direct accompaniment between students and teachers in especially critical situations. These proposals are particularly interesting as they are in line with the Theory of Moral Development by Kohlberg (1987). For this author, moral reasoning refers to judgments on the acceptance or deviation from social norms, analyzed using moral dilemmas or role playing paradigms, closely associated with morality, age and psychological development. The application of this theory and moral paradigms has led to the development of a moral reasoning scale. On the other hand, the results of this study agree with Chihuailaf-Vera et al. (2024) in the validation of an instrument to measure gender stereotypes in sport with a sample of 321 university students found more sexist beliefs in the male gender and the students seek to eliminate the binomial established by professional sport over women's sports specialties. For all of the above, it is recommended: (1) to work on the debates from the social perspective, giving space for the presentation of each of the students; (2) To exemplify through didactic material, use of images and video the involvement of women in the world of sport; (3) Show women's sports results and open debates about them; (4) To provide spaces for teacher-student mentoring, to clarify doubts; (5) Involve the family in training related to gender stereotypes in sport.

An analysis of the pre-intervention results show a positive and significant correlation between Personal Responsibility and Basic Psychological Needs and between Personal Responsibility and Personal Behavior. The results after the intervention show a positive correlation between Personal Responsibility and Basic Psychological Needs and between Personal Responsibility and Personal Behavior. Analysis also revealed a negative correlation between Personal Responsibility and Gender Stereotypes, in line with the findings of a study by Valero-Valenzuela et al. (2020) using a sample of 55 students and using an educational program based on a hybrid model of Social Responsibility and innovative gamification strategies. The results confirmed the prevalence of Personal Responsibility and the need for autonomy. This indicates that Personal Responsibility is the cornerstone of personal growth and prosocial behavior among students. The authors also found that the 8-month education program oriented towards improving motivation and physical activity led to a significant reduction in disruptive and violent behavior and anxiety and significant improvements in emotional well-being.

Limitations

This study has certain limitations, one of which is the absence of external actors, such as family members, or the lack of individual mentoring offering the possibility for discussion with researchers. Another limitation was the use of the "It Grows" program alone and the absence of another program such as de Deportes (2010). The intervention period should be more extensive, 10 months rather than the 5 months in this study. The absence of a control group is another shortcoming.

Future research

The aim is for this study to serve as a reference for future lines of research into gender stereotypes in physical activity in relation to the type of sports participants pursue and their recreation habits. Another future line of research may be the relation between gender stereotypes and the family experience of participants. Finally, there should be further research into the link between gender stereotypes, the classroom environment and academic results.

Conclusion

The results of this research confirm the effectiveness of the "It Grows" program in developing attitudes of Gender Equality, Prosocial Behavior, improving Personal Responsibility and Basic Psychological Needs among university students. Furthermore, these results include a dedication to overcoming Gender Stereotypes in sports. The use of multi-dimensional methodologies such as "Self-determination Theory," the Sport Education model and socio-critical pedagogy enhance the rigor of the intervention program, particularly through group dynamics, debates, video-analysis, case resolution, role playing in sports competition, etc. The participants in the research associate a program promoting gender equality with the development of Prosocial Behavior and the elimination of Gender Stereotypes in sports.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statement

The studies involving humans were approved by Universidad Francisco de Vitoria, registrado con el número 49/2021 y titulado: "It Grows Educación Física, Deporte y Mujer," dirigido por D. Eulisis Smith Palacio, ha sido valorado en sus aspectos metodológicos, éticos y legales, en la sesión del CEI del día 3 de noviembre de 2021 obteniendo. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

ES: Conceptualization, Funding acquisition, Writing – original draft. AB-S: Formal analysis, Software, Supervision, Writing – review & editing. GD: Investigation, Methodology, Software, Supervision, Writing – review & editing, Writing – original draft. JF: Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1402373/full#supplementary-material

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Enhancing engineering students' satisfaction with online learning: factors, framework, and strategies

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Introduction: The learning experience has undergone significant changes recently, particularly with the adoption of advanced technology and online lectures to address challenges such as pandemics. In fields like engineering, where hands-on classes are essential, the online learning environment plays a crucial role in shaping students' experiences and satisfaction.

Methods: This study aimed to explore the key factors affecting engineering students' satisfaction with online learning. A structured survey was administered to 263 students across various engineering disciplines and academic levels, all of whom had experienced both in-person learning before the pandemic and online learning during the pandemic. Factor analysis and multiple linear regression were employed to analyze the data.

Results: The analysis identified interactions, services, and technology as the main factors positively influencing online learning satisfaction. The regression analysis further revealed that students' satisfaction is significantly dependent on the availability and quality of online learning services, assessment and interaction tools, and technology.

Discussion: This study highlights the critical factors that enhance engineering students' satisfaction with online learning. It offers strategies for educators to improve online learning environments, emphasizing the importance of quality services, assessment, and interaction tools. These findings can guide the development of more effective online learning experiences in engineering education.

KEYWORDS

online learning experience, factor analysis, multiple linear regression, user experience, learning quality, engineering education

1 Introduction

During the last decade, many worldwide disruptions have challenged the continuity of the in-class learning process. Since the outbreak of the COVID-19 pandemic, universities around the world have resorted to online learning as a temporary solution to education during the crisis. Online learning can be utilized not only during pandemics but also in response to various risks and disruptions that challenge the continuity of the educational process, such as earthquakes and natural disasters. In such events, when physical education buildings may be damaged and rendered unusable, online learning provides a resilient alternative to ensure the continuity of education.

Given that unforeseen events could disrupt face-to-face learning, the importance of online learning is expected to grow. For example, the pandemic forced more than 1.7 billion students worldwide to continue their education through online learning due to its spread (Husain, 2021). Initially, due to sudden changes and lack of necessary training, not all teachers coped with the situation, leading to unsatisfactory results (Na and Jung, 2021). However, the situation forced instructors to adopt online learning tools in a short time, which required them to be knowledgeable about technology and creative in conducting study material through online platforms (Amin et al., 2002). For example, the University of New South Wales in Sydney developed a pedagogy for construction engineering students using Augmented Reality to create an immersive learning experience using accessible tools such as smartphones (Sepasgozar, 2020).

The adaptation of online learning in various educational institutes during outbreaks, especially during the pandemic, resulted in the need for several electronic devices, leading to a significant change in the educational field (Hamad, 2022). However, problems such as difficulty or uncertainty in understanding the material, media, or receiving sound given by the lecturer during online lectures have been reported (Hermiza, 2020). Several studies have explored factors that affect the quality of the learning experience and students' satisfaction with online learning in the pandemic era, including Palmer and Holt (2009), Zeng and Wang (2021), and Landrum et al. (2021). One of the quality measures of student learning in higher education is their satisfaction (Parahoo et al., 2016). Multiple studies concluded that learners' perceptions of the effectiveness of a learning experience are a key factor in determining its overall effectiveness, and thus user satisfaction can be used in evaluating the study process (Violante and Vezzetti, 2015). Student satisfaction in evaluating learning experience has been studied widely, such as by Cole et al. (2014), Nagy (2018), Dashtestani (2020), Yu (2022), and Maican et al. (2024).

Students in all parts of the world have experienced a swift transition in their learning environment, suddenly moving from a traditional face-to-face system to online lectures and assessments. After experiencing such a transition, it is crucial to learn and adapt the integration of technology into engineering education, enhancing the resilience of the education process. This adaptation ensures the ability to seamlessly execute potential transitions, preventing any negative experience that limits student learning.

This study is conducted to evaluate this transformative experience and improve it for future potential disruptions that can cause a shift from in-class learning to online modalities. As a result, in this paper, we investigate and develop a framework that represents the relationship between different factors that influence students' experience of online learning and affect their satisfaction, particularly in engineering disciplines. The remainder of the paper includes a review of the literature, methodology, data analysis, results, discussion, and finally, a conclusion and limitations.

2 Review of the literature

Access to educational institutions is affected by disruptions like natural disasters. Organizations such as UNICEF make various efforts to ensure the continuity of education (Spond et al., 2022). Online learning has the potential to replace traditional methods with its coping property with uncontrollable disruptions of the learning process (Dhawan, 2020). This is especially evident after the COVID-19 pandemic that caused a major disruption in higher education, resulting in a shift to online learning in many higher education institutes (Aristovnik et al., 2023). While previous studies have highlighted both the challenges and opportunities of online learning (Adedoyin and Soykan, 2020), significant gaps remain in measuring the success of the online learning process and how to improve it especially is math and lab-based disciplines like engineering.

Bourne et al. (2005), identified key challenges in implementing online programs for engineering education, particularly the difficulty of conducting laboratory activities. Despite this, it was concluded that online engineering education would eventually be widely accepted, offering quality equivalent to traditional education and broad accessibility. Historically, online engineering education was primarily at the graduate level due to the complexity of delivering mathematics and science courses online for undergraduates (Bourne et al., 2005). In fact, conducting laboratory activities online is especially challenging for undergraduate students, yet these activities are crucial for their education (Widharto et al., 2021).

As a result, many studies focus on measuring the effectiveness of online learning. Student satisfaction with online learning is indicated to measure the quality of the knowledge and the student's perspective of the achieved success (Puška et al., 2020; Sampson et al., 2010). Student satisfaction is a comprehensive measure to improve learning quality, defined by efficiency and effectiveness (Puriwat and Tripopsakul, 2021), and it represents the difference between learners' expectations and their actual experiences (Yu, 2022).

There are different categories of factors that were covered in the literature that affect students' satisfaction with online learning including pedagogical and students' demographic information, and technological factors (Adeniyi et al., 2024; Yu, 2022). Pedagogical and student demographic factors that affect students' satisfaction were covered by different studies, for example, it was stated that self-regulation and teacher-student interactions significantly influence student motivation and satisfaction, with students experiencing a blend of dissatisfaction and satisfaction (Zhang and Liu, 2024). On the other hand, Said et al. (2022) applied machine learning which resulted in identifying quality, interaction, and comprehension as key predictors of student satisfaction, while demographic factors like class, gender, and nationality were found to be insignificant regarding online learning. Blended learning and the use of multiple tools in the teaching process are effective strategies to engage students and support their educational development (Ayari et al., 2012). Puška et al. (2020) examined the relationship between independent factors (self-efficacy, metacognition, strategies, and goal setting) and dependent factors (social dimension and environmental structure). They concluded that these factors directly or indirectly contribute to student satisfaction. The study also noted the importance of considering other influences on student satisfaction, such as age, gender, and previous experience with technology. Alam et al. (2021) developed a framework with five factors to make online learning successful, including instructor, information, learner, system, and institutional factors. A study of Indian university students highlighted the positive impacts of instructor quality, course design, prompt feedback, and student expectations on satisfaction and performance (Gopal et al., 2021). Further research confirmed that self-regulation, self-efficacy, task value, and learning design are crucial for students' satisfaction (Yalçın and Dennen, 2024). While Gachigi et al. (2023), studied post-COVID e-learning and identified course delivery, modes

of assessment, sense of belonging, and technological quality as significant predictors of student satisfaction, underscoring the importance of these factors in the design of effective online learning environments. Similarly, during the pandemic, a survey was conducted at the University of Bacau (Romania) to assess the quality of online education. The survey targeted engineering students who required various online learning activities, including lectures, labs, and experiments. It showed general satisfaction with online learning, though some students were dissatisfied due to communication difficulties with instructors and discomfort from prolonged monitor exposure (Radu et al., 2020).

On the other hand, technology emerges as a crucial factor, significantly influencing the online learning experience. For example, Prasetya et al. (2020) stated that the speed and reliability of internet connectivity, and the quality of the hardware affect students' satisfaction with the online learning process. Similarly, Dinh and Nguyen (2020) noted challenges like poor internet quality affecting participation and satisfaction, but there is a potential for adapting to online methods through improved engagement strategies due to student dissatisfaction with online interaction.

Sun et al. (2008) showed that flexibility and technology play an important role in student satisfaction with online learning. Jiang et al. (2021) identified factors using the Technology Satisfaction Model to show that student satisfaction is strongly linked to their ability to manage computers and online learning platforms. Similarly, Njoroge et al. (2012) studied two aspects of technology in student learning that lead to satisfaction, identifying four key factors: preference, assessment, performance, and proficiency. The study emphasized that the availability and accessibility of technology are crucial when assessing student satisfaction with e-learning technology.

Other technological characteristics covered in the literature that influence students' satisfaction with online learning include the ease of operating necessary software, streamlined procedures, user-friendly interfaces, and high-quality media (Piccoli et al., 2001; Sun et al., 2008; Suryani et al., 2021).

A non-exhaustive list of recent significant contributions in this area includes Yu (2022), Maican et al. (2024), and AlBlooshi et al. (2023). In addition to literature review papers done by Zhao et al. (2022), Nortvig et al. (2018), Zeng and Wang (2021), and Refae et al. (2021).

In the literature, various factors affecting students' satisfaction with online learning have been identified. However, no study has yet provided a comprehensive framework that combines technology aspects with instructional and learning design specifically tailored to engineering students. This article aims to fill that research gap by mapping independent variables related to technology and classroom interaction that impact online learning in engineering disciplines. Engineering education involves extensive applications and practices in science, mathematics, and technology, requiring collaboration and engagement in diverse activities and projects. The main contribution of this study is to connect these variables to students' satisfaction with online learning, using a real case study at a college of engineering in the Gulf Region, and to examine the influence of different characteristics on online education preferences.

3 Methodology

Based on the reviewed literature, seven key variables were identified as contributing to satisfaction with online learning methods. These variables were processed through the research methodology to

pinpoint the critical factors affecting the satisfaction of engineering students. The methodology flow, represented in Figure 1, outlines the steps taken to achieve this objective.

Step one: defining variables and constructing the framework

The first step involved defining the variables to be tested and constructing the suggested framework. Seven preliminary factors that potentially affect online learning satisfaction were identified: availability of online learning services, online assessment tools, online interaction tools, online learning course flexibility, technical support, internet quality, and technology quality. Table 1 presents each variable's name, its definition, and the source from which it is adapted.

Based on the variable definitions and to cope with the defined methodology process, the preliminary research model is depicted in Figure 2 which maps the possible relationship between the independent and dependent variables.

Step two: basic statistical analysis

To ensure the validity of the identified variables, basic statistical analyses were conducted. This included Cronbach's Alpha Test to measure internal consistency and descriptive statistics to provide a summary of the data.

Step three: data analysis

The data analysis phase involved four different methods that are factor analysis, regression analysis, normality check, and ANOVA and *T*-test (Fox, 2015; Montgomery and Runger, 2010). The reason behind each method is defined as follows:

- *Factor analysis:* This was conducted to identify the latent factors behind the variables. Factor analysis helps in understanding the underlying relationships between the dependent and independent variables, which is exactly the purpose of this study. In addition, it helps in identifying hidden patterns and relationships between the variables by reducing the number of variables to a smaller set of factors, making the data easier to understand and interpret these factors and target them with improvement plans.
- *Normality, linearity, and homoscedasticity check:* Ensuring that the data follows a normal distribution which is crucial for the validity of the regression models.
- *Regression analysis:* Multiple linear regression analysis was performed to determine the influence of the latent factors on student satisfaction. Regression analysis is essential for understanding how different variables impact the dependent variable.
- *ANOVA and T-test:* ANOVA and *t*-tests were conducted to compare groups stratified by demographic factors such as age, gender, and the number of semesters studied online. These tests help in identifying any significant differences between groups.

Step four: results and discussion

The final step is finalizing and presenting a framework for engineering online learning satisfaction. This framework was developed based on the identified factors and their impact on student satisfaction, providing insights into how to enhance the online learning experience for engineering students.

3.1 Data collection

To follow the defined methodology a data collection is required for building a realistic framework. A newly developed survey, designed specifically for this case study, used a structured
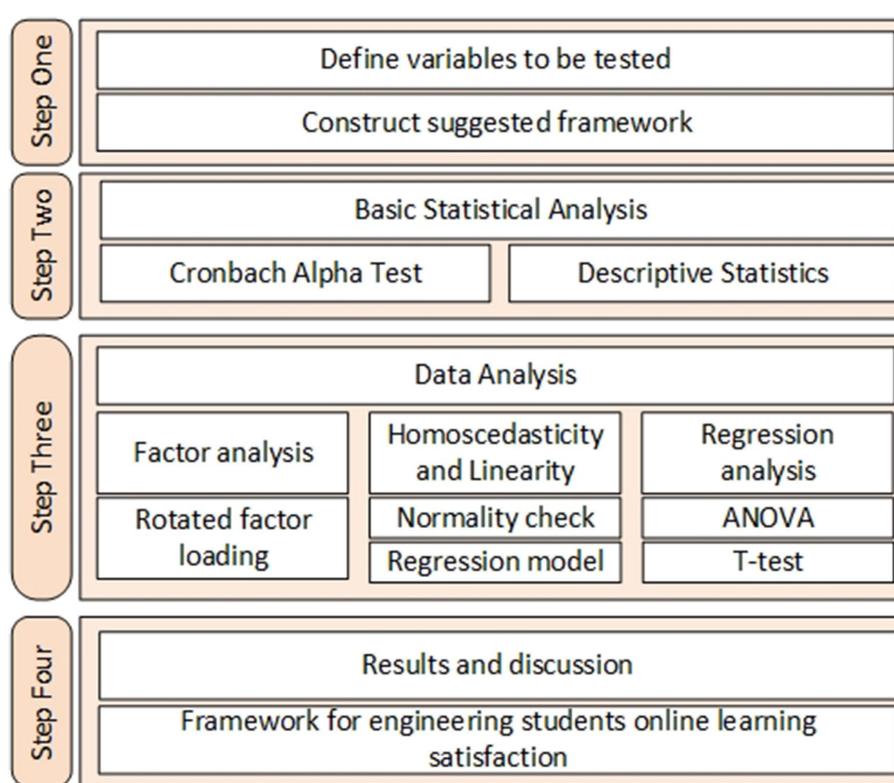
FIGURE 1
Research methodology.

questionnaire for data collection. The questionnaire is composed of two parts; the respondent information part (age, gender, major, and online learning experience) and the main question part using a 5-Likert scale (1 for the lowest satisfaction and 5 for the highest satisfaction). To ensure internal consistency in the instrument, three questions per variable were assigned, consisting of seven independent variables and one dependent variable (overall satisfaction). The reason for including three questions per variable is to facilitate the calculation of Cronbach's Alpha. This approach is commonly practiced by many scholars, as evidenced by Taber (2018). This resulted in a total of 24 questions presented in the English language, consistent with the instructional language used at the university. Additionally, an open-ended question was included at the end of the survey to gather feedback or comments from the students. This approach allowed respondents to provide comments that clarified the reasons behind their responses, facilitating further analysis. The distributed survey is presented in Appendix I.

Before the pandemic, the instruction method relied on the traditional face-to-face teaching method, encompassing both lectures and hands-on labs. The background of these students is mainly from traditional teaching method schools. On campus, students had access to various study areas that were equipped with computer devices tailored to the specific requirements of engineering coursework and featured uninterrupted WIFI connectivity. These designated spaces were accessible at any required time while the campus was open.

However, in the context of this study, students are reflecting on their experiences with online learning during the pandemic, a period in which the educational process shifted to a remote setting, and

students engaged in learning activities from home using personal devices. To cope with these challenges, the university management helped by providing laptop devices available to those in need, ensuring that everyone had the necessary technology for their studies during the pandemic and access to materials.

The used surveying technique to collect responses was a combination of Stratified Sampling and Convenience Sampling. The survey was distributed electronically to university students, with access restricted to university email accounts to ensure the authenticity and relevance of the respondents allowing only one-time access to it. Additionally, the survey was specifically sent to students who were admitted before or during the pandemic to ensure they had experienced both online and in-person classes at the university. This criterion was essential to gather comprehensive insights into their experiences and preferences regarding different modes of learning. To collect responses, the student population was divided into distinct subgroups based on their academic major, and academic classification. This stratification ensured that each major, and classification was adequately represented in the survey, providing a more accurate reflection in the collected feedback. Within each subgroup, a random selection process was initially intended to identify potential participants. However, given practical constraints such as time, accessibility, and the need to maximize response rates, Convenience Sampling was applied. This meant that responses were collected from those students who were willing to participate at the time of the survey distribution, and the survey was open for 2 weeks to collect responses. This hybrid approach allowed for a more efficient and practical data collection

process while still striving to maintain a representative sample from each demographic group.

As a result, in total 263 engineering students participated in the survey. Engineering students are enrolled in the engineering program at the university, which contains nine undergraduate programs and 11 graduate programs. The undergraduate programs include Architecture, Chemical Engineering, Civil Engineering, Computer Science, Computer Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering, and Mechatronics Engineering. While the graduate program includes Architecture, Chemical Engineering, Civil Engineering, Computer Science, Computer

Engineering, Electrical Engineering, Engineering Management, Environmental Engineering, Industrial Engineering, Material Science, and Mechanical Engineering.

As shown in Table 2, among the 263 participants, 238 were undergraduate students, 14 were master's students, and 11 were PhD students, all enrolled in the College of Engineering. The participants were representative of the engineering student population, encompassing a wide range of disciplines and academic levels. However, there were some differences among the three groups in terms of their distribution across the various programs. Due to the significant variation in the number of participants from different classifications (undergraduate, master's, and PhD), an analysis to identify differences between these groups was not conducted. The collected feedback reveals a significant gender disparity in responses, with 75% coming from female students and 25% from male students. This finding is further validated by examining the distribution of responses by major: 36% of the total responses were from Chemical Engineering students, and 34% were from Computer Science and Engineering students. These figures contrast with the actual population distributions in these majors, where approximately 75 and 60% of the students, respectively, are female.

3.2 Data analysis

Minitab 8.0 was used for data analysis. A Cronbach's alpha test was initially carried out to check the internal consistency of the questionnaire, which is a measure of reliability. As shown in Table 3, Cronbach's alphas for all variables were >0.6, which is considered in the acceptable range for exploratory research. These values prove the questionnaire is valid for analysis. In fact, values greater than 0.6 are considered in the acceptable range for exploratory research, while values above 0.7 are generally preferred for established research (Griethuijsen et al., 2015).

The scores for all variables were higher than 3 out of 5, demonstrating that the satisfaction rate among students is above satisfactory for all categories. The flexibility of the online learning course was the most satisfactory (4.34) and the online interaction tool was the least satisfactory (3.24). The overall satisfaction result was 3.44 out of 5. Therefore, to get a more clear conclusion, a box plot is performed to see the distribution of the data. Figure 3 presents a positive trend in satisfaction with key variables, including the availability of online learning, the flexibility of e-learning courses, technical support, the quality of the Internet, and the quality of technology.

TABLE 1 Online learning variables affecting online learning satisfaction.

Variable	Definition	References
Availability of online learning services	The availability of learning and support services provided to students, such as learning support.	Kim and Lee (2011)
Online assessment tools	Online tools are used to assess students' knowledge levels, such as blackboard tests, multiple choices, etc.	Thurmond et al. (2002)
Online interaction tools	Online software that is used to increase engagement, transmit expression, and deliver ideas during classes and meetings	Pituch and Lee (2006)
Online learning course flexibility	Learners can access resources when needed, with adaptability to the needs and preferences of each learner.	Arbaugh (2000)
Technical support	Having appropriate assistance to students for solving their curriculum and technical difficulties with accessing materials and email.	MacDonald et al. (2001)
Internet quality	Internet speed and connection properties	Sun et al. (2008)
Technology quality	Quality of the used hardware (computer, electronic tablets, etc.)	Sun et al. (2008)

FIGURE 2
Research suggested framework.

TABLE 2 Demographic information of the respondents.

Profile	Classification	Frequency	Percentage
Gender	Male	68	26%
	Female	195	74%
Age	18–22 years	189	72%
	23–27 years	55	21%
	28 years and above	19	7%
Level of education	First year	46	18%
	Second year	62	23%
	Third year	63	24%
	Fourth year	67	26%
	Master student	14	5%
	Ph.D. student	11	4%
Number of semesters studied online	One semester	37	14%
	Two semesters	49	19%
	Three semesters	115	44%
	Four or more	62	24%
Total		263	100%

TABLE 3 Cronbach's Alpha test and statistics.

Variable	Cronbach alpha	Average rating
Overall satisfaction	0.7879	3.44
Availability of online learning services	0.7770	3.87
Online assessment tools	0.7879	3.49
Online interaction tools	0.8072	3.24
Online learning course flexibility	0.7967	4.34
Technical support	0.8597	3.69
Internet quality	0.8658	3.83
Technology quality	0.6559	3.84

Notably, 75% of the data points for these variables are distributed above the value of 3 on the satisfaction scale. This signifies that a substantial majority of respondents express satisfaction levels exceeding the neutral point, indicating positive feelings toward the evaluated variables.

To assess the impact of various student characteristics on satisfaction, we performed a two-sample t-test stratified by gender and a one-way ANOVA based on age group and number of semesters studied. The results indicate that there is no statistically significant effect of classification factors on overall student satisfaction.

Then, exploratory factor analysis was conducted to identify the underlying structure of the data and to group related variables into factors, thereby simplifying subsequent analysis and interpretation. Exploratory factor analysis was chosen because the factor structure was not known beforehand and needed to be discovered, as suggested by the literature (Howard, 2023). Maximum likelihood extraction was performed to estimate the factors, and Varimax rotation was applied to achieve a simpler factor structure. A factor loading threshold of 0.4 was used to include only variables with significant relationships to the factors, following standard practices in factor analysis (Stevens, 2002). Based on the analysis Table 4 shows that technical support and

internet quality in factor 1, online assessment tools and online interaction tools in factor 2, and availability of online learning services and flexibility of online learning courses in factor 3 were identified.

Taking into account the common features of the variables in each factor, the latent factors are named as follows:

- Technical factor: This factor includes technical support, internet quality, and technology quality. These components are integral to the technical infrastructure and support required for effective online learning.
- Interactive factor: This factor includes online assessment tools and online interaction tools. Both elements are central to the interactive aspects of online learning, facilitating engagement, communication, and assessment.
- System service factor: This factor includes the availability of online learning services and the flexibility of online learning courses. These variables reflect the system's ability to provide accessible and adaptable learning options to students.

These factors are named according to the defining features of the variables they incorporate, ensuring clarity and relevance to the context of online learning. As a result, Figure 4 presents the updated framework, now incorporating factor analysis, and includes the associated variables to be tested in the upcoming regression analysis.

Then a multiple regression analysis was performed to examine the relationship between student satisfaction and independent variables. As a residual pre-test, a normality test was conducted at $\alpha = 0.05$. As shown in Figure 5, the residuals of the normality of the data were secured ($p = 0.299$) to use a linear regression analysis.

A homoscedasticity test was performed using a residual plot of overall satisfaction vs. fitted values as shown in Figure 6. The residuals were randomly scattered around the horizontal axis with no pronounced patterns, indicating randomness and centering around zero. This suggests that the model fits the data well. Additionally, the residual plot confirms that the assumption of linearity is largely satisfied. The random distribution of residuals around the zero line suggests that the relationship between the predictors and the response variable is well-represented by a linear model. Therefore, the data is suitable for regression analysis, meeting both homoscedasticity and linearity assumptions.

As shown in Table 5, the variance inflation factor (VIF) of all variables is <5, which shows that there are no significant multicollinearity issues with all variables. However, three independent variables (online learning course flexibility, technical support, and Internet Quality) were found to be not significant ($p > 0.05$) in the regression model.

After removing the insignificant variables from the model, the final regression model with four independent variables (availability of online learning services, online assessment tools, online interaction tools, and technology quality) was obtained as shown in the Equation 1.

$$\begin{aligned}
Overall\ satisfaction = {}& 0.623 \\
& + 0.3118\ availability\ of\ online\ learning\ services \\
& + 0.2342\ online\ assessment\ tools \\
& + 0.3133\ online\ interaction\ tools \\
& + 0.2673\ technology\ quality \qquad\qquad (1)
\end{aligned}$$

($R^2 = 63.83\%$ and $R^2_{(adjusted)} = 63.13\%$)

FIGURE 3
Box plot of students' satisfaction regarding the seven variables.
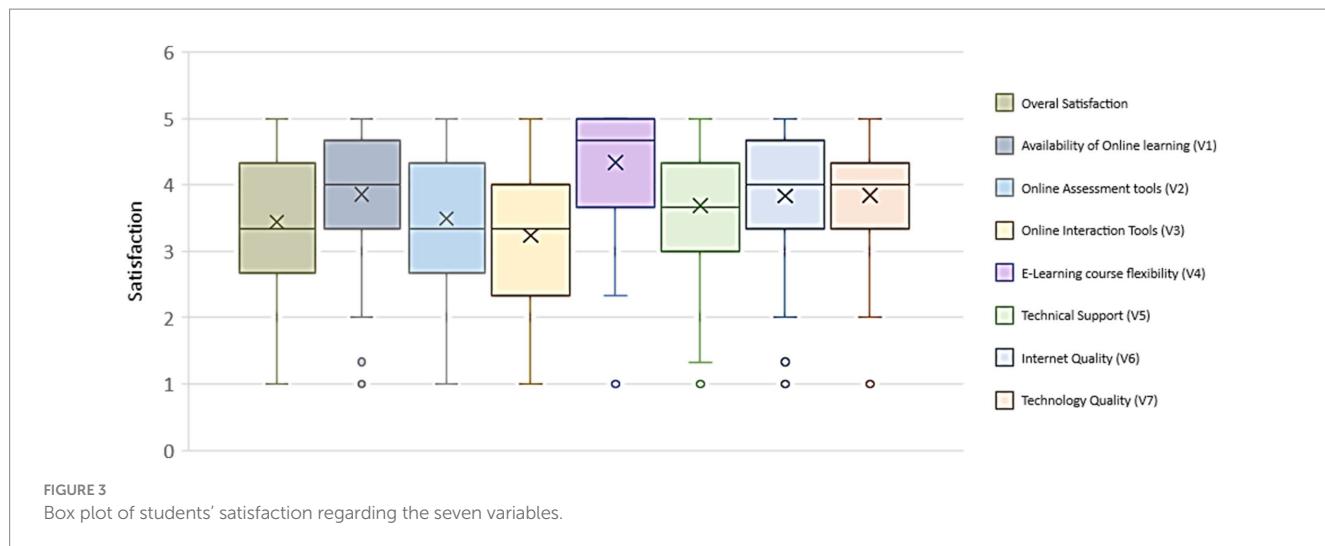
TABLE 4 Factor analysis.

Variable	Factor 1	Factor 2	Factor 3
Availability of online learning services			0.674
Online assessment tools		0.498	
Online interaction tools		0.937	
Online learning course flexibility			0.535
Technical support	0.528		
Internet quality	0.790		
Technology quality	0.640		

Four independent variables are significant at $\alpha = 0.05$ ($p < 0.05$) with no multicollinearity issue among the variables (VIF < 5), which shows the relevance of the regression model using the independent variables (Table 6).

According to the regression analysis, 63.83% of the variance in student satisfaction was explained by the regression model ($R^2 = 63.83\%$). Given the fact that there is no large difference between R^2 (63.83%) and $R^2_{(adjusted)}$ (63.13%), it was found that there is no significant over-fitting issue. Online interaction tools (0.3133) and availability of online learning services (0.3118) showed greater contributions to increasing student satisfaction with online learning than online assessment tools (0.2342) and quality of technology (0.2673) to increase online learning experience.

4 Results and discussion

First, from the analysis, we can conclude that student characteristics such as gender, age group, and number of semesters studied do not have a statistically significant impact on overall student satisfaction. This suggests that these classification factors do not contribute meaningfully to variations in satisfaction levels among students.

Secondly, we can see that several key factors significantly affect the satisfaction of engineering students with online learning. From the regression analysis, these variables include the availability of online

learning services, online assessment tools, online interaction tools, and technology quality, resulting in the framework presented in Figure 7. The framework presents the grouping factors and the variables. The factor analysis was conducted to enhance the reliability of the framework by grouping variables into distinct latent factors. This approach provides a structured overview of the data but does not imply that only the identified variables influence these factors. Other variables may also affect the latent factors, which warrants further investigation. While incorporating a regression analysis with the latent factors as independent variables could yield a more comprehensive understanding of their relationships and effects, the primary focus of this study was on assessing the impact of individual variables. The survey questions were specifically designed to evaluate these variables directly, rather than the latent factors themselves.

In-depth exploration of the latent factors was beyond the scope of this paper. Our primary aim was to analyze the effects of the individual variables. The latent factors were included as additional insights to refine the framework and provide a foundation for future research by other scholars.

This is justified as it plays a crucial role in shaping the overall perception of online lectures among engineering students. Furthermore, these variables directly influence the effective delivery and interpretation of online educational content during online lectures that used to be done face-to-face. Other variables such as technical support, flexibility of the online course, and quality of the Internet were integral components of the educational process even before the pandemic.

The university has been providing students with comprehensive access to learning materials through platforms such as Blackboard. In addition, a robust technical support system, facilitated by an IT helpdesk, was always available to students at all times. Additionally, the campus and various locations throughout the country, including study areas, coffee shops, and, in general, each residence, have consistently offered high-quality Internet access.

Therefore, the analysis suggests that the satisfaction of engineering students with online learning is closely related to these variables, emphasizing the importance of continued support and enhancement of these variables for an optimal online learning experience.

FIGURE 4
Research suggested framework with factor analysis.

FIGURE 5
Normality check with residuals.
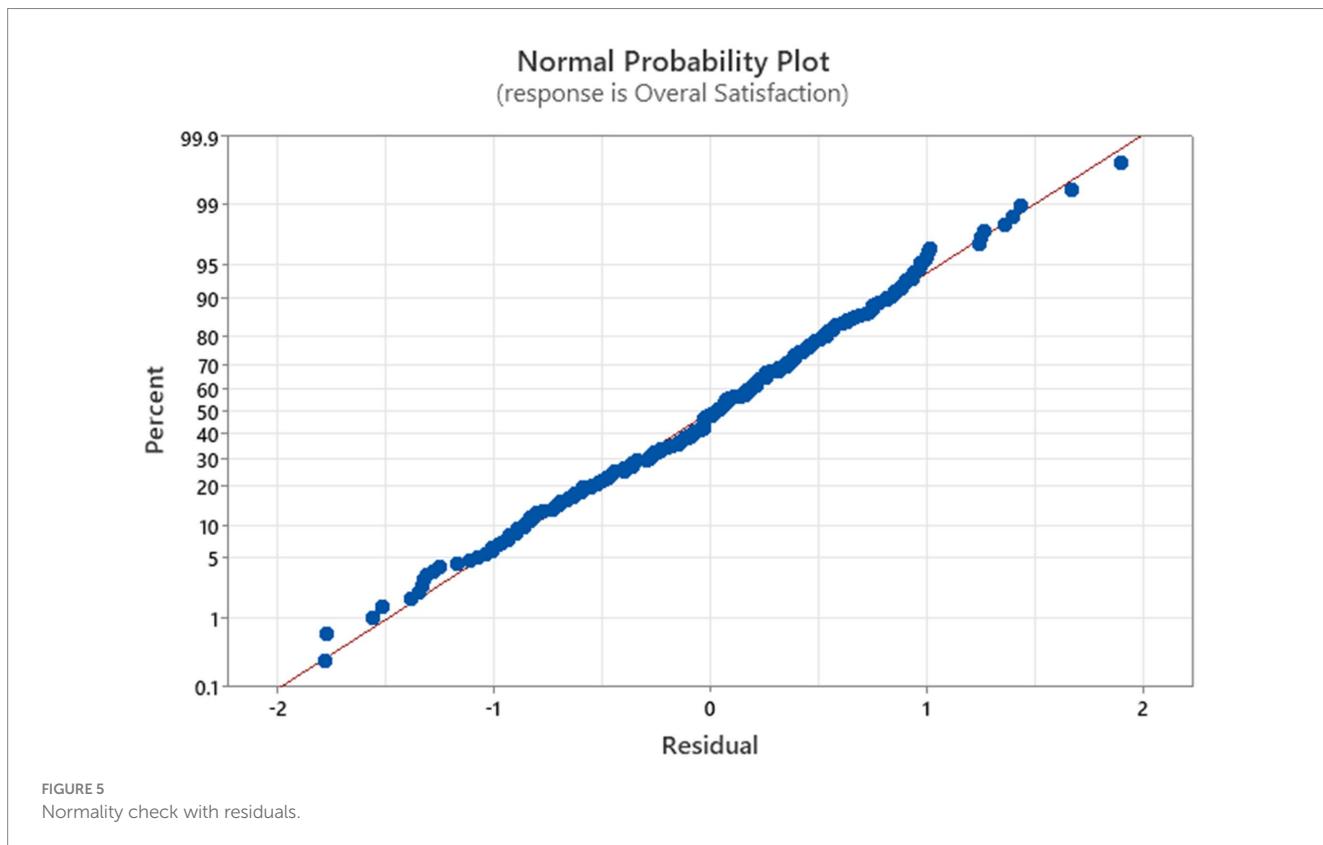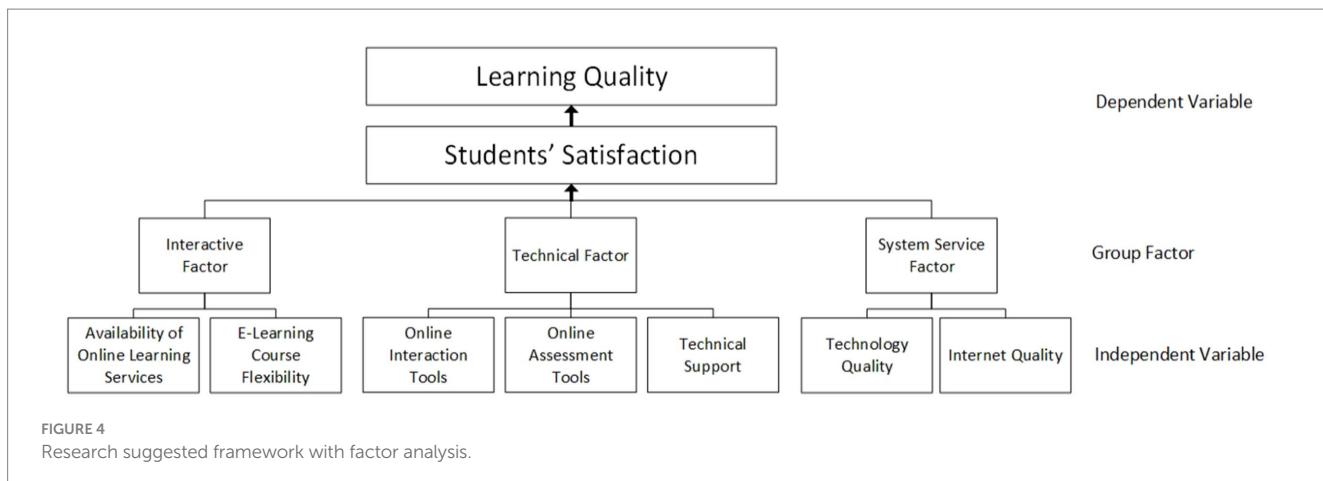
The results indicate that the quality of interactions, communications, and services between students and instructors affects the online learning experience as much as technical quality. This is consistent with the fact that online learning differs from offline learning primarily in terms of interactions, communication, and services, as opposed to the physical environment. Based on students' feedback in the open-ended question (shown in Appendix I), it is beneficial to use similarity or likeness-based metaphors of offline learning as much as possible. The advantage lies in reducing the disparity between face-to-face and online learning, particularly in mitigating the loss of facial expressions and interactive elements. This can be achieved by incorporating emoticons or animations in communications to mimic offline interactions or communications, demonstrating a classroom or a meeting room with a

graphic layout that stimulates the affordance of the interaction tool in the environment. Furthermore, based on student feedback, they expect online communication to be similar to offline communication in classrooms, meeting rooms, and laboratories. The main effort to improve online learning should be given to improving communication clarity and speed, considering that two main measures to assess communication quality are transmitted information (transmitted entropy) and channel capacity (Lehto and Landry, 2012). For example, the implementation of a live support service can help users resolve misunderstandings that occur for engineering students, such as using WebEx Board. WebEx Board, an interactive whiteboard designed for virtual meetings and presentations, serves as a hub for online collaboration and communication. Upgrading the WebEx Board with a
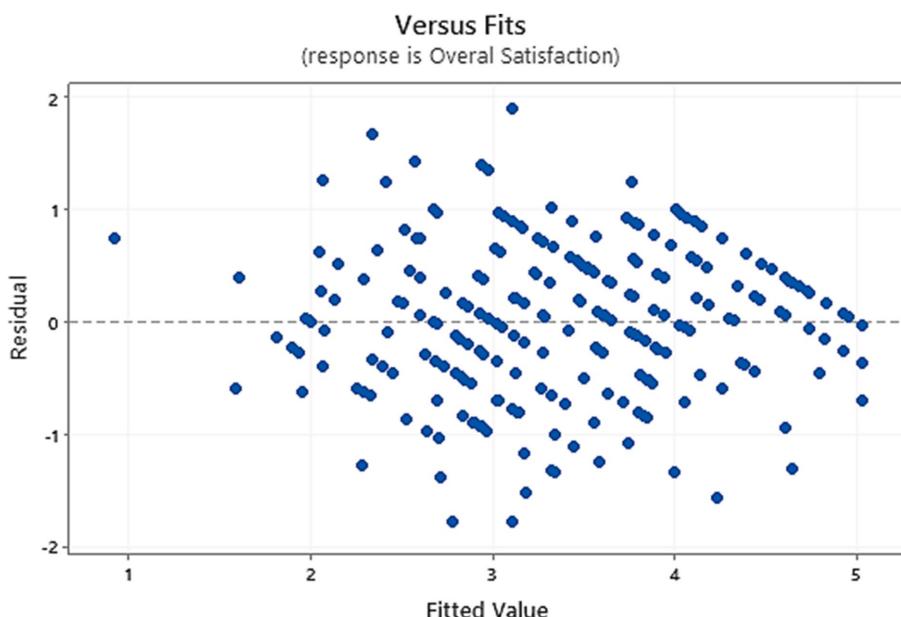
FIGURE 6
Homoscedasticity test.

TABLE 5 Regression analysis specifications.

Term	Coef	SE Coef	T-value	p-value	VIF
Availability of online learning	0.31	0.06	4.88	0	1.9
Online assessment tools	0.22	0.06	3.81	0	2.02
Online interaction tools	0.30	0.05	5.47	0	2.21
E-learning course flexibility	−0.01	0.07	−0.27	0.784	1.64
Technical support	−0.001	0.06	−0.02	0.987	1.95
Internet quality	0.101	0.06	1.72	0.086	1.82
Technology quality	0.21	0.07	3.15	0.002	1.93

wireless presentation screen, a digital whiteboard, and an audio/video conferencing system can improve online interactions. This enhancement can also capture a virtual image of the room, facilitating nonverbal communication through body language or facial expression, which is missing in applications such as WebEx or Teams which are just conferencing platforms.

As a result, this adaptation to online learning results more easily and efficiently in improving online learning satisfaction among engineering students. However, considering that technical quality improvement takes time and cost. Moreover, enhancing online learning satisfaction presents a challenge in training users, both instructors and students, on the specialized tools and pedagogy tailored for online education. The use of multiple tools often leads to difficulties in navigation and utilization.

Linear regression analysis found that about two-thirds of online learning satisfaction is affected by the quality of online learning services, online assessment tools online interaction tools, and quality of technology. Interestingly, software components such as the availability of online learning services and online interaction tools contribute more to online learning satisfaction than technical quality.

Evaluation is a challenge in online learning, although it is one of the significant factors in the regression model. There is no perfect way to monitor a test due to issues such as cheating, privacy, and system failure, which are context, culture, or technology-dependent.

Technology improvements based on virtual reality, artificial intelligence, machine learning, and the fifth-generation mobile network (5G) are expected to partially reduce the aforementioned issues (communication barriers, assessment invigilation, etc.) (Kumar et al., 2022).

Although online learning is not new, it had not been implemented worldwide until the COVID-19 pandemic broke out. The pandemic is pushing societies to utilize technological advancements. Online learning was urgently implemented without prior preparation, like most universities around the world. This study showed that students were fairly satisfied with online learning, although it needs improvements in services, tools, technologies, and assessments. Without a doubt, online learning is not just a short trend due to COVID-19, and it is expected to continue along with offline learning, supplementing each other's drawbacks. The role of online learning is expected to increase even after the pandemic ends.

TABLE 6 Specifications of the four significant independent variables.

Term	Coef	SE Coef	t-value	p-value	VIF
Availability of online learning services	0.31	0.22	5.04	< 0.001	1.73
Online assessment tools	0.23	0.06	4.11	< 0.001	1.92
Online interaction tools	0.31	0.05	5.86	< 0.001	2.02
Technology quality	0.26	0.05	4.55	< 0.001	1.42

FIGURE 7
Framework for online learning satisfaction in engineering disciplines.
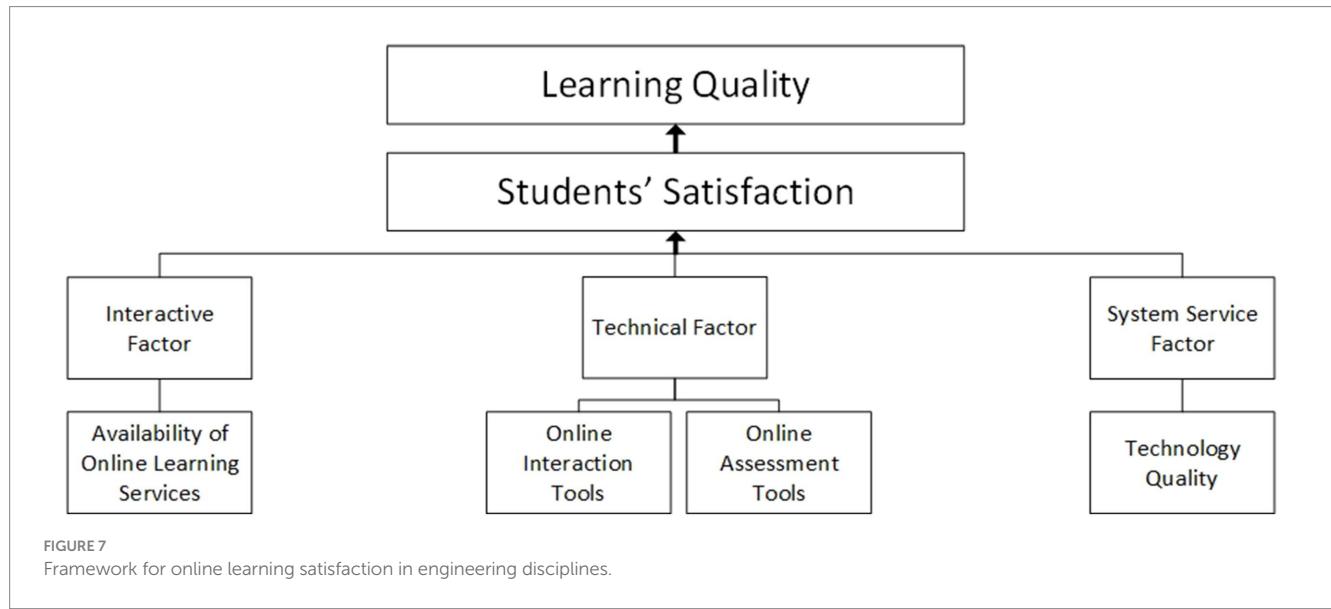
Finally, following a comprehensive review of the relevant literature, we have identified a notable gap in research concerning the impact of various factors on engineering students, particularly those engaged in advanced mathematical and laboratory-based coursework. To date, there appears to be no study that specifically examines how variables such as the availability of online learning services, online assessment tools, online interaction tools, and technology quality affect engineering students who traditionally rely on face-to-face instruction due to the complex and hands-on nature of their studies. This gap is significant given that engineering education has always involved in-person interactions with the practical and mathematical aspects of the discipline. Therefore, any attempt to compare our findings with existing research may not be appropriate, as our study is the first of its kind in its exploration of this relatively unexplored area. The novelty of this study lies in its focus on understanding how engineering students interact with online learning environments and identifying critical factors that influence their online educational experience. Key areas of interest include the availability and effectiveness of online learning services, the utility of online assessment tools, the functionality of online interaction tools, and the overall quality of technology used in online learning settings. These factors are crucial for developing effective online learning strategies tailored to the needs of engineering students.

5 Conclusion and limitations

This research presents a framework for understanding the factors influencing online learning satisfaction in engineering disciplines. The study utilized real-case data from a college of engineering, with a total of 263 students participating from different engineering disciplines. These students engaged in both online and in-person learning throughout their studies. Various statistical methods were employed, including Cronbach's alpha test, descriptive statistics, factor analysis, regression analysis, normality checks, regression modeling, ANOVA, and t-tests. The findings indicate that satisfaction with online learning was consistent across different student groups, with no significant differences based on demographic factors such as age, gender, or duration of online learning experience. Through exploratory factor analysis, the study identified technical factors, interactive factors, and system service factors as key variables enhancing online learning satisfaction. After conducting regression analysis and removing insignificant variables, the final model revealed that four key independent variables significantly impact satisfaction: availability of online learning services, online assessment tools, online interaction tools, and technology quality. This comprehensive framework, which integrates both factor and regression analyses, is designed to improve students' satisfaction with online learning by focusing on these critical factors. As a result, the study presents a comprehensive framework designed to improve students' satisfaction with online learning by focusing on these critical factors.

While this study offers valuable insights into factors affecting engineering students' satisfaction with online learning, it has several limitations that should be addressed in future research. First, future research should include a broader range of variables,

such as the impact of long-term technology use and its influence on student interactions. Second, the study's focus on the Gulf Region may not be generalizable to other regions; thus, surveying a larger and more diverse population could validate the findings. Additionally, the study did not explore the perspectives of academic educators, which could offer valuable insights into the perceived effectiveness of online teaching methods. Moreover, a comparative study should examine these factors across various disciplines to identify any differences or similarities in their impact on student satisfaction. Finally, future research should examine personal and intellectual factors, such as individual traits and mental or physical challenges, which could significantly impact the online learning experience. Addressing these limitations will enhance understanding and contribute to the development of more effective online learning strategies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The research protocol was reviewed and approved by the Institutional Review Board (IRB) at Qatar University under the reference number QU-IRB 042/2024-EM. Written informed consent from the (patients/ participants OR patients/participants legal guardian/next of kin) was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

MA-K: Writing – original draft. AA: Writing – original draft. MT: Writing – original draft. AK: Writing – original draft. MA: Writing – review & editing. PC: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1445885/full#supplementary-material

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Enriching computing identity frameworks: integrating current constructs and unveiling new dimensions for today's tech-savvy world—a systematic review

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This systematic review seeks to improve the existing framework for developing students' Computing Identity (CI) by integrating contemporary elements and identifying new dimensions. A meticulous selection of 31 articles followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, ensuring a comprehensive and systematic approach. The findings highlight factors that influence students' CI and also the constructs defining the frameworks for developing students' CI. The identified existing constructs are competence/performance, interest, sense of belonging, and recognition in computing, with competence/performance being the most explored and recognition the least. The review proposes a new framework for developing students' CI that includes the "social context" as it interweaves with existing constructs to shape the multifaceted process of CI formation. The findings underscore a research gap concerning the inclusion of diverse perspectives, which is essential for a richer understanding of CI. Additionally, the study emphasizes the potential to incorporate new elements to enhance the existing frameworks for developing students' CI, along with its validation in diverse contexts.

KEYWORDS

computing identity frameworks, computing identity, computing identity constructs, identity, systematic review

Introduction

A critical factor influencing enrollment and continuity in any academic field is students' disciplinary identity—how they perceive themselves within a specific discipline. This concept has garnered attention in academic discussions (Cribbs et al., 2015; Hazari et al., 2010). Identifying identity within a discipline plays a vital role in understanding students' self-perceptions, which significantly impact their learning, perseverance, and professional aspirations (Mahadeo et al., 2020). In today's tech-savvy world, the rising demand and appeal of computer science (CS) continue to grow significantly. In today's rapidly evolving digital landscape, possessing certain skills and competencies is essential for individuals to thrive in various domains. Tech-savvy pertains to a strong understanding and proficiency in utilizing technology effectively, such as navigating digital platforms, engaging with various digital tools,

and leveraging technology to enhance productivity and efficiency (Yu et al., 2022). In the high-tech era, being tech-savvy is increasingly associated with perceptions of effective leadership, who can understand and harness the potential of emerging technologies, enabling them to make informed decisions and drive innovation (Nagpal et al., 2023). In this context, the development of a strong computing identity (CI) is crucial, particularly for underrepresented groups in CS and STEM fields. CI refers to an individual's sense of belonging and identification with the field of CS (Rodriguez and Lehman, 2017). Cultivating a positive CI can significantly influence one's academic persistence and commitment to pursuing a career in technology-related fields.

Scholars have considered CI as something individually possessed, constructed, or negotiated through interaction (Kinnunen et al., 2018). To comprehend how CI is developed, it is crucial to examine the framework for developing CI (referred to as CI framework). A widely acknowledged framework for developing students' CI comprises four key constructs: competence/performance, recognition, interest, and a sense of belonging (refer to Figure 1) (Taheri, 2019; Taheri et al., 2018). Various constructs within the CI framework are defined as follows. "Performance/Competence" pertains to a student's belief in their capacity to understand, execute, and achieve success in computing endeavors (Çakır et al., 2017). "Interest" signifies the level of passion, motivation, or curiosity that students hold toward

computing and related fields. The "recognition" element relates to how students self-recognize and perceive others' opinions or viewpoints about their computing abilities (Çakır et al., 2017). "Sense of Belonging" refers to students' perceptions of their fittingness within the computing community. It involves feeling accepted, valued, and supported in the social environment associated with computing (Çakır et al., 2017; Boyer et al., 2010).

However, various studies have approached the development of these CI frameworks differently. For example, Mahadeo et al. (2020) proposed three CI constructs—belief in one's performance/ competence, interest, and recognition in computing—to form a framework for developing students' CI. Their research demonstrated that a CI defined by these constructs significantly predicted students' choices of careers in CS-based fields (Mahadeo et al., 2020). In contrast, studies by Taheri (2019) and Taheri et al. (2018) encompassed a broader spectrum by including four CI constructs: belief in one's performance/competence, interest, sense of belonging, and recognition of persistence in CS-related fields. Washington et al. (2016) devised the Computer Science Cultural Attitude and Identity Survey (CSAIS) to evaluate students' attitudes and identity in CS, employing the elements of "confidence" and "interest". Similarly, the framework, used to prioritize K-12 computing curricular standards, was developed based on constructs such as technical excellence in CS, leadership, civic engagement and service, and community outreach
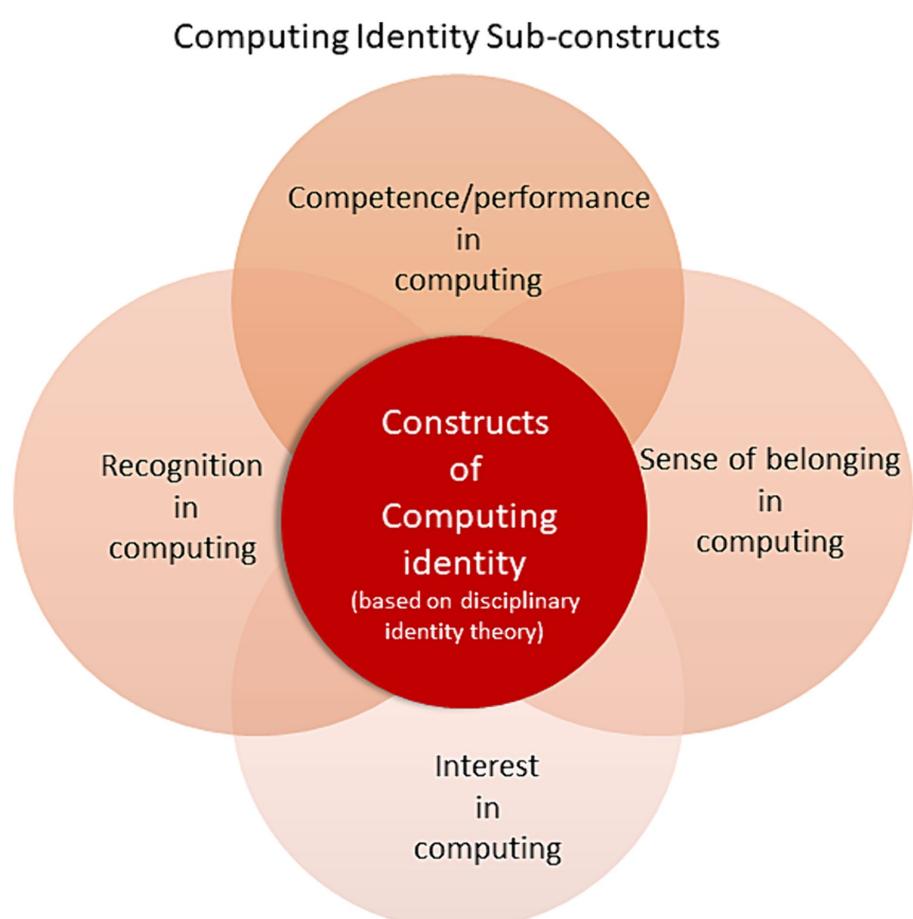
FIGURE 1
CI sub-constructs, including competence/performance, recognition, interest, and sense of belonging (5).

(Bell-Watkins et al., 2009). These differing approaches in constructing the framework for developing students' CI highlight the absence of consensus in conceptualizing and operationalizing CI constructs. Such differences in approach pave the way for a richer understanding of CI, by embracing diverse viewpoints and contributing to a dynamic landscape, aiming to formulate a comprehensive and universal framework. Although limited research has been conducted on CI frameworks, there has been considerable work on engineering identity, that could help gain a holistic overview (Capobianco et al., 2012; Mangu et al., 2015; Morelock, 2017; Patrick and Borrego, 2016). The engineering identity framework is often defined as a combination of cognitive, affective, and performance variables, which is significantly influenced by social context. According to Morelock (2017), engineering identity formation stems from related experiences, and environmental and social aspects. The perspectives on engineering identity frameworks solicited from students include their problem-solving ability, technical knowledge in math and science, creativity and innovation, communication and collaboration, integrity and ethics, and the positive social application of knowledge (Morelock, 2017).

The current review's theoretical foundation rests on the underpinning principles found in social-cognitive theories and disciplinary identity theories, which often form the core of CI research. Identity theories often intertwine with social theories, as students' identities and actions are influenced by their socially constructed environment, norms, regulations, and societal expectations. Previous studies investigating students' learning, retention, and persistence in CS have delved into various social determinants encompassing personal factors such as age, gender, nationality, family background, environmental factors related to school settings, and the support received from peers and teachers. Additionally, motivational factors like expectations and self-efficacy have been considered in these studies (Mangu et al., 2015; Bahar and Adiguzel, 2016; Dabney et al., 2013; Nugent et al., 2015; Sahin et al., 2015). Indeed, research on CIs frequently relies on a widely utilized framework among researchers to elucidate the processes involved in educational and career decision-making: Bandura's social cognitive career theory (SCCT) (Lent et al., 1994; Lent et al., 2000). SCCT stands as a popular theoretical model showcasing the influence of personal, environmental, and motivational factors on educational and career choices, as well as persistence and satisfaction within these domains. This theory emphasizes the substantial impact of these elements on individuals' choices and their levels of contentment within educational and career trajectories. While, identity theories outline how students' perceptions of their competence/performance, recognition, interest, and sense of belonging contribute to the formation of their identities (Taheri et al., 2018). When assessing the CI theory, the initial conceptualization has primarily focused on evaluating the degree to which students perceive themselves as individuals aligned with the identity of computer scientists or computing individuals (Taheri, 2019).

Despite extensive research focusing on identifying students' disciplinary identities in areas like STEM, science, engineering, and mathematics (Cribbs et al., 2015; Capobianco et al., 2012; Patrick and Borrego, 2016; Aschbacher et al., 2010; Kim et al., 2018), work is scarce in the realm of computing (Bell-Watkins et al., 2009; Smith et al., 2005; Galliher et al., 2017). Also, researchers have highlighted

the need for an enhanced intersectional framework for developing CI, to support diversity and inclusion in the tech industry (Rodriguez and Lehman, 2017; Rodriguez et al., 2020). Thus, this systematic review aims to bridge this gap by comprehensively exploring all literature related to CI and its associated constructs. The research explores existing frameworks for developing students' CI, aiming to offer valuable insights into the current factors and potential new elements that contribute to fostering students' CI. The primary research questions (RQs) guiding this study are:

> RQ 1: What factors have been linked to CI development?
> RQ 2: What are the established constructs influencing/defining the frameworks for developing students' CI?
> RQ 3: What potential additions could further enrich these frameworks to align with the requisites of today's tech-savvy world?

Methodology

Search strategy

To comprehend the factors influencing CI formation, a systematic review has been conducted (Pantic and Clarke-Midura, 2019). For this, eligible research articles were consolidated using common web search engines such as "Web of Science," "Journals for Educational Research Information Center (ERIC)," and "Scopus." Specific keywords were included for searching the articles with explicit operators (AND or OR "*"), i.e., [("CI" OR computer science identity" OR "computational identity" OR "programming" OR "coding") AND ("framework" OR "identity") AND ("computer science" OR "IT" OR "ICT" OR "engineering" OR "information technology" OR "computer engineering")]. A systematic literature review technique aligning with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was followed (Page et al., 2021). PRISMA is an evidence-based protocol for reporting in systematic reviews and meta-analyses.

Drawing on PRISMA methodology, the screening of relevant studies was executed in three stages (refer to Figure 2). In the initial search, a total of 985 papers were identified using the keyword search: Scopus ($n = 330$), ERIC ($n = 314$), and Web of Science ($n = 341$). Five hundred and forty-five articles were discarded due to duplication. Studies were selected through an initial review of titles and abstracts to gage relevance, followed by a rigorous examination of contextual alignment and sample description in adherence to inclusion and exclusion criteria. This methodical process ensured that only articles closely pertinent to computing identities and meeting predefined standards were included in the review.

Inclusion/exclusion criteria

The criteria used for article selection in this study were stringent and aimed at ensuring a focused exploration of computing identities within relevant disciplines such as computer science and IT. Included articles were restricted to those published in English up to January 2023, encompassing both journal articles and conference papers. Conversely, exclusion criteria were applied

PRISMA Flow Diagram for Study Selection

Identification

Total Records identified (*n* = 985)
Scopus (*n* = 330)
ERIC (*n* = 314)
Web of Science (*n* = 341)

→ **Records removed:**
Duplicate records removed
(*n* = 545)

Screening

Records screened for (*n* = 440)
•Papers with Computing identities
•Subjects like CS, IT, Computing.
•Extracted from 2000-2023 January
•Articles, conference papers, reports.
•Articles in English.

→ **Records excluded due exclusion criteria (*n* = 244)**
•Identities for science subjects (e.g., cyber security, data science, cloud computing, Physics, Chemistry, Biology,)

Reports sought for retrieval (*n* = 196)

→ **Reports not retrieved (*n* = 15)**

Reports assessed for eligibility (*n* = 181)

→ **Reports excluded (*n* = 150)**
•No sufficient information on computing identity
•No sufficient information on constructs of computing identity
•Study results with non-student variables (e.g., teachers' perception, parents/peers' insights, author's opinions, etc.)

Included

Studies included in review (*n* = 31)

FIGURE 2
PRISMA 2020 flow diagram revealing the inclusion–exclusion criteria for studies included in the meta-analysis (28).

rigorously, excluding articles lacking comprehensive information on CI or its constituent constructs. Studies not centered on variables directly impacting students, such as opinions unsupported by empirical research or studies focusing on perspectives from teachers, parents, or peers, were also excluded. Additionally, posters, doctoral consortium articles, and publications shorter than two pages were deemed ineligible for inclusion. Adherence to the PRISMA methodology guided this thorough selection process, resulting in the inclusion of 31 meticulously chosen articles that met the study's exacting criteria (Figure 2).

Coding procedure

Two experienced authors with over 15 years of educational research background undertook the coding of the studies. Each paper was individually reviewed, and the data extraction process utilized the content analysis technique and subsequently, an interrater-reliability test was conducted to assess the level of agreement between the two coders. Cohen's kappa statistic was employed for inter-rater reliability analysis, yielding a value of 0.93, indicative of "almost perfect

agreement." Any occasional discrepancies between the coders were addressed through discussions and consensus.

Shortlisted articles

Supplementary Figure S1 shows the number of articles shortlisted by (A) the type of document, (B) study design, (C) educational level, (D) year of publication, and (E) country of publication. Supplementary Figure S1A demonstrates an almost equal proportion of peer-reviewed and conference articles selected in our review (refer to Supplementary material). Most articles employed a quantitative research design (Supplementary Figure S1B). Most of the articles incorporated participants at the school level (*n* = 20) (Supplementary Figure S1C). The maximum number of relevant articles were published in 2018, 2019, 2021, and 2022, revealing that CI is an underexplored and emerging field of research (Supplementary Figure S1D). Finally, Supplementary Figure S1E shows that most studies were conducted in the U.S.A. (*n* = 19), followed by Hong Kong (*n* = 3).

Supplementary Table S1 illustrates the descriptive features of the 31 studies shortlisted for the review: (a) Studies, (b) study design, (c)

participants, (d) CI constructs, (e) CI sub-constructs, (f) study results, and (g) country of publication (refer to Supplementary material).

Results and discussion

CI is an important predictor of students' enrollment, persistence, retention, and career choices in CS and related fields. Arguably, the CI framework will help assess/develop CI formations. While numerous researchers have delved into CI contents, processes, and relationships using diverse methodologies and theoretical frameworks, there remains a gap in the literature (Bell-Watkins et al., 2009; Smith et al., 2005; Galliher et al., 2017). Specifically, there is a deficiency in cohesive knowledge regarding universal CI constructs, and there is a need for literature (review studies) that consolidates existing insights while proposing new additions. Such an approach is essential to create a clearer and more comprehensive understanding of the contributing constructs in the establishment of frameworks for developing students' CI. Therefore, this section offers a detailed analysis and discussion of articles, addressing the proposed RQs.

RQ 1: what factors have been linked to CI development?

To fully grasp the factors influencing the CI framework, it is essential to initially evaluate the influential determinants of CI. Through thorough examination, four established constructs, albeit with varying terminologies, have been identified as pivotal determinants of students' CI. These constructs encompass competence/performance, interest, sense of belonging, and recognition within the computing/programming fields, and have been elaborated upon subsequently (Table 1). The findings indicate that perceived competencies/performance in CS are the most examined constructs of CI with 28 articles ($\approx$ 90%) addressing this topic. In contrast, perceived recognition in CS is the least explored, with only 9 articles ($\approx$ 29%). Interest in CS and a sense of belonging in CS are covered in a similar number of articles, 23 ($\approx$ 74%) and 22 ($\approx$ 71%) respectively (Table 1).

Competence/performance in CS

Competence/performance in CS has been identified as one of the constructs influencing CI formation ($n = 28$). When individuals develop proficiency in CS (skills and knowledge), they often begin to identify themselves more strongly associated with the field of computing. Various research studies have used different subscales of related terminologies to define this construct. For instance, terms such as competence in CS (Mahadeo et al., 2020; Taheri, 2019; Taheri et al., 2018; Lunn et al., 2021a,b; Mooney et al., 2018; Parker, 2018), self-efficacy in CS (Deechuay et al., 2016; Hughes et al., 2021; Wofford et al., 2022; Zahedi et al., 2021), performance in CS (Taheri, 2019; Taheri et al., 2018; Hughes et al., 2021; Rollins et al., 2021), confidence in CS (Çakır et al., 2017; Washington et al., 2016; Wofford et al., 2022), ability and knowledge in CS (Kapoor and Gardner-McCune, 2019a; Kapoor and Gardner-Mccune, 2022; Peters and Pears, 2013), experience with computers (Rawhiya Jacob et al., 2022), programming

actualization & goal setting (Atman Uslu, 2023; Kong and Lai, 2022; Kong and Wang, 2020), and excellence & leadership in CS (Boyer et al., 2010; Bell-Watkins et al., 2009) have been utilized. A relatively new term of "programming actualization" refers to students employing programming for more elevated and meaningful objectives, thereby facilitating their self-actualization processes (Atman Uslu, 2023; Kong and Lai, 2022; Kong and Wang, 2020). Researchers claim that enhanced computer usage is often linked to better confidence in CS (Tupou and Loveridge, 2019). Additionally, improved confidence and competence with computers lead to a positive attitude in CS, thereby shaping their CI formation (Washington et al., 2016).

Interest in CS

Interest in CS has been recognized as another construct influencing CI formation ($n = 23$), often relating to individuals' willingness to engage deeply within the realm of computer-related tasks and challenges. Authors have defined interest in CS in terms of their self-interest in CS (Mahadeo et al., 2020; Kinnunen et al., 2018; Taheri, 2019; Taheri et al., 2018; Washington et al., 2016; Lunn et al., 2021a,b; Rollins et al., 2021; Kapoor and Gardner-Mccune, 2022; Garcia et al., 2018; Kapoor and Gardner-McCune, 2019b), self-determination in CS (Wofford et al., 2022), engagement in CS (Çakır et al., 2017; Bell-Watkins et al., 2009; Parker, 2018; Peters and Pears, 2013; Kong and Lai, 2022; Kong and Wang, 2020), enjoyment in CS (Zahedi et al., 2021; Kapoor and Gardner-Mccune, 2022; Kapoor and Gardner-McCune, 2019b), satisfaction in CS (Kapoor and Gardner-Mccune, 2022; Kapoor and Gardner-McCune, 2019b), motivation to explore and learn in CS (Wofford et al., 2022; Zahedi et al., 2021), participation and imagination in CS related tasks (Tupou and Loveridge, 2019), and initial positive expectation of university and computing careers (Kinnunen et al., 2018). Kapoor and Gardner identified several factors contributing to students' dedication and interest in pursuing a career in computing. These include their intrinsic interest that stems from engagement in informal activities like hackathons, and participation in professional development opportunities such as internships and conferences (Kapoor and Gardner-Mccune, 2022; Kapoor and Gardner-McCune, 2019b). Frequent computer gameplay was reported to be strongly associated with an increased probability of CS career interest (Shah et al., 2023). According to Peters and Pears (2013), the trajectories of practices that lead to engagement in CS often instigate computer usage. Furthermore, the shift from computer usage to computer programming leads to further engagement in CS (Peters and Pears, 2013). Thus, researchers have concluded that students' engagement in CS will likely impact their perception of being a part of the computing community and eventually impact their CI formation (Peters and Pears, 2013; Tupou and Loveridge, 2019).

Sense of belonging in CS

Another construct, i.e., a sense of belonging, often described as the feeling of "fitting in," plays a critical role in nurturing student interest and persistence ($n = 22$). This concept extends beyond mere inclusion to encompass how individuals perceive their alignment with future career roles in CS and their broader societal roles. To study

TABLE 1 Study descriptive based on CI constructs that have been employed or investigated.

Study	Constructs influencing CI				
	Competencies/performance	Interest	Sense of belonging	Recognition	Social context
Washington et al. (2016)	Confidence in CS	Interest in CS	Perception of CS professionals		Ethnic identity
Atman Uslu (2023)	Programming actualization	Programming engagement	Programming imagination and affiliation		Gender disparity
Bell-Watkins et al. (2009)	Excellence and leadership in CS	Engagement in CS	Sense of belonging		Community Outreach, Civic engagement and service
Boyer et al. (2010)	Excellence and leadership in CS				
Çakır et al. (2017)	Confidence and competence	Engagement in CS	Sense of belonging		
Cummings et al. (2019)	Programming resilience, self-efficiency		Sense of belonging		Personal and social identities, support from parents and teachers
Deechuay et al. (2016)	Computing self-efficiency				Parental support
DuBow et al. (2017)	Persistence		Sense of belonging		Support from parents and teachers
Garcia et al. (2018)	Competence in CS	Interest in CS		Recognition by self, family, friends, teachers in CS	
Jacob et al. (2022)	Experience with computers		Perception of CS and computer scientists		Support from parents, friends and teachers, informal learning environments
Kapoor and Gardner-McCune (2019a)	Ability and knowledge in CS	Interest, enjoyment, and satisfaction			informal activities, internships, social support
Kapoor and Gardner-Mccune (2022)	Ability, knowledge in CS,	Self-interest, enjoyment, satisfaction			Informal activities, conferences, clubs
Kinnunen et al. (2018)		Interest, initial expectations of university study and career	Preferred identity of future CS professionals		
Kong and Lai (2022)	Programming empowerment, Programming actualization	Engagement in CS	Programming imagination and affiliation		
Kong and Wang (2020)	Programming actualization, goal setting	Engagement in CS	Programming imagination and affiliation		
Lunn et al. (2021a)	Competence in CS	Interest in CS	Sense of belonging	Recognition by family, friends, and teachers in CS	Educational experiences
Lunn et al. (2021b)	Competence in CS	Interest in CS	Sense of belonging, professional experiences	Recognition by family, friends, and teachers in CS	Cultural experiences
Mahadeo et al. (2020)	Competence in CS	Interest in CS	Sense of belonging	Recognition by family, friends, and teachers in CS	
Mooney et al. (2018)	Competence in CS		Sense of belonging		

(Continued)

TABLE 1 (Continued)

Study	Constructs influencing CI				
	Competencies/performance	Interest	Sense of belonging	Recognition	Social context
Parker (2018)	Competence in CS	Engagement with Professional Practices	Self-concept of future professional		Internships, capstone courses
Peters and Pears (2013)	Knowledge in CS	Engagement			Experiences of technology in society
Rawhiya Jacob et al. (2022)	Experience with computers	Interest in CS	Perception of CS and Self-perception of computer, scientists		Support from parents, friends, and teachers
Rollins et al. (2021)	Competence and performance in CS	Interest in CS	Interpersonal closeness and STEM centrality	Recognition by family, friends, and teachers in CS	
Shah et al. (2023)	Competence in computer usage				Family's support and interest in CS
Taheri (2019)	Competence and performance in CS	Interest in CS	Sense of belonging	Recognition by self, family, friends, teachers in CS	
Taheri et al. (2018)	Competence and performance in CS	Interest in CS	Sense of belonging	Recognition by self, family, friends, teachers in CS	
Tupou and Loveridge (2019)	Programming, reification, and alignment in CS	Participation and imagination in CS	Perception of CS and future roles in CS		
Wofford et al. (2022)	Self-efficiency and confidence	Self-determination and motivation	Psychosocial perceptions of current and future selves, communal career motivation	Recognition of self and by others	Institutional environments and support in computing departments
Wong (2016)			Perception of CS professional		
Zahedi et al. (2021)	Self-efficiency in CS	Enjoyment, motivation			
Hughes et al. (2021)	Self-efficiency and performance in CS			Recognition by teachers and peers	
Total	28	23	22	9	16

students' sense of belonging in CS, authors have gaged their perception of CS professionals (Washington et al., 2016; Jacob et al., 2022; Wong, 2016), self-concept of future professionals (Kinnunen et al., 2018; Parker, 2018; Wofford et al., 2022; Tupou and Loveridge, 2019), perception of CS (Rawhiya Jacob et al., 2022; Tupou and Loveridge, 2019; Jacob et al., 2022), programming imagination & affiliation (Atman Uslu, 2023; Kong and Lai, 2022; Kong and Wang, 2020), and communal career motivation (Wofford et al., 2022). In this context, "imagination" involves envisioning potential aspirations and commitments related to computing, while "affiliation" signifies a sense of belonging among peers within the field (Atman Uslu, 2023; Kong and Lai, 2022; Kong and Wang, 2020). And, the communal career motivation of students is crucial as it determines whether their future careers enable them to assist others, contribute to humanity, serve as role models in the community, collaborate effectively with others, and more (Wofford et al., 2022). A better sense of belonging is related to a stronger CI, which in turn leads to greater persistence in computing education and future roles in the field (Mooney et al., 2018).

Recognition in CS

Recognition in CS has been identified as another construct, often involving self-acknowledgment, self-value, and recognition by others in the field, that profoundly influences the development of CI ($n = 9$). When individuals are acknowledged for their achievements or expertise in CS, it reinforces their CI within the CS community. The literature included emphasizes that recognition from parents, teachers, and peers is crucial for the development of students' CI (Mahadeo et al., 2020; Taheri, 2019; Taheri et al., 2018; Lunn et al., 2021a,b; Hughes et al., 2021; Wofford et al., 2022; Rollins et al., 2021; Garcia et al., 2018). According to several studies, self-recognition typically involves seeing oneself as a tech-savvy individual or an exemplary student in the field of computing, which contributes to CI formation (Taheri, 2019; Taheri et al., 2018; Wofford et al., 2022; Garcia et al., 2018).

After investigating the factors associated with CI, the study has compiled a table outlining the characteristics of several studies that specifically focused on the relationship between CI and various factors, constructs, and contexts (refer to Table 2). Most of these studies assessed CI, computing persistence, or computing careers by scrutinizing commonly employed CI constructs, such as interest, competence, recognition, and the sense of belonging in the computing field (Hazari et al., 2010; Taheri, 2019; Taheri et al., 2018; Mooney et al., 2018; Hughes et al., 2021; Garcia et al., 2018). Other studies used slightly different constructs to define CI (i.e., "engagement," "imagination," "affiliation," and "actualization") in gaging CI through computational thinking and programming empowerment (Kong and Lai, 2022; Kong and Wang, 2020). In these articles (Kong and Lai, 2022; Kong and Wang, 2020), "engagement" refers to individual students' active involvement in computing and programming activities, and "imagination" denotes a sense of possible aspirations/commitments of oneself to computing. Additionally, the papers delineated "affiliation," referring to a sense of belonging with peers, and "actualization" as entailing learners' self-actualization in the learning of programming. It's noteworthy that most of these quantitative studies have explored the importance of social context (i.e., school-related factors, support from parents, peers, teachers, ethnocultural background, educational experience etc.) in CI

formation (Lunn et al., 2021a,b; Parker, 2018; Deechuay et al., 2016; Wofford et al., 2022; Rawhiya Jacob et al., 2022; Kong and Lai, 2022; Kong and Wang, 2020; Tupou and Loveridge, 2019; Kapoor and Gardner-McCune, 2019b).

RQ 2: what are the established constructs influencing/defining the frameworks for developing students' CI?

While the majority of existing literature addresses various facets of CI, there is a scarcity of research specifically concentrating on validated frameworks for developing students' CI ($n = 11$) (Mahadeo et al., 2020; Taheri, 2019; Taheri et al., 2018; Washington et al., 2016; Bell-Watkins et al., 2009; Lunn et al., 2021b; Rawhiya Jacob et al., 2022; Kong and Lai, 2022; Kong and Wang, 2020; Garcia et al., 2018; Jacob et al., 2022). Most shortlisted articles have developed survey frameworks for measuring CI. These survey frameworks were quantitatively assessed for reliability through confirmatory factor analysis (CFA). Of these studies, four incorporated structural equational modeling (SEM), revealing the relationship (direct, indirect links) between CI and constructs/contexts (Taheri, 2019; Taheri et al., 2018; Kong and Lai, 2022; Kong and Wang, 2020).

In this regard, dichotomizing these studies, we revealed that some research developed a survey model theorizing the CI constructs (performance/competence, interest, sense of belonging, and recognition in computing), which are significant predictors of students' CS-based career aspirations (5) and persistence in CS (Taheri, 2019; Taheri et al., 2018). Likewise, Washington et al. (2016) proposed a survey instrument named CSAIS (computer science attitude and identity survey), which investigated students' confidence, interest, gender, and professional identity to measure the impact of identity development on CS students. A study by Garcia et al. (2018) also established a survey instrument examining the CI of high-achieving underserved computing students based on recognition, interest, and competencies in CS. Their study findings were insightful in showcasing those females (than males), students in IT (than CS, CE), and freshmen (than juniors/seniors) have lower levels of CI (Garcia et al., 2018). On the contrary, some studies employed a framework using survey instruments to measure students' identity in CS by examining constructs such as students' experiences with computers and perception of CS (performance/interest), their perceptions as computer scientists (recognition), and their family support (social context) (Rawhiya Jacob et al., 2022; Jacob et al., 2022).

A few studies employed CI frameworks that incorporated structural equation modeling (SEM), thereby revealing the relationship between CI and constructs/contexts/processes (Taheri, 2019; Taheri et al., 2018; Kong and Lai, 2022; Kong and Wang, 2020). SEM is an analytical instrument employed to establish quantitative relationships, explaining direct/indirect links. In this regard, findings from a study by Taheri (2019) and Taheri et al. (2018) are thought-provoking, as they showcase that "interest" in computing has the strongest direct effect on computing persistence. Students' computing "competencies" are also significant predictors of computing persistence with both direct and indirect effects (Taheri, 2019; Taheri et al., 2018). "Recognition" in computing has both direct and indirect effects on persistence (Taheri, 2019; Taheri et al., 2018). "Sense of

TABLE 2 Studies gaging the quantitative relationship of CI with constructs/contexts.

S. No.	Study	Relationships studied
1	Atman Uslu (2023)	CT (computational thinking) performance and CT self-efficiency ↔academic resilience and CI
2	Cummings et al. (2019)	Adaptive, resilient identity ↔ CI
3	Deechuay et al. (2016)	Parental support ↔ CI (computing self-efficiency, value belief)
4	Garcia et al. (2018)	Recognition, interest, competence ↔CI
5	Jacob et al. (2022)	Experience with computers, perception of CS, social supports, perception of computer scientists ↔ CI
6	Kapoor and Gardner-McCune (2019a)	Self-interest, ability, personality, enjoyment, satisfaction, knowledge, utility, perception, informal activities, social support ↔ CI
7	Kong and Lai (2022)	Programming empowerment ↔ CI (Engagement, imagination, affiliation)
8	Kong and Wang (2020)	Computational thinking (ability to express, connect, and question) ↔ CT perspectives (Programming engagement, affiliation, actualization, goal setting)
9	Lunn et al. (2021a)	Educational experiences relating to computing ↔ CI
10	Lunn et al. (2021b)	Professional experience, cultural experience ↔ CI
11	Mooney et al. (2018)	Sense of belonging in computing↔ CI
12	Parker (2018)	Computing professional identity ↔ CI
13	Rollins et al. (2021)	Interpersonal closeness, competence in CS, performance, recognition, STEM centrality ↔ CI
14	Taheri (2019)	CI constructs (competence, performance, recognition, sense of belonging) ↔ computing academic persistence
15	Taheri et al. (2018)	CI constructs (competence, performance, recognition, sense of belonging) ↔ computing academic persistence
16	Tupou and Loveridge (2019)	Participation, imagination, reification, and alignment in CS ↔ CI
17	Wofford et al. (2022)	Academic psychosocial perceptions ↔ CI
18	Hughes et al. (2021)	Recognition in computing↔ CI

↔shows direct/indirect quantitative relationship between the CI, factors, constructs, or context.

FIGURE 3
The proposed framework for developing students' CI, depicting the influential factors.
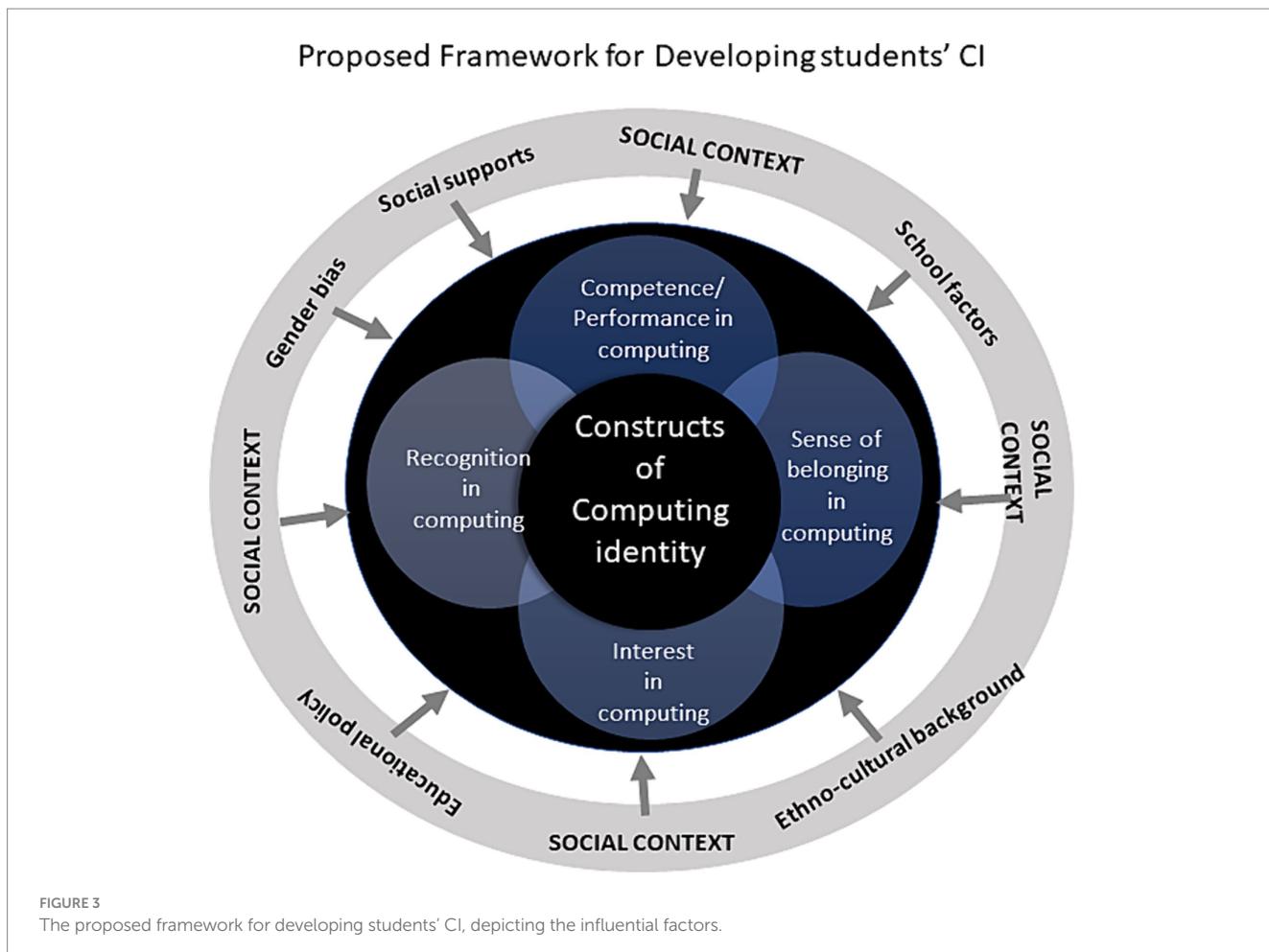
belonging" in computing has a direct effect on CS competence and thereby influences persistence (Taheri, 2019; Taheri et al., 2018). Another study carried out by Kong and Lai (2022) based on SEM analysis depicted the relationship between programming empowerment and CI. These researchers investigated the links between infrequent sub-constructs for programming empowerment (i.e., meaningfulness, self-efficiency, and impact) and CI (engagement, imagination, and affiliation). Their findings illustrate that perceived "meaningfulness" and "self-efficiency" in programming are positively related to all sub-constructs of CI (i.e., engagement, imagination, and affiliation). However, the perceived "impact" of programming was only related to students' future imagination about computing/careers, not to current engagement and affiliation in computing (Kong and Lai, 2022). Other research undertaken by Kong and Wang (2020) revealed a significant relationship between CT perspectives (ability to express, connect, and question) and CI constructs (engagement, affiliation, actualization, goal setting). Findings from this study reveal that students' "ability to question" can foster CI formation through their "ability to express" while their "ability to connect" can directly foster CI formation (Kong and Wang, 2020). Additionally, study by Bell-Watkins et al. (2009), emphasizes a framework for K^{-12} computing standards. In their study, the constructs considered in developing the CI were "technical excellence" in CS, "leadership," "civic engagement and service," and "community outreach." The framework was based on the principles including (1) identity development, (2) psychological

support, (3) social support, (4) academic support, (5) sense of belonging, and (6) leadership development. According to them, the establishment of framework to develop CI was a significant tool for navigating computing-related curricular standards and for identifying CS-related course characteristics that would maximize the impact of nurturing computing identities in K-12 students (Bell-Watkins et al., 2009). After gaining insights into established constructs and their interrelationships influencing the framework for developing CI, the study aims to explore potential new additions to enhance and expand the existing frameworks defining CI.

RQ 3: what potential additions could further enrich these frameworks to align with the requisites of today's tech-savvy world?

It is noteworthy that a significant portion of the studies has explored the importance of the "social context" ($n = 16; \approx 52\%$). The literature extensively examines how the social environment influences students' CI, encompassing factors such as gender bias, community outreach, civic engagement, school-related aspects, informal learning environments, educational experiences, support from parents, peers, and teachers, as well as considerations related to socio/ethnocultural backgrounds, among others. Figure 3 visually depicts these elements,

providing a graphical representation that enhances understanding of the framework for developing students' CI, based on its constructs. This illustration serves as a valuable tool for researchers seeking to develop or validate instruments for assessing and fostering students' CI. Therefore, a potential addition to the existing CI frameworks is the inclusion of the "social context." Interestingly, while the social context is not typically defined as a direct construct of CI, many studies have included and evaluated this concept due to its profound influence on CI formation (see Table 1).

When gaging the individual studies critically, studies conducted by Çakır et al. (2017) and Zahedi et al. (2021), underscore the importance of the social environment within school settings, particularly through game-based workshops, as a means to enhance students' interest in computing through identity exploration. Consequently, there is a recognized need for a curriculum focused on programming, as asserted by Kong and Lai (2022), Kong and Wang (2020) and reiterated by Jacob et al. (2022). Their research indicates that participation in a culturally and linguistically responsive computer science curriculum over the course of a year is pivotal for the development of CI. According to Kong and Lai, research/job experiences, mentoring others, club participation, presenting, networking, and obtaining. Help from advisors, working with others, and having encouraging friends in computing have a positive effect on developing CI (Kong and Lai, 2022). Wofford et al. (2022) further reveal that sustaining the aspirations of undergraduate students in computing relies on positive social environments and interactions, which significantly contribute to the development of CI. Additionally, educational experiences, such as internships, supportive teachers, engagement in coursework, and peer mentoring, are crucial for CI development (Bell-Watkins et al., 2009; Lunn et al., 2021a; Parker, 2018; Kapoor and Gardner-McCune, 2019a; Jacob et al., 2022). According to Kapoor and Gardner, the formation of CI involves intrinsic interest and confidence in their abilities, the relevance of coursework, engagement in informal activities like hackathons, and participation in professional development opportunities such as internships and conferences (Kapoor and Gardner-Mccune, 2022; Kapoor and Gardner-McCune, 2019b). Social support and early exposure to computers are also identified as vital aspects of computing identity development (DuBow et al., 2017). Furthermore, Deechuay et al. (2016) find that social support for using computers, both from parents and peers, positively correlates with computer self-efficacy and value beliefs in both male and female students, ultimately contributing to the development of CI. In addition, a gender-enriched study by DuBow et al. (2017) inspected factors influencing the CI of females. Their qualitative findings revealed that females who are persistent in CS-related fields believe that having an early reinforced CI, and supportive computing communities at home/school are critical in the development of CI.

In summary, the "social context" plays a crucial role in influencing competence, interest, sense of belonging, and recognition in computing, by shaping the multifaceted process of CI formation (Rodriguez and Lehman, 2017; Rodriguez et al., 2020; Rodriguez and Stevens, 2023). CI in this context is not singular but rather a composite of interacting constructs within a social framework. This phenomenon has been extensively comprehended through disciplinary identity theory, in conjunction with SCCT. This combination showcases the influence of personal, environmental, and motivational factors on educational and career choices, thereby impacting CI formation. For instance, social interactions within educational settings and professional communities, mentorship programs, and peer interactions can provide opportunities for skills and knowledge development and contribute to building "competence/performance" in CS (Çakır et al., 2017; Boyer et al., 2010; Hughes et al., 2021; Zahedi et al., 2021; Rollins et al., 2021). Social influences, such as role models in the CS community, or supportive peer networks, can spark and sustain students' "interest" in computing. Exposure to diverse perspectives and experiences (personal, educational, professional) through social interactions broadens students' understanding and appreciation of CS domains. Social contexts, including supportive peer groups, perception of future roles, professional value beliefs, and recognition of diverse contributions, foster a "sense of belonging" in CS. Students who feel accepted and valued, i.e., "recognized" within their CS communities are more likely to identify themselves as part of the field and engage actively in learning and career pursuits. According to Morelock (2017), experiences, and environmental and social conditions work in conjugation for positive identity formation. In essence, the social context provides a foundation and reinforcement for the development of competence, interest, sense of belonging, and recognition in CS. By nurturing supportive social environments and promoting inclusive practices, educators and institutions can enhance students' computing identities and facilitate their success in the field (Chen et al., 2023). Consequently, it is proposed as a potential new addition to the CI framework. This inclusion is anticipated to contribute to a more nuanced and comprehensive conceptualization of CI frameworks, fostering a better understanding of the multifaceted factors shaping CI.

Conclusion

This systematic review provides a synthesized and comprehensive framework for developing the CI, consolidating various constructs and factors pivotal to its development. The review extensively examines the factors influencing the formation of students' CI. The findings identify related terminologies and subscales of the established constructs such as competencies/performance, interest, recognition, and sense of belonging within the realm of computing. For instance, some studies have employed terms like actualization, goal setting, affiliation, and engagement in CS to describe CI constructs, which collectively emphasize the same aforementioned CI constructs. A significant observation from the review is the varying depth of research across these constructs. Competencies/performance in CS has emerged as the most extensively studied aspect of CI, whereas perceived recognition in CS remained comparatively underexplored in the literature. This imbalance underscores opportunities for further investigation into how recognition influences CI development and its implications for educational strategies and policies.

In summary, the synthesis of the literature reveals that the existing framework for developing students' CI is predominantly characterized by four core constructs: recognition, performance, interest, and a sense of belonging in computing contexts. These constructs operate within and are influenced by the broader social contexts in which students engage with computing education and practice. Thus, CI is a multifaceted domain that includes the four core constructs, all of

which are intricately intertwined with the social context in which they manifest. Conclusively, this paper proposes a refined CI framework based on a comprehensive analysis of existing literature and identified gaps, by including "social context." By deepening our understanding of the multifaceted factors shaping CI, this framework aims to provide educators, policymakers, and researchers with valuable insights into fostering positive identity formation in computing. It is anticipated that this study will guide efforts toward enhancing educational practices that support the development of robust CI among students, ultimately contributing to the advancement of the field.

The findings of this study should be considered in light of certain limitations. Such as the concept of identity is inherently vague, and previous systematic reviews have utilized various search terms like "self-concept," "self-perception," "self-image," "reflective practice," and "professional values," among others. In this study, we focused primarily on specific search terms related to computing identity, such as "CI," "identity in CS," "programming identity," and "coding identity," during the article search process. This approach aimed to ensure the relevance of the article as per the scope of the review. While the study synthesizes findings across multiple articles, the generalizability of conclusions may vary depending on specific contexts, such as educational systems, cultural backgrounds, and demographic characteristics of student populations. Future comparative studies across different educational settings or cultural contexts could provide richer insights into these dynamics. Given the significant role of social contexts in shaping CI, future studies could explore its direct influence on CI formation. The proposed refined framework for developing CI could be validated through quantitative empirical studies across diverse student populations and educational settings.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MS: Data curation, Formal analysis, Writing – original draft. NS: Methodology, Writing – original draft. AS: Validation, Writing – review & editing. JB: Validation, Writing – review & editing. ZA:

Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1366906/full#supplementary-material

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New challenges for higher education: self-regulated learning in blended learning contexts

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Introduction: The study on self-regulated learning in blended learning (BL) environments highlights its crucial relevance for both the academic development of students and the evolution of contemporary educational methods. This research focused on conceptualizing self-regulated learning in university contexts with a BL modality, using direct student perceptions.

Methods: An inductive qualitative approach with a phenomenological design was employed. Responses from 312 undergraduate students who had completed their first or second year were analyzed; 65 participated in 10 focus groups (two per area of knowledge according to OECD classification), and 247 participated through a survey. Descriptive analysis was used to obtain a range of content and meanings associated with students' perceptions of SRL-BL.

Results: The study conceptualized SRL-BL as a process where students structure, monitor, and evaluate their learning using self-reflection and digital technologies, with particular emphasis on planning. Significant differences were identified between SRL-BL and traditional SRL; in face-to-face education, teacher supervision is greater, while in SRL-BL, students take on more responsibility and autonomy, developing self-management skills. Although SRL-BL fosters autonomy and responsibility, students face obstacles such as distractions from social media and leisure technologies, which affect their concentration and study planning.

Discussion: It is essential to address the new challenges students face to maintain a high level of SRL in Blended Learning environments (SRL-BL) and the strategies they use to overcome them. The need to update the concept of self-regulated learning (SRL) in the current educational context, influenced by technological advances, is concluded.

KEYWORDS

self-regulated learning, online education, blended learning, university students, quality in education, education

1 Introduction

Self-regulated learning (SRL) is a construct with strong empirical support regarding its importance for success in higher education (Bernardo et al., 2020). Self-regulated students are more successful in learning because they plan, set goals, organize, and self-evaluate throughout their learning process (Yahya et al., 2021).

Research in higher education associates self-regulated learning with successful academic pathways by promoting better performance and higher retention rates (Barrera Hernández et al., 2020; Díaz et al., 2019a; Merchan and Hernández, 2018; Panadero et al., 2016; Sáez et al., 2018), greater engagement in academic activities (Barrera Hernández et al., 2020), and better adjustment to university life (Hernández Barrios and Camargo Uribe, 2017). Interventions aimed at fostering self-regulation have proven effective in improving performance and preventing dropout (Díaz-Mujica et al., 2017; Dörrenbächer and Perels, 2016; Järvelä et al., 2019; Sáez et al., 2018; Yan, 2020).

SRL is understood as a cyclical and interdependent process that integrates the control, planning, and adaptation of thoughts, behaviors, and feelings aimed at achieving a learning goal (León-Ron et al., 2020). According to Zimmerman's (2000) Social Cognitive Theory, self-regulation is achieved through three cyclical phases during learning: planning, execution, and evaluation. In the planning phase, students set goals they aim to achieve; in the execution phase, they deploy cognitive learning strategies (e.g., reading and note-taking) and metacognitive monitoring processes to complete tasks (e.g., time management); in the evaluation phase, students assess their progress and understanding of the material and evaluate the factors contributing to their performance. Based on these reflections, students may decide to modify their behaviors to achieve current tasks or begin new ones. These phases are interdependent and do not necessarily occur in a sequential order, nor do they happen only once during a task (Zhang et al., 2021).

Promoting this competence in university contexts is especially important. Higher education faces significant challenges, including the massification of enrollments, a new student profile, and high dropout rates in the early years of study (Díaz et al., 2019a; Ferreyra et al., 2017; Munizaga et al., 2018). Not all students have the tools to successfully face higher education; there are significant gaps in the knowledge level with which they enter university, their learning strategies and thinking skills, their behaviors in adjusting to university life, and their ability to autonomously control and manage their learning (Bernardo et al., 2020; Díaz et al., 2019b; Taranto and Buchanan, 2020).

Continuing studies during the pandemic relied on online education, a modality that demanded a more active and autonomous role from students (Besser et al., 2022; Kincade et al., 2020; Lobos et al., 2021). Research conducted in this scenario (Hodges et al., 2020; Viberga et al., 2018) indicates that online education exacerbates the previously mentioned gaps, as it requires students to have greater capabilities to self-regulate their learning compared to face-to-face education.

Post-pandemic higher education is expected to predominantly feature hybrid or Blended Learning (BL) models (Almazán Gómez, 2020; Lederman, 2020; Portillo, 2020). Research conducted with 8,265 Chilean university students during the confinement period (Lobos et al., 2021) comparing expectations versus experiences with Emergency Remote Education (ERE) indicated that the experience with ERE improved students' perceptions of the quality and benefits of online education, contrasting with their initial expectations at the beginning of the confinement period. In Israel, a study with 1,217 university students (Besser et al., 2022) found results consistent with those of the Chilean students, concluding that adaptability and facing challenges with ERE generate a positive perception among students toward online education, facilitating the establishment of a post-pandemic Blended Learning model.

Recent research indicates that online teaching and learning have become imperative (Kamali and Bagheri-Nesami, 2022), setting a precedent for a new reality in higher education (Gqibani, 2022).

There is a need to offer mixed teaching, as this style combines many advantages of both virtual and face-to-face formats while minimizing their disadvantages (Pollock, 2022). In line with this, Jamilah and Fahyuni (2022) suggest that online teaching should be modified and combined with face-to-face learning in mixed teaching methods, which can overcome the deficiencies of online and face-to-face learning alone. This vision is shared by teachers, students, and administrators, as concluded by the study by Guppy et al. (2022).

In the BL modality, the virtual component is carried out through virtual classrooms that provide a suitable environment for the development of resources and asynchronous learning activities. The use of virtual classrooms has steadily grown worldwide, not only due to the emergency created by the pandemic but also because of the impact of new digital technologies and the increasing demand for graduates with digital skills to address the ongoing digital evolution in our society (Afify et al., 2023).

The virtual classroom is identified as a space for educational innovation, characterized by its flexibility and the versatile integration of content through a variety of resources and learning activities (Martínez and Jiménez, 2020). As such, virtual classrooms represent one of the most important applications of educational technology and are a primary means in interactive online education systems (Afify et al., 2023). They emphasize student independence and motivation, aiming to strengthen autonomous learning, critical thinking, and collaborative work through interaction and the development of academic activities (Martínez and Jiménez, 2020).

Learning Management Systems (LMS) also serve as essential technological support for teaching and learning in universities worldwide (Ghazal et al., 2018). They provide teachers with platforms that allow for information dissemination and classroom management (Simon et al., 2024). LMSs host a variety of tools that can facilitate user communication, such as discussion forums, real-time chat modules, and email clients (Turnbull et al., 2023). All these changes position self-regulated learning as a necessary competency for every student facing higher education.

1.1 Self-regulated learning and online education

Online education depends on the student being in a different location from the teacher or the source of information (Ibrahem Qetesh et al., 2020; Quezada Cáceres and Salinas Tapia, 2021). This modern educational phenomenon has evolved with technological advancements (Eljak et al., 2023; Kaplan and Michael, 2016).

During the pandemic, this modality was referred to as Emergency Remote Education (ERE) because it did not meet all the requirements of online education but was considered a step toward it (Talidong, 2020). Post-pandemic, it is anticipated that there will be a process of curriculum flexibilization, not to migrate entirely to online teaching, but to integrate online teaching with traditional teaching and leverage its benefits (Almazán Gómez, 2020; Lederman, 2020; Pardo and Cobo, 2020). In this context, ERE helped increase awareness of the influence of self-regulated learning in higher online education (Ibrahem Qetesh et al., 2020; Quezada Cáceres and Salinas Tapia, 2021), highlighting areas of concern for post-pandemic BL education (Cobo-Rendón et al., 2022; Shesha, 2023).

The teaching modality that combines in-person components with online components through computer systems is known as BL, a

relatively new term in literature that began to be used and researched in the late 1990s (Hrastinski, 2009). BL can be described as a teaching method with bimodal delivery (in-person and online) that aims to holistically, intentionally, and effectively integrate technologies, strategies, and pedagogical activities, optimizing time by eliminating barriers of space, time, and resources (Freeman et al., 2014; Sia et al., 2023).

BL education promotes interaction, reflection, critical thinking, and facilitates spaces for collaborative work and an active attitude toward the learning process (Singh and Thurman, 2019). Implementing this educational model poses significant challenges for students who struggle to self-regulate their learning (Besser et al., 2022; Kincade et al., 2020; Lobos et al., 2021). For example, in the planning phase of self-regulation, students must consider various factors such as access to a computer at home, internet connection quality, and plan a workload by estimating the time required for asynchronous activities (Zhang et al., 2021). Aristovnik et al. (2020) noted that BL online education created a perception of a heavier workload among students due to time management and academic work organization difficulties.

In the execution phase, students face higher barriers to seeking help, maintaining concentration, and actively monitoring the time spent on each task (Adnan and Anwar, 2020). Leveling strategies like mastery paths encourage the use of various cognitive strategies for the same content and force students to monitor their performance when they do not reach the expected level (Goksoy, 2018). In the evaluation phase, students must make value judgments about their learning outcomes and study processes, considering new factors like the organization of materials in the virtual environment and their digital competence. Online evaluation systems often allow multiple attempts, which can encourage students to reflect on their performance and take corrective measures in their learning processes (Zhang et al., 2021).

In this new scenario, where virtual classrooms are an integral part of university education and the online component complements and enhances learning, it is necessary to update the concept of self-regulated learning (SRL) to meet the new demands of the Blended Learning context. This study's objectives are to:

1 Conceptualize the process of Self-Regulated Learning in the context of Blended Learning (BL), identifying its characteristics and specific strategies.
2 Compare and contrast the differences between the process of Self-Regulated Learning in Blended Learning (SRL-BL) and the traditional approach (SRL-T), highlighting the necessary adaptations for the contemporary educational context.
3 Identify the main benefits and obstacles students face in implementing Self-Regulated Learning in BL modalities, to propose effective strategies for overcoming them.

2 Method

2.1 Design

An inductive qualitative approach with a phenomenological design was employed. This design aims to identify and systematize the ways people understand, experience, conceptualize, and perceive aspects of reality (Marton, 1981). Hermeneutic text analysis was used to understand the meaning and significance of students' discourses on SRL BL (Martínez Miguélez, 2002). This approach combines phenomenology, which focuses on describing lived experiences as they are experienced, with hermeneutics, which emphasizes the interpretation of the meanings of those experiences (Izcara, 2014). This combination allows researchers to gain a rich and deep understanding of students' experiences by integrating both the detailed description of the experiences and the interpretation of their deeper meanings.

2.2 Participants

The sample consisted of 312 undergraduate students who had completed their first or second year of study. Sixty-five participated in 10 focus groups (two focus groups per knowledge area according to the OECD classification), and 247 participated in a survey. Of the participants, 56% (166) were women and 44% (131) were men, with an average age of 19.07 (SD 1.56). 48% (142) had completed their first year of study, and 52% (155) had completed their second. The students belonged to four Chilean universities that use the BL modality through their virtual classrooms. Table 1 describes the number of students according to their scientific area (OECD) and the type of participation in the study.

2.3 Instruments

2.3.1 Focus groups

The focus groups were conducted in the classrooms of the participating universities, lasting between 45 and 70 min. The focus group script included the following topics: (a) Conceptualization of SRL (Example: What do you understand by SRL in a blended learning educational context?) (b) Differences between SRL in face-to-face and BL contexts (Example: What could be the differences between a student who self-regulates their learning in face-to-face education versus one who learns in both face-to-face and virtual teaching environments?) (c) Planning strategies used for SRL in BL (Example: How do you plan to meet the academic commitments of the virtual classroom?) (d) Execution strategies for SRL in BL (Example: What do you do to monitor your level of learning during your study in the virtual classroom?) (e) Evaluation strategies for SRL in BL (Example: Once you have completed a study cycle, what do you do to evaluate your learning?) and (f) Benefits and obstacles for SRL in BL (Example: In a blended learning study modality, what would be the benefits of possessing good self-regulated learning skills; what obstacles could you face for self-regulation in a blended learning context?).

TABLE 1 Description of participants by scientific area and type of participation in the study.

OCDE area	Focus Groups	Surveys
Natural Sciences	16	36
Medical and Health Sciences	10	46
Humanities	12	23
Agricultural Sciences	9	0
Social Sciences	8	103
Engineering and Technology	10	39
Total	**65**	**247**

2.3.2 Survey on self-regulated learning in BL environments

Written discourses were obtained from a survey with three open-ended questions created specifically for the research. The questions addressed the following topics: (a) students' understanding of SRL in BL (How would you define SRL in BL?) (b) strategies they use for SRL in BL (What strategies would you use for SRL in BL?) and (c) differences they find between SRL in BL and traditional SRL (What differences could there be between SRL in a face-to-face educational context and SRL in BL?).

2.4 Procedure and ethical considerations

The survey was administered digitally via Google Forms and sent to the students of the participating universities through institutional email. Participants for the focus groups were obtained through non-probability sampling using the snowball technique. University professors with prior connections to the researchers were asked to invite 12 students from their courses to participate in the focus groups, ensuring that the courses covered the six OECD areas. Three of the seven focus groups were conducted in person, and four were conducted via videoconference using the Teams platform. Ethical guidelines and principles were followed, including the use of informed consent, secure storage of information in coded databases, and ensuring the confidentiality of the information.

2.5 Analysis plan

The analysis of the discourses was conducted in three main stages: (1) reviewing the information, (2) identifying units of analysis, and (3) categorizing. Using the constant comparison method, the information was coded and analyzed simultaneously. Coding continued until theoretical saturation of the generated categories was reached, meaning no new data provided additional information (Krause, 1995). Through descriptive analysis, a range of contents and meanings associated with students' perceptions of SRL-BL was obtained.

To accomplish this, an immersive reading process is carried out, where the transcriptions are read multiple times to familiarize yourself with the content and gain a general overview. Notes are taken on general impressions and recurring themes. Then, for the phenomenological description, the text is divided into smaller meaning units that capture specific aspects of the experiences associated with SRL in BL described by the students. Codes are assigned to these meaning units, labeling them in a way that reflects their essential content. For the hermeneutic analysis, a reflection on the underlying meanings of the meaning units is conducted, considering the BL university context and the individual perspectives of the participants. The meaning units are then grouped into broader themes that capture recurring and significant patterns in the discourses about SRL in BL. Finally, the interpretations are reviewed and refined by comparing them with the existing literature.

3 Results

The study aimed to conceptualize self-regulated learning in university education contexts with a BL modality from the students'

perspectives. Their discourses were analyzed, and the results were organized into the following areas: (a) how they define it, (b) what competencies they consider it requires, (c) what strategies would facilitate better levels of SRL BL, (d) differences between SRL BL and SRL traditional, and (e) situations that threaten the achievement of SRL BL.

3.1 Definition of SRL in BL education

Students define SRL-BL considering the same three stages of traditional SRL: planning, execution, and evaluation. "I understand it as a process of self-reflection and action where the student structures, monitors, and evaluates their learning," (E39) adding the use of technologies. However, when asked for a more detailed description of SRL-BL, their narratives focus on the planning stage and to a lesser extent on execution, with no content associated with the evaluation stage. "I understand it as a concept that encompasses everything that is an academic organization, which the student must develop independently, establishing schedules and finding the most suitable and efficient method for them using these virtual platforms" (E46). In less precise responses, students equate SRL-BL to autonomous learning. "It consists of having the necessary tools for proper learning without needing someone to regulate it," and "I understand it as my autonomy to better manage my studies" (E44).

The students' emphasis on planning and autonomy, coupled with the limited focus on execution and evaluation, suggests that they perceive SRL-BL primarily as a preparatory and organizational process. This may indicate a need for educational interventions that emphasize the iterative and cyclical nature of self-regulation, including reflection and self-assessment. The integration of technology in their definition's points to an evolving understanding of SRL-BL, where digital tools are not merely aids but integral components of the learning process. This evolution reflects broader shifts in educational practices, emphasizing the role of technology in facilitating self-regulated learning. The lack of attention to evaluation suggests potential areas for development in instructional design and support. Educators might focus on enhancing students' reflective practices and self-assessment skills to foster a more comprehensive understanding of SRL-BL that encompasses all stages of the self-regulation cycle.

This analysis reveals that while students recognize the fundamental components of SRL in blended learning environments, their conceptualizations are skewed toward planning and autonomy, with less emphasis on execution and evaluation. Addressing these gaps through targeted educational strategies could enhance students' self-regulatory skills and contribute to more effective learning outcomes in blended contexts.

3.2 Skills for SRL BL

Regarding the necessary skills for SRL BL, students mention the need for emotional, digital, and distraction management skills (see Table 2). Additionally, students report that self-regulation in learning does not mean dedicating oneself solely to study but making personal and academic life coexist (see Table 2).

The identification of emotional, digital, and distraction management skills reflects a complex understanding of what

self-regulation in BL environments entails. Students appear to be aware that these skills not only facilitate learning but also contribute to their ability to manage stress and maintain a healthy balance between study and personal life. The emphasis on integrating personal and academic life suggests that students view self-regulation as a holistic process. It is not solely about achieving academic goals but about building a lifestyle that supports their overall development. This perspective indicates a mature understanding of self-regulation, where education is part of a broader context of personal growth. This analysis reveals that students perceive self-regulated learning in BL contexts as a multifaceted process requiring emotional, digital, and distraction management skills. Additionally, they emphasize the importance of balancing personal and academic life as an integral part of their learning experience. This comprehensive approach can guide the development of educational strategies that support not only academic success but also the overall well-being of students in blended learning environments.

3.3 Strategies for SRL in BL contexts

Students describe strategies they use to self-regulate their learning in BL educational contexts. These strategies correspond to the three stages of self-regulation in a differentiated manner (see Table 3).

3.3.1 Planning stage

To prepare their study, students indicate developing strategies such as listing tasks, prioritizing tasks, setting goals, organizing evaluations, and self-care actions. The tools used in this process are mainly analog, technological, and virtual, associated with time planning and activity organization (see Table 3). They also mention actions related to maintaining healthy routines, including good nutrition and taking care of rest and leisure spaces.

3.3.2 Execution stage

In the execution stage, students report using self-monitoring strategies such as asking themselves questions and taking formative tests. They also value feedback and help spaces, differentiated into (a) peer instances, (b) with teachers, and (c) online support materials such as tutorials, exercise videos, chat, and specialized forums (see Table 4). Notably, teacher support is mentioned by only one student and in exceptional situations.

In the realm of self-monitoring their learning progress, students indicate that in BL contexts, there are more comparison parameters as their own and peers' performance is visible in the virtual environment, and it is common for professors to use rubrics (see Table 5).

3.3.3 Evaluation stage

Regarding the evaluation stage, students mention strategies that refer to judgment and reaction processes toward their study. Judgments

TABLE 2 Competencies for SRL in BL education scenarios.

Category	Dimension	Analysis unit
Competencies	Emotional	"Able to control frustration, not everything always works (refers to connections and internet and virtual tools)" (E58), "…Stress, knowing how to handle it, when platforms fail… for example you have everything planned and you cannot do anything… you waste time" (E49).
	Digital	"You must have very good knowledge of the use of virtual platforms" (E39), "He easily master's the way of doing virtual work and the necessary platforms, knows the tools and can make the most of the virtual space" (E131)
	Distraction management	"…do not pay attention to social networks, use the cell phone only to look for information and things like that" (E15), "Getting away from everything that is a distraction, so I can concentrate 100% on what I am doing (E30)
	Teleworking (Make study coexist with life)	"I think that a good student regulates himself by having a defined study schedule and his daily life outside of the university" (E22), "…He has a good balance between his studies and his personal life" (E30)

TABLE 3 Planning Strategies Reported by Students in BL Scenarios.

Category	Dimension	Analysis unit
Planning strategies	Listing and prioritization of tasks	"I try to make lists" (E13), "First I identify all the tasks that I must perform, then I order them by priority and/or the time it will take me to complete them and then I use the Pomodoro method" (E135)
	Goal proposal	"Establishing small but clear objectives" (E31), "Establishing more realistic goals according to each person's context" (GF4).
	Organize evaluations	"Use a calendar by setting the tests… schedule the evaluations" (E196)
	Award planning	"Setting small but clear goals which I compensate with small rewards" (E31)
	Self-care actions	"Sleep well" (E28), "The ways I use to regulate is to take study times and rest times (E112)
	Space preparation	"I try to find a comfortable and quiet place to study, a quiet place" (GF2), "I put on calm music and organize the space where I am going to study" (E209)
	Planning time and activities	"Setting schedules where I carry out my activities and defining which activities have the highest priority" (E106)
Planning tools	Analog	"I make a calendar… have a schedule" (E20), "Organizing myself with an agenda" (E118).
	Technological	"…With a stopwatch" (E93), "Normally I set a cell phone timer, a timer, to keep track of the time I use" (E111).
	Virtual	"Google calendar, for example, is a tool that is very useful for organizing activities" (E111), "Saving information in the virtual cloud to have it and read it whenever you want" (E34)

TABLE 4 Execution strategies reported by students in BL Scenarios.

Category	Dimension	Analysis unit
Self-monitoring of learning achievement	Subject questions	"…ask questions about the subject, question" (E9)
	Subject exercises	"I exercise on the subject to check that I am learning" (E220)
	Formative evaluations	"Through virtual flashcards, exams from other institutions, exercises… I evaluate myself" (E71) "Perform diagnostic tests" (E39)
Self-monitoring of the study process	Correct time organization	"I define what I study each day, or if I am deficient in a certain field, I study that field during the schedule of the field that I handle the most" (E40)."I take a break when I lose focus and return 15 min later" (E171)
	Correct study strategy	"He can recognize which methods are useful and apply changes when necessary" (E209)
	Verify completion of activities	"…and I also use a checklist to see what I should study and what I have already studied" (E112) "With everything do list" (E124)
	Manage distractions	"I use earplugs or white noise in the background" (E179)
	Regulates emotions	"He does not get frustrated so quickly if (the study) does not work for him but rather he looks for solutions" (E214)
Seeking help	Of colleagues	"Keeping in touch to support each other, to have a study network, share material and resolve doubts" (E39), "Form a good study group… Ask questions with colleagues using platforms such as Microsoft Teams" (GF4).
	From the teacher	"…talking with classmates and even the teacher himself if necessary" (E54)
	From online materials	"He used digital tools to be able to study what he saw in classes, for example, videos explaining exercises seen in classes or tutorials of programs used," (E24) "…When I do not understand the subject, I look for help on the Internet" (E46).

TABLE 5 Self-monitoring parameters in BL Scenarios.

Category	Dimension	Analysis unit
Personal level of advancement	Amount	"That you can see your progress of what you are learning on the virtual platform" (E18)
Companion advancement level		"I see how my classmates are doing, if I'm late or not… how many they have delivered (refers to the delivery of a task)" (GF2)
Peer learning level	Successes	"It's just that if everyone is pointing at him (refers to giving correct answers) and I'm not, I do not know, it means that something is happening, that I'm missing" (GF7)
	Mistakes	"If you look, and everyone was wrong, then you are not so bad" (GF4)
Ratings	Grades	"Virtual platforms help me check if I handle the content and analyze my notes" (E40) "Be guided by the note" (GF5)
Subject expectations		"It's easier to know what they expect from you…teachers leave you guidelines or rubrics in the virtual classroom" (GF3)

are made about their study processes (materials, technological devices, physical space, study strategies, activity organization, and time planning) and their learning achievement (goals, grades, competencies, knowledge, and learning retention over time).

Students react by developing responses in two areas: their learning and their motivation. For learning, reactions are based on negative events where expected results are not achieved, whereas for motivation, students deploy responses for both good results (praise and rewards) and poor results (self-encouragement and avoidance of pessimistic thoughts) (see Table 6).

The strategies students describe reveal a detailed and differentiated understanding of the stages of self-regulated learning in BL contexts. Planning focuses on establishing a conducive and organized learning environment, emphasizing the importance of balancing study and personal well-being. Execution is characterized by social interaction and the use of online resources, indicating an adaptation to the digital BL environment. Evaluation shows critical self-awareness, where students reflect on their practices and outcomes, adjusting their methods and motivation based on self-assessment. The infrequent mention of teacher support in students' self-regulation strategies underscores a shift toward personalized learning in blended learning

contexts. Students are increasingly proactive in their self-regulation, relying on peer support and digital resources. This adaptability is a key feature of the evolving landscape of blended learning. The analysis reveals that students apply various self-regulated learning strategies in BL environments distributed across the planning, execution, and evaluation stages. These strategies emphasize organization, self-monitoring, and critical reflection, highlighting student autonomy and integrating technological tools and support resources. Fostering these strategies can enhance students' academic success and personal well-being in blended learning environments.

3.4 Differences between SRL-BL and SRL-T

Student narratives highlight differences between SRL-BL and traditional SRL (SRL-T) (see Table 7). In face-to-face education, there is a certain control exerted by the presence of the teacher, helping them concentrate on academic tasks, whereas in a BL context, self-control is required, which is seen as a challenge for SRL BL. In face-to-face education, the responsibility for learning falls on the teacher, while in a BL context, the responsibility shifts to the student, making self-regulation skills more critical.

TABLE 6 Evaluation strategies in BL Scenarios.

Category	Dimension	Analysis unit
Study process	Materials	"I see if I used the notes or materials, maybe I did not have everything I needed" (GF10)
	Devices	"For example, if I had to do a job and I chose an app, maybe I wasn't the most educated" (E28), "I realized that the computers in the laboratory are super good and so I do the work there" (GF8)
	Physical space	"I studied at a classmate's house, and it was fatal, a lot of distraction and noise, the slow internet… we did not make any progress" (GF9),
	Study strategy	"Evaluate whether your study methodology was effective" (E225)
	Organization of time and activities	"It was not a good idea, we did a "central attack" and it went badly for all of us" (GF3), "I had distributed the tasks poorly, I gave little time to things that were not so fast" (GF1).
Learning achievement	Goals	"See if it meets the goals it sets" (E215)
	Note	"The grade, the grade tells you how well you did" (GF2)
	Competencies	"If I learned… that, I do know how to do it, apply it" (GF3)
	Knowledge	"You realize how much you handle the subject, then you know, it shows that you handle the subject" (GF6)
	Durability of learning over time	"If you miss the subject, do not forget it the next day" (GF1)
About learning	Review material again	"Understand and analyze failures in my learning by reviewing bad answers" (E238), "Look for weak or strong points and if I have not had a positive result, use another method that improves previous results" (GF1)
	Make decisions to improve your study	"I am looking for another way to study" (GF5), "I modify my study method" (GF6)
About motivation	Self-praise	"I congratulate myself; I tell myself that I am top, that I am the best" (GF3)
	Awards	"…Through self-rewards for meeting small study goals" (E7) "Setting small but clear goals which I compensate with small rewards" (E32)
	Encouraging messages	"I remember the commitment I have to my studies, and I try to motivate myself" (E48)
	Managing negative thoughts	"Put away negative thoughts, so as not to get depressed" (GF2), "You start to think that it is useless, that it is bad, that nothing is going to work for you, but you have to get rid of those thoughts and move on (GF10).

TABLE 7 Differences between SRL-BL and SRL-T.

Category	Dimension	Analysis unit
Responsibility SRL BL	Student	"That it depends on me to learn and use the tools that the university provides me" (E3), "I think it is where learning depends purely on me, deciding whether I want to learn more or less" (E16)
Responsibility SRL T	Teacher	"Trying not to get distracted, it helps to be close to the teacher" (E85), "It's different, because we are with the teacher and he draws attention, so it regulates us," (GF3).
Features SRL BL	Level	"The use of the platforms that exist to help level the subject to be learned" (E56), "It helps you understand the subject because if you never get an average…if you do not understand it will not be of any use" (E5)
	Complement	"Use virtual platforms to provide feedback or complement my learning" (E37) "Deepen what is learned in classes, for example, investigate more about a topic" (E177)
	Aid	"Knowing how to use these tools to help yourself in your studies is necessary" (E23).
Features SRL T	Optimize	"You get more out of studying" (GF2), and "you do better because you organize yourself better" (GF3).

In face-to-face study, self-regulated learning (SRL) is implemented through academic activities provided by the teacher. In contrast, in SRL-BL, the student defines what and how to study, adapting it to their own needs. Related to this idea, SRL-BL is seen as a skill that levels, complements, and/or aids learning, leading to additional study actions required in a face-to-face context (see Table 7). From the students' narratives, it is inferred that the virtual component favors SRL by providing a global view of the learning process and the academic load it will entail, which in face-to-face learning is limited to a more linear view of the learning process discovered class by class. This global view of the learning process particularly favors SRL BL in its execution stage (see Table 7).

The perceived differences between SRL-BL and SRL-T highlight a significant shift in the dynamics of responsibility and control in the learning process. In traditional environments, the external control provided by the teacher structures learning, whereas in BL, students must take a more active and autonomous role. This shift toward self-regulation in BL implies that students need to develop and apply planning, execution, and evaluation skills independently. The ability to adapt learning to their personal needs and the global view of the learning process in BL can facilitate a richer and more personalized learning experience. The analysis reveals that students perceive SRL-BL as an approach that requires more advanced and autonomous self-regulation skills compared to SRL-T. The need for self-control and personal responsibility in BL challenges students to become more

TABLE 8 Threats to SRL-BL.

Category	Dimension	Analysis unit
Distractors	Social networks	"Not paying attention to social networks, using the cell phone only to search for information and things like that" (E14), "He takes his time to disconnect from social networks and focuses on his studies and learning" (E22)
	Leisure technologies	"Ability to resist temptations such as the telephone, the computer" (E41) "He does not lose concentration or is distracted by Instagram-type applications or pages" (E132)
	Daily activities	"Getting away from everything that is a distraction… a good balance between your studies and your personal life" (E29)
	Organization of the virtual environment	"Have your virtual space organized while worrying about possible distractions" (E20)

independent learners. At the same time, the flexibility and global view of learning in BL contexts offer opportunities for more effective self-regulation and adaptive learning. Fostering these skills can enhance learning effectiveness and prepare students for more self-directed educational environments.

3.5 Threats to SRL BL

The main threat perceived by students to SRL BL is distraction. Students express that concentrating in a virtual learning environment is more difficult, making it more complex to adhere to study planning, requiring additional effort. For students, the BL scenario presents a learning context with new challenges where factors such as social networks, leisure technologies (TV, consoles, among others), personal activities, and the disorganization of the virtual environment become threats to SRL (see Table 8).

Students' perceptions of threats to SRL in BL contexts highlight the importance of a structured and distraction-free learning environment for successful self-regulation. The presence of multiple sources of distraction in the virtual environment challenges students to develop effective strategies to maintain concentration and adhere to their study plans. The need for additional effort to manage distractions suggests that students must be more conscious and deliberate in implementing self-regulation strategies in BL contexts. This includes setting clear boundaries for the use of leisure technologies and social networks, as well as creating an organized study environment that minimizes distractions.

The analysis reveals that distractions pose a significant threat to self-regulated learning in BL contexts, requiring conscious effort from students to stay focused and adhere to their study plans. Fostering self-regulation skills that specifically address these distractions can enhance learning effectiveness and help students face the unique challenges of blended learning environments.

4 Discussion

Discussing self-regulated learning in blended learning (SRL-BL) environments is not only relevant for the academic development of students but also for the continuous evolution and improvement of modern educational methods (Gqibani, 2022). This study aimed to conceptualize self-regulated learning in university educational contexts with a B-L modality, based on students' perceptions.

The SRL-BL is defined as a process in which students structure, monitor, and evaluate their learning using both self-reflection and digital technologies. Students describe this process following the

same three stages of traditional SRL: planning, execution, and evaluation, although with a notable emphasis on planning and, to a lesser extent, on execution, while the evaluation stage receives less attention. SRL-BL is also perceived as synonymous with autonomous learning, highlighting the student's independence and the effective use of virtual platforms to organize their studies.

Self-regulated learning promotes autonomy and responsibility in students, crucial skills for their academic and professional success. In blended learning environments, where face-to-face teaching is combined with online instruction, these skills become even more important (Zimmerman, 2000). The results show that students understand SRL-BL as an integral process of self-reflection and action, structured in three stages: planning, execution, and evaluation, but with particular emphasis on the first two. This understanding reflects an adaptation of the traditional self-regulated learning model to the blended learning context, where digital technologies play a crucial role.

The lesser focus on the evaluation stage suggests a possible area for improvement in training students for more complete and effective self-regulation. This aligns with findings from other research indicating low metacognitive processes due to a lack of training in metacognition. Metacognition is often not a central component of the curriculum in many educational institutions. Students may not be familiar with effective self-assessment techniques, such as critical reflection, the use of rubrics or checklists, and self-observation. Another influencing factor is that in many educational systems, evaluation is traditionally centered on teachers and standardized tests, which can prevent students from developing self-assessment skills. If students do not see the value of self-assessment or are not motivated to reflect on their learning, they are less likely to develop metacognitive skills.

4.1 Necessary skills for SRL-BL

For SRL-BL, students identify emotional, digital, and distraction management skills, as well as the ability to balance study with personal life, highlighting the multifaceted nature of SRL-BL. These skills are essential to face the specific challenges of learning in mixed environments, where the physical presence of the teacher and the traditional classroom structure are largely replaced by the student's autonomy and the use of digital tools.

Regarding emotional skills, virtual education can increase isolation and reduce social support, favoring feelings of loneliness and anxiety. High levels of stress and frustration can particularly decrease motivation and commitment to studies. Students may feel overwhelmed and demotivated, leading to procrastination behaviors that affect their academic performance. Similarly, various studies

(Avdija, 2022; Hinds and Sanchez, 2022; Knezevic et al., 2023) indicate that stress and frustration negatively affect concentration, memory, and decision-making capacity.

Research during the pandemic period (Hodges et al., 2020) indicates that one of the obstacles identified by students for good performance in virtual education is the excessive workload, its poor distribution, and the lack of prioritization among the types of resources contained in virtual classrooms for learning. A well-planned curriculum of the academic load assigned to students, with a better balance in the amount and types of academic commitments, would stimulate a less stressful and frustrating learning environment that favors participation, information retention, and overall satisfaction with the educational experience.

Concerning the above, self-care behaviors mentioned by students (sleep care, nutrition, and leisure spaces) could be measures to combat stress and frustration. When these are absent, there is a greater likelihood of negative effects on physical health, such as insomnia, headaches, and other health problems. Similarly, another measure declared as relevant by students was the ability to maintain a healthy balance between academic responsibilities and personal life, a challenge associated with greater overall well-being.

In the case of digital skills, students highlight the mastery of virtual platforms and digital tools as a necessary aspect, implying that educational institutions must ensure students receive adequate training in these competencies (Afify et al., 2023). Additionally, including digital competencies in higher education is crucial for the current job market, where these skills are essential for almost all professions, bridging the gap between education and market demands, ensuring a workforce prepared for the challenges and opportunities of the 21st century, and driving economic and social development.

Finally, effective self-regulation requires students to learn to manage distractions, a significant challenge in virtual learning environments where social networks and other leisure technologies are constantly available (Turnbull et al., 2023). In this scenario, being able to create an appropriate study space (without TV, loud noises, constant traffic, etc.), having a fixed study schedule can help maintain discipline, turning off notifications on the phone and other electronic devices, or using applications that block access to social networks and websites unrelated to study during work hours, keeping the digital desk tidy, closing unnecessary tabs and using applications and tools that help maintain focus, such as task list apps and time managers, even communicating needs to family, friends, and peers to ask them to respect those times to minimize interruptions. Using active study techniques like taking notes, making summaries, and participating in online discussions can keep the mind active and engaged with the study material. This together would help students better manage distractions and create a more productive learning environment.

4.2 Strategies for self-regulated learning in blended learning contexts

The strategies for SRL-BL mentioned by students are abundant and varied, indicating that the experience with virtuality has significantly transformed how university students' study. Some examples include the increased possibility of collaborative study through tools like Google Docs, Microsoft Teams, and Slack, which allow students to work together in real-time regardless of geographic distance. Multimedia materials like videos, podcasts, and others enrich learning and enable students to access information in different formats. Virtual and augmented reality allow students to participate in simulations and conduct experiments in a safe and controlled environment. Immersive technologies offer more interactive and engaging learning experiences, which can improve the understanding of complex concepts. Despite all these opportunities provided by technologies, they can also maintain and/or exacerbate existing gaps among students, as not all possess the necessary skills to successfully face these challenges, including SRL skills.

In SRL-BL, students mention the use of analog and digital tools for planning, suggesting that students combine traditional methods with modern technologies to manage their learning, resulting in a greater repertoire of strategies for SRL. These strategies give students more opportunities to anticipate the study strategy that might be most favorable, estimate the effort it will require, evaluate its complexity to visualize additional support needs, all desired behaviors that favor academic success.

In the execution stage, students report implementing self-monitoring strategies that focus on learning achievement, how the study process is carried out, and seeking help. The self-monitoring and help-seeking strategies reflect a deep understanding of the importance of continuous reflection and collaborative support. The lesser mention of teacher support may indicate greater autonomy, but it also suggests that teachers need to be more available to assist when necessary (Trespalacios et al., 2021). Finally, in the evaluation stage, students express developing some judgment and reaction processes. Self-judgment and reaction strategies highlight the importance of critical reflection on the learning process and the adaptation of strategies based on the results obtained. It is worth noting that in the reaction processes, strategies associated with addressing motivational cognitive states appear, such as setting aside negative thoughts in response to a learning failure evaluation or self-reward in the case of success, aspects less considered in the conceptualization of SRL and therefore little considered in programs aiming to promote it.

4.3 Differences between SRL-BL and SRL-T

The perceived differences between SRL-BL and SRL-T highlight the central role of the student in their learning in a BL environment. In face-to-face education, the presence of the teacher provides greater structure and supervision, whereas in BL education, the student must take on more responsibility. This implies that students need to participate more proactively and autonomously in their learning, developing self-management and self-control skills that are less demanded in a traditional environment where the teacher more actively regulates learning (Ryan and Deci, 2017). Consequently, in SRL-BL, students need to have a more comprehensive view of their learning process and the academic load it generates, facilitating better planning and execution of their studies compared to face-to-face education, where the learning process is discovered more linearly and sequentially.

4.4 Threats to SRL-BL

The main threat identified for SRL-BL by students is distraction. Virtual environments present numerous distractors, such as social networks, leisure technologies (television, video game consoles), everyday activities, and the disorganization of the virtual environment (Aristovnik et al., 2020). These factors make it difficult to concentrate and adhere to study planning, requiring extra effort to maintain

self-regulation of learning in BL contexts. These distractions can reduce the effectiveness of learning and increase the effort needed to stay focused and follow study plans. This would be a cross-cutting threat present throughout the entire SRL cycle, regardless of the stage.

The study's results underscore the complexity of self-regulated learning in BL environments, highlighting both the necessary competencies and the challenges students face. Educational institutions must consider these findings to design interventions and supports that strengthen SRL-BL. The results highlight the need to provide training instances for students that include both digital skills and strategies for managing stress and frustration associated with online education.

Despite the fact BL promotes a role for students with greater autonomy and independence, the teacher's role remains fundamental in the learning process. It is necessary to emphasize that teaching in digital environments does not seek to eliminate the teacher's role but to optimize this relationship through more channels and means of teaching. This allows activities with active methodologies to be carried out during synchronous and/or face-to-face sessions, where the teacher can convey expectations, attitudes, values, experiences, and expertise, aspects that are difficult to teach otherwise.

It is important to note that the number of cases in this study is limited, which restricts the scope of its results. This is particularly sensitive in analyzing the differences that SRL-BL might present between areas of knowledge and/or educational levels of students. Future research should expand and diversify participants (e.g., students who are not in their first year of study, from different educational levels and different areas of science) to enrich knowledge on this topic and delve into the specific strategies that students deploy to increase the effectiveness of SRL. Current instruments that measure SRL do not consider virtual environments or new technologies, making them outdated. Future studies could focus on developing and studying the psychometric characteristics of instruments that measure SRL-BL, providing the opportunity for experimental designs to estimate the impact of SRL-BL intervention programs and identify the most effective strategies.

5 Conclusion

It is concluded that it is crucial to update the concept of self-regulated learning in an educational setting that has been impacted by technological advancements. Attention must be given to the new challenges students face in achieving a good level of SRL-BL and the strategies they are using to address these challenges.

The study has conceptualized the process of SRL-BL environments, where students structure, monitor, and evaluate their learning using self-reflection and digital technologies. It has been observed that students follow the traditional stages of planning, execution, and evaluation, although with a particular emphasis on planning and less on evaluation. This adaptation reflects the student's independence and the effective use of virtual platforms to organize their studies.

Significant differences have been identified between SRL-BL and SRL-T. In face-to-face education, the presence of the teacher provides greater structure and supervision, while in B-L education, the student assumes greater responsibility and autonomy. This implies that students need to participate more proactively in their learning, developing self-management and self-control skills that are less demanded in a traditional environment. SRL-BL requires a more

comprehensive view of the learning process and better planning due to the physical absence of the teacher to actively regulate learning.

Among the identified benefits are the promotion of autonomy and responsibility in students, crucial skills for their academic and professional success. However, students face significant obstacles such as distraction caused by social networks, leisure technologies, and the poor organization of the virtual environment. These factors negatively affect concentration and adherence to study planning, requiring additional strategies to effectively manage self-regulated learning in B-L contexts.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The study was authorized by Comité de Ética, Bioética y Bioseguridad of Universidad de Concepción, whose identifier code is CEBB 1099-2022. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

KL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. RC-R: Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. DB: Conceptualization, Investigation, Writing – original draft, Writing – review & editing. JS: Investigation, Writing – original draft, Writing – review & editing.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The impact of extent and variety in active learning methods across online and face-to-face education on students' course evaluations

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Introduction: In recent years, numerous studies have compared traditional face-to-face (F2F) learning on campus with online learning, seeking to establish how the learning environment (online vs. F2F) affects outcomes such as student satisfaction and achievement. In a separate line of research, scholars have examined various facets of active learning—an approach that makes use of interactive learning methods—separately in online and F2F environments. However, few studies have compared the effects of active learning in classes taught online vs. F2F. The present study addresses this gap. It follows an earlier study in which we examined the effects of active learning in an online environment, particularly how the extent and variety of interactive teaching methods used affect students' course evaluations (overall evaluations and perceived clarity of the teaching).

Methods: The present study repeats the setup of that previous study in a F2F environment, allowing us both to gain new insights into the effects of active learning in this context and to directly compare the examined outcomes in F2F vs. online learning.

Results: The results reveal consistent trends in both studies: more extensive and more varied use of interactive learning methods improves overall student evaluations and perceptions of the clarity of teaching in the course. Crucially, minimal use of interactive teaching methods results in notably lower student evaluations and perceptions of teaching clarity in F2F settings compared to online classes.

Discussion: The findings highlight the essential need for instructors to adopt diverse interactive methods in F2F environments to improve educational outcomes and reinforce the effectiveness of active learning.

KEYWORDS

active learning, interactive learning methods, student evaluation, online learning, F2F learning

1 Introduction

The COVID-19 pandemic prompted an urgent and significant transformation in educational delivery, accelerating the transition from traditional face-to-face (F2F) instruction to online learning environments. This shift was not merely logistical but also pedagogical, intensifying the focus on active learning—an educational approach that engages students through interactive methods.

Active learning techniques place students at the center of the learning process, making them protagonists of discovery rather than passive receivers of information (Deslauriers et al., 2019). These methods benefit the learning process in four main ways: (1) engaging students directly with the content, leading to deeper learning (Chi and Wylie, 2014); (2) challenging students to apply, analyze, and evaluate information rather than simply memorize facts, thereby developing higher-order cognitive skills (Konopka et al., 2015); (3) engaging students by using relevant real-world applications, such as problem-based learning techniques that often draw from real-world scenarios (Chi and Wylie, 2014); and (4) developing collaborative skills through group work, which helps students build important teamwork and communication abilities while improving academic achievement (Froyd, 2007; Saunders and Wong, 2020). Moreover, active learning seems to be especially valuable not only for raising achievement across the board, but for reducing achievement gaps for underrepresented students in STEM (Science, Technology, Engineering, and Mathematics) disciplines, as found by Theobald et al. (2020) in a comprehensive review. This finding highlights the potential of active learning to promote equity in education. The present study is part of ongoing research in which we focus on the effects of four specific active learning methods [see section "2 Background (active learning methods)"].

While extensive research has explored the efficacy of active learning within distinct online (Mou, 2021) or F2F contexts, comparative analysis of these methods across both modalities remains scant. Our prior research (Barnett-Itzhaki et al., 2023) also primarily examined these environments in isolation, potentially overlooking how active learning strategies influence student assessments depending on the instructional context. In that earlier work, we explored how students experienced active learning online during the COVID-19 period with respect to three main questions: (a) how students evaluated the course; (b) how students perceived the clarity of the teaching; and (c) how students assessed the effectiveness of online learning. That study was based on approximately 30,000 teaching evaluation surveys filled out by undergraduate and graduate students at our institution during the COVID-19 period. We analyzed these outcomes in relation to various factors, such as class characteristics and student demographics, to determine how the use of interactive learning methods influences students' experiences when learning online. Our findings indicated that both the extent and the variety of interactive learning methods used significantly affect the perceived effectiveness and clarity of teaching.

In the 2021–2022 academic year, students at our institution returned to campus and to a face-to-face (F2F) learning environment. Simultaneously, the teaching staff adapted some of the methods and approaches acquired during the COVID-19 period for F2F learning, particularly the use of interactive learning methods. This situation prompted us to carry out a follow-up study to see how students experience active learning in a F2F environment, focusing on the same primary concerns as the previous study: (a) students' evaluations of the course, and (b) how students perceived the clarity of the teaching in the course. The third aspect examined in the previous study, the perceived effectiveness of online learning, is not relevant to the present study.

Within the educational literature, the return to campus following the pandemic has led to several academic studies aimed at comparing online learning to F2F learning. However, most of these studies focus on differences in student performance and satisfaction between these two environments (Chisadza et al., 2021; Spencer and Temple, 2021; Shah et al., 2022). For instance, Regmi and Jones (2020) executed a systematic review to compare the effectiveness of online and F2F learning in health professions education. Their findings suggest that online learning is at least as effective as traditional F2F.

As far as we can tell, there are insufficient comparative studies that have examined online learning versus F2F learning in the context of how active learning impacts students' perceptions and evaluations.

Addressing this gap, our current study aims to evaluate the impact of the extent and variety of interactive learning methods on student assessments in both online and F2F settings. We formulated two objectives: (a) to explore the active learning experience in a F2F environment, focusing on students' course evaluations and perceived teaching clarity; and (b) to conduct a comparative analysis, examining students' experiences of active learning in F2F versus online environments. To ensure as precise a comparison as possible, we drew our data from the same sources (teaching surveys filled out by students), in the same format as previously, and analyzed the data using the same methodology. For convenience, in what follows, the previous study is termed "the online study," while the current study is termed "the F2F study."

By employing a consistent set of measures and methodologies to evaluate approximately 30,000 teaching evaluation surveys, this study offers new insights into the comparative effectiveness of active learning across different learning environments. On the one hand, the findings of the F2F study are similar to those of the online study. Overall, they show that both the extent and variety of interactive teaching methods used significantly affect the studied outcomes: greater extent and variety are associated with significantly improved student evaluations of the course, and significantly higher perceived teaching clarity. However, classes with little or no use of interactive methods had statistically significant lower evaluations and lower perceived clarity in F2F compared to online classes.

This research innovatively dissects not merely the presence but also the diversity and intensity of active learning techniques, by directly comparing the impacts of these educational settings. Ultimately, this research contributes to a broader educational dialog on best practices in active learning, underscoring its pivotal role in ensuring student satisfaction and academic success across diverse instructional landscapes.

The rest of the paper is organized as follows: in section 2, we provide background on active learning methods; in section 3 we

elaborate on related work; in section 4 we present our research objective and questions; in section 5 we describe the research methods; and in section 6 we present our findings. Finally, in section 7, we discuss the results and outline directions for possible future work.

2 Background (active learning methods)

Active learning has been widely recognized as an effective pedagogical approach, leading to improved student outcomes across various disciplines in higher education (Theobald et al., 2020). According to Freeman et al. (2014), "Active learning increases student performance in science, engineering, and mathematics." In recent years, many active learning methods have been developed (Lombardi et al., 2021). In our current and previous research (Barnett-Itzhaki et al., 2023), we have chosen to focus on four active learning methods: (1) small working groups for discussion, thinking through, or performing a task; (2) independent work during lessons (via written assignments or producing digital learning products, such as videos, posters, or web pages); (3) student presentations during lessons; and (4) short knowledge tests during lessons (e.g., quizzes and questionnaires).

In Table 1, we elaborate on the characteristics, benefits, and effects on learning with respect to each of these four methods.

In sum, these active learning techniques—small working groups, independent work, student presentations, and short knowledge tests—each contribute uniquely to enhancing the learning process. They promote active engagement, critical thinking, and deeper understanding, all of which are essential for effective learning.

3 Related work

Extensive research has explored various facets of active learning methodologies, examining their implementation in both online and F2F educational environments. In addition, numerous scholarly inquiries have delved into comparisons between online and traditional F2F education, with a particular emphasis on evaluating student performance, gauging satisfaction levels, and exploring pertinent influencing factors. However, in examining the existing literature, we identified a lack of studies comparing the use of active learning in the online and F2F modalities. This is the focus of the current research. Consequently, to put our research in context, in this section we offer an in-depth review of scholarly works that comprehensively compare these learning modalities (online and F2F) from perspectives other than active learning.

Several studies have examined students' performance, satisfaction, or both in online versus F2F environments based on data collected in a specific course or teaching domain (e.g., Summers et al., 2005; Friday et al., 2006; Smith and Stephens, 2010; Ary and Brune, 2011; Biel and Brame, 2016; Paul and Jefferson, 2019; Regmi and Jones, 2020; Thai et al., 2020). Of these, most (e.g., Summers et al., 2005; Friday et al., 2006; Ary and Brune, 2011; Biel and Brame, 2016) found no statistically significant differences in student performance between the online

and traditional environments. Smith and Stephens (2010) found a statistically significant difference in mean scores achieved on the final exam, with online students earning a markedly higher mean score. However, the study found no significant disparities in student satisfaction as assessed through student evaluations. In contrast, Summers et al. (2005) report that students who enrolled in the online version of a course rated their satisfaction markedly lower than their peers in the traditional classroom setting. Those authors recommended that instructors should carefully consider pedagogical factors, including student characteristics, motivation, and levels of instructor support, during the development of online courses to bolster student satisfaction; and they called for future research to delve deeper into the specific factors influencing student satisfaction in online courses. Biel and Brame (2016) offer several recommendations to enhance the effectiveness of online instruction, including the implementation of an online orientation for students, fostering interactions through digital communication tools, and incorporating elements that encourage student self-reflection and self-assessment.

Mali and Lim (2021) found that students perceived blended learning (BL) more positively during the COVID-19 pandemic, but preferred face-to-face (F2F) learning when COVID was no longer a concern. In a study with undergraduates using mixed methods, they showed that F2F is favored due to better interaction with lecturers, group work, peer engagement, class involvement, and the ability to ask technical questions. They argue that to improve BL, policymakers should incorporate social elements into netiquette frameworks to enhance the student experience and mitigate negative attitudes toward online/BL learning.

In a broader effort to assess the effectiveness of online versus traditional F2F instruction, Paul and Jefferson (2019) examined outcomes for an environmental science class that was offered both F2F and online between 2009 and 2016. Overall, they found no statistically significant differences in student performance between the two groups; and these conclusions remained consistent when considering factors such as gender and class rank. However, this study was context-specific, focusing primarily on a specific course tailored to non-STEM majors, which may constrain the extrapolation of these results to other academic disciplines or student populations.

Some studies have compared student achievement and satisfaction without restriction to specific teaching domains (e.g., Dell et al., 2010; Atchley et al., 2013). Intriguingly, Atchley et al. (2013) observed significant variations in course completion rates between different academic disciplines. Their study examined 14 different disciplines and found that course completion varied significantly by subject. Notably, reading courses had the highest completion rate at 98.2%, while finance courses had the lowest at 82.2%.[1] These findings align with previous research suggesting that some disciplines may be better suited to online delivery than others (Noble, 2002; Carnevale, 2003; Nelson, 2007; Paden, 2006; Smith et al., 2008). This variation in completion rates across disciplines highlights the importance of considering subject matter

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1   While Atchley et al. (2013) do not provide a precise definition of "reading courses," given the context of their study and the other disciplines examined, these likely refer to courses focused on teaching reading or developing reading skills, presumably within teacher education programs or the field of education.

TABLE 1 The chosen methods: characteristics, benefits, and effects on learning.

Method	Characteristics	Benefits	Effects on learning
Small working groups (Michaelsen et al., 2023; Jones, 2007)	Active participation Engage actively with material and each other	Enhanced understanding Learn more and retain info longer compared to traditional formats	Increased engagement Fosters deeper understanding and critical thinking
	Specific task Groups work on a defined task or problem	Peer accountability Accountable to their peers	Improved retention Collaborative learning helps students retain information longer
	Reflection on the learning process and outcomes	Exposure to diverse perspectives Benefit from hearing different viewpoints for solving problems	Motivation Community and accountability increase motivation to learn
Independent work (Lombardi et al., 2021; van Hout-Wolters et al., 2000)	Self-directed Students take control of learning process, planning, pacing	Autonomy Take responsibility for learning, fostering independence and self-regulation	Enhanced motivation autonomy and choice increase intrinsic motivation
	Variety of outputs Written assignments, digital products, posters, web pages, etc.	Creativity Express their understanding in various formats	Critical thinking analyzing and synthesizing information enhances critical thinking skills
		Personalized Learning Focus on areas where they need more practice	Self-Regulation Develops skills in planning, monitoring and evaluating learning
Student presentations (Nouri and Shahid, 2005; Tesfaye and Berhanu, 2015)	Public speaking Presenting work to the class, developing communication skills	Confidence building Build confidence in public speaking and presenting ideas	Improve understanding preparing and delivering presentations requires deep understanding of the material
	Peer learning Learning from each other's presentations	Immediate feedback Peers and instructors feedback improve performance	Communication skills Enhances ability to communicate complex ideas clearly and effectively
Short knowledge tests (Zainuddin et al., 2020; Murphy et al., 2023)	Frequent assessment regular, low-stakes testing during lessons	Retrieval practice frequent tests reinforce learning through the retrieval practice effect	Focused learning helps students focus their study efforts on areas that need improvement
	Immediate feedback on students' understanding	Focused study Helps identify areas which need more study, leading to more efficient learning	Active engagement Ensures active engagement with the material, preventing passive learning

when designing and implementing online courses. By contrast, Dell et al. (2010) found no statistically significant disparities in the quality of work between the two environments. Both these studies highlight the need for further research given the burgeoning popularity of online learning, including the potential role of variables such as student characteristics and prior experience with online learning (Atchley et al., 2013). Dell et al. (2010) also emphasize the paramount importance of instructional strategies that promote active learning, encourage student interaction, and facilitate self-reflection and self-regulation.

Other papers (e.g., Shah et al., 2022; Chisadza et al., 2021; Spencer and Temple, 2021; Kemp and Grieve, 2014; Driscoll et al., 2012; Johnson et al., 2000) also compared the effectiveness of online and face-to-face instruction in terms of satisfaction levels, performance, and other variables. The studies of Driscoll et al. (2012) and Johnson et al. (2000) found that F2F students exhibited marginally more favorable perceptions of instructors and course quality. F2F cohorts reported greater satisfaction with student interaction and the support provided by instructors and academic departments. However, no statistically significant differences were found in learning outcomes. The authors of both studies underscored the need for enhancing communication in online education settings. Shah et al. (2022) found a significant disparity

in engagement and satisfaction emerged, favoring F2F classroom settings. They called for qualitative research to help explore these disparities and for the development and implementation of training programs aimed at enhancing the quality of online education. Kemp and Grieve (2014) found that students exhibited a preference for F2F activities over their online counterparts and that F2F discussions were perceived as more engaging and conducive to immediate feedback. However, as in other studies reviewed here (e.g., Driscoll et al., 2012; Johnson et al., 2000), there were no statistically significant differences in test performance.

Chisadza et al. (2021) examined factors influencing students' performance during the transition from face-to-face to online learning due to the COVID-19 pandemic, using survey responses and grade differences from a South African university. The results indicate that good WiFi access positively impacted performance, while difficulty in transitioning to online learning and a preference for self-study over assisted study were associated with lower performance. The study suggests enhancing digital infrastructure and lowering internet costs to mitigate educational impacts of the pandemic.

To summarize, previous studies have yielded a range of results concerning the efficacy of online and traditional education. While some studies observed no significant disparities between the two

formats, others reported variations in academic outcomes (e.g., completion rates and grades) and student perceptions. Variables such as student characteristics, engagement levels, instructor support, and course design were identified as influential in shaping the success of online learning experiences. In essence, online education emerges from this literature as a viable alternative to F2F learning, but studies consistently call for further research into ways to improve its effectiveness. Notably, students tend to favor F2F discussions for their interactive and feedback-rich nature, even though both modalities can lead to comparable academic performance outcomes. Therefore, improving communication and engagement in online learning environments is imperative.

Within the academic literature, there is a conspicuous dearth of comprehensive studies offering a comparative analysis of active learning in online and F2F education, particularly regarding student satisfaction and perspectives. The present research aims to address this gap in the literature.

4 Research objectives

As mentioned, the current study (the F2F study) has two objectives: (a) to investigate the experience of active learning among students in a F2F environment, using the same measures as in our previous online study; and (b) to compare the effect of active learning on students in an online versus F2F environment, based on the findings of the previous study and the present study, respectively. In both studies, active learning is expressed through the use of one or more of the following four interactive learning methods: (1) small working groups for discussion, thinking through, or performing a task; (2) independent work during lessons (via written assignments or producing digital learning products, such as videos, posters, or web pages); (3) student presentations during lessons; and (4) short knowledge tests during lessons (e.g., quizzes and questionnaires). Further, in both studies, we account for the following student and class characteristics: instructor's gender, student's gender, and student's year of study.

Based on the above, we formulated the following research questions:

RQ (1) How do the extent and variety of interactive learning methods in a F2F course affect students' evaluations of the course and students' perceptions of the clarity of teaching in the course, alongside the different class and student characteristics (instructor gender, student gender, student year of study)?

RQ (2) What differences (if any) exist between online and F2F classes in students' course evaluations and perceived clarity of the teaching in relation to the extent and variety of active learning?

Accordingly, we have two dependent variables and seven independent variables: four for the different interactive learning methods (numbered 1–4), and three for the student and class characteristics (numbered 5–7). The variables are presented and described in Table 2.

5 Materials and methods

The research relied on evaluation surveys filled in by students during semesters A (autumn) and B (spring) of the 2021–2022 and 2022–2023 academic years, for a total of four semesters in all. Such surveys are routinely distributed by academic institutions to evaluate measures of student fulfillment and satisfaction. The surveys for both studies included questions related to the use of interactive learning methods.

5.1 Participants and procedure

Participants were all students at the same academic institute. The surveys related to classes in 23 departments in the four faculties of the institution: (1) Social and Community Sciences, (2) Marine Sciences, (3) Engineering, and (4) Economics and Business Administration. We analyzed only surveys referring to lecture-style classes (i.e., we did not include seminars, as these are naturally discussion-based and interactive, and so inherently employ active learning techniques). Thus, the findings specifically relate to the use of active learning methods in traditional lecture settings.

Students were asked to complete a survey for each class in which they were registered, resulting in multiple survey responses per student. Hence, the number of surveys is substantially larger than the number of students. The response rate was high, reflecting robust participation from the student body.

With respect to the gender distribution, the sample included both male and female students. The exact number of responses from male and female students was tracked but not individually identifiable due to anonymization. More precisely, as survey responses were anonymous, we cannot link particular surveys to particular students. However, the institute's Teaching Promotion Unit (TPU), which administered the surveys, collected demographic information, including gender, during the survey administration process. This

TABLE 2 Dependent and independent variables.

Dependent variables	(1) Overall course evaluation (a teaching evaluation from the student's point of view). (2) The student's perception of the clarity with which the course was taught.
Independent variables	(1) Use of small working groups for discussion, thinking through, or performing a task (in online classes, using breakout rooms on Zoom). (2) Independent work during lessons (via written assignments or producing digital learning products, such as videos, posters, or web pages). (3) Student presentations during lessons. (4) Short knowledge tests during lessons (e.g., quizzes and questionnaires). (5) Lecturer's gender. (6) Student's gender. (7) Student's year of study. Students in their first through third years of study were working toward a bachelor's degree. Students in their fourth year of study were primarily studying toward a master's degree, while typically also working in the industry.

TABLE 3 Summary of the research data.

Academic year	Semester	No. of students	No. of students returning surveys	*Response rate	Total no. of surveys	Total no. of classes	Total no. of lecturers
2021–22	A	4,667	2,660	57%	33,146	1,900	483
	B	4,417	2,169	49%			
2022–23	A	4,467	2,784	62.3%	32,035	1,859	474
	B	4,205	2,113	50%			

*The response rate represents the proportion of students who returned at least one completed survey.

information was then provided to the researchers in a de-identified format, allowing them to track the gender distribution of responses for each class without compromising student anonymity. We also examined the gender of the instructor to test for potential differences in teaching evaluations based on instructor gender.

Table 3 provides a detailed breakdown of the sample.

5.2 Measures

The items included in the surveys were designed to elicit students' assessments and perceptions of the course. We used six questions that appeared in the survey. Two questions solicited respondents' overall evaluation of the class, and how they perceived the clarity of the teaching. Students were asked to rate their agreement or evaluation on a scale from 1 (lowest/most negative) to 6 (highest/most positive). The other four questions referred to the four interactive learning methods described above: (1) small working groups; (2) independent work during lessons; (3) student presentations during lessons; and (4) short knowledge tests during lessons. Students were asked to report the frequency with which the interactive learning methods were used in the class on the following scale: (1) Never used: The method was not used at all during the course. (2) Rarely used: The method was used occasionally, but not in most lessons. (3) Sometimes used: The method was used in some lessons, but not consistently throughout the course. (4) Frequently used: The method was used regularly in most or all lessons. Note, however, that these assessments are inherently subjective, as they reflect the students' perceptions and experiences. Even the lowest score, "never used," can vary in interpretation among students depending on their personal engagement and recollection.

5.3 Analytical strategy

As the course evaluation scores have a non-normal distribution, we analyzed them using nonparametric tests. Wilcoxon unpaired tests were used to compare the evaluation scores of male and female students and to compare evaluation scores given to male and female lecturers. We further compared scores given to male and female lecturers separately for male and female students. Pearson and Spearman correlations were used to calculate

relationships between evaluation scores, perceived clarity, and student's year of study.

As class sizes ranged widely, we created class-related entries based on the average evaluation scores and average use of interactive learning methods reported for each class. Wilcoxon tests were used to compare the use of interactive learning methods by male and female lecturers. Spearman tests were used to identify correlations between the extent to which interactive learning methods were employed and the two dependent variables (course evaluation scores and clarity of the teaching).

Next, we examined the effect of using a variety of interactive learning methods. Toward this end, we defined two groups of classes: those that made high use of a variety of interactive learning methods (at least three different methods, with interactive learning used in most of the lessons), and those that made little or no use of these methods (one method at most, and used only once). The dependent variables were compared between the two groups using Wilcoxon unpaired tests. Classes that fell between these groups, using one or two interactive learning methods infrequently but more than once, were not examined in this analysis.

Finally, we used Wilcoxon unpaired tests to address our second research question, comparing F2F and online classes for each of the two groups (the high-use/high-variety group and the low-use/low-variety group). All statistical analyses and prediction models were performed using Matlab© version R2021b.

6 Results

Before analyzing our research questions, we first examined the effects of student and class characteristics on evaluation scores. In both the 2021–22 and 2022–23 academic years, courses taught by female lecturers received statistically significantly higher scores than courses taught by male lecturers ($p < 0.001$; see Table 4). In addition, female students awarded statistically significantly higher evaluation scores overall than male students ($p < 0.001$; see Table 4). There were no differences between the scores given to male vs. female lecturers within each of the student gender groups. No statistically significant correlations were found between evaluation scores and student's year of study.

Next, we present the findings related to the research questions. All statistical results (mean, standard deviation, median, and r) are summarized in Table 5.

TABLE 4 Effects of student and class characteristics on evaluation scores for online and F2F classes.

		Measure	Online	F2F 2021–22	F2F 2022–23
Effects of student and class characteristics on evaluation scores	Female lecturers	Mean ± std	5 ± 0.7	5.02 ± 1.28	4.9 ± 1.36
		Median	5.17	5	5
	Male lecturers	Mean ± std	4.8 ± 0.8	4.8 ± 1.42	4.8 ± 1.41
		Median	5	5	5
	Female students	Mean ± std	5 ± 1.3	4.9 ± 1.3	5 ± 1.3
		Median	5	5	4.9
	Male students	Mean ± std	4.74 ± 1.4	4.8 ± 1.4	4.75 ± 1.4
		Median	5	5	5

The differences between female and male lecturers and the differences between female and male students were statistically significant ($p < 0.001$, Wilcoxon nonparametric test).

TABLE 5 Full comparison between online and F2F studies*.

		Measure	Online	F2F 2021–22	F2F 2022–23
RQ1- Correlations between the use of interactive learning methods and course evaluation scores	Small working groups	r	0.21	0.19	0.19
	Independent work during lessons	r	0.21	0.29	0.29
	Student presentations	r	0.17	0.22	0.18
	Short knowledge tests	r	0.25	0.29	0.3
RQ1–Correlations between the use of interactive learning methods and perceived clarity of the teaching	Small working groups	r	0.21	0.15	0.15
	Independent work during lessons	r	0.21	0.23	0.25
	Student presentations	r	0.17	0.18	0.15
	Short knowledge tests	r	0.25	0.24	0.28
RQ2–Effects of using a variety of interactive learning methods	Evaluation score—Low use/low variety	Mean ± std	4.6 ± 0.82	4.06 ± 0.92	4.06 ± 0.92
		Median	**4.71**	**4.22**	**4.05**
	Evaluation score—High use/high variety	Mean ± std	5.21 ± 0.6	5.24±0.61	5.2 ± 0.73
		Median	5.40	5.38	5.43
	Clarity of course content—Low use/low variety	Mean ± std	4.55 ± 0.92	4.15±1.1	4.08 ± 0.9
		Median	**4.72**	**4.27**	**4.14**
	Clarity of course content—High use/high variety	Mean ± std	5.09 ± 0.66	5.1±0.71	5.13 ± 0.77
		Median	5.30	5.29	5.33

*Bold values were statistically significantly different ($p < 0.05$, Wilcoxon test).

6.1 RQ1: Effects of interactive learning methods in F2F courses

6.1.1 Interactive learning methods (extent of use)

Overall, the students perceived that interactive learning methods were used more by female lecturers than by male lecturers (see Figure 1). This was also true for three of the four methods when considered individually: all the methods except short knowledge tests were statistically significantly perceived as more used by female compared to male lecturers ($p < 0.001$).

For short knowledge tests, there was no statistically significant difference between male and female teachers.

Importantly, there were statistically significant correlations ($p < 0.05$) between the use of interactive learning methods and both outcome variables. The results are presented in Table 5.

6.1.2 Interactive learning methods (variety)

Comparison of the two dependent variables (course evaluation scores and clarity of teaching) between the two examined groups of classes—those that used a variety of interactive learning methods
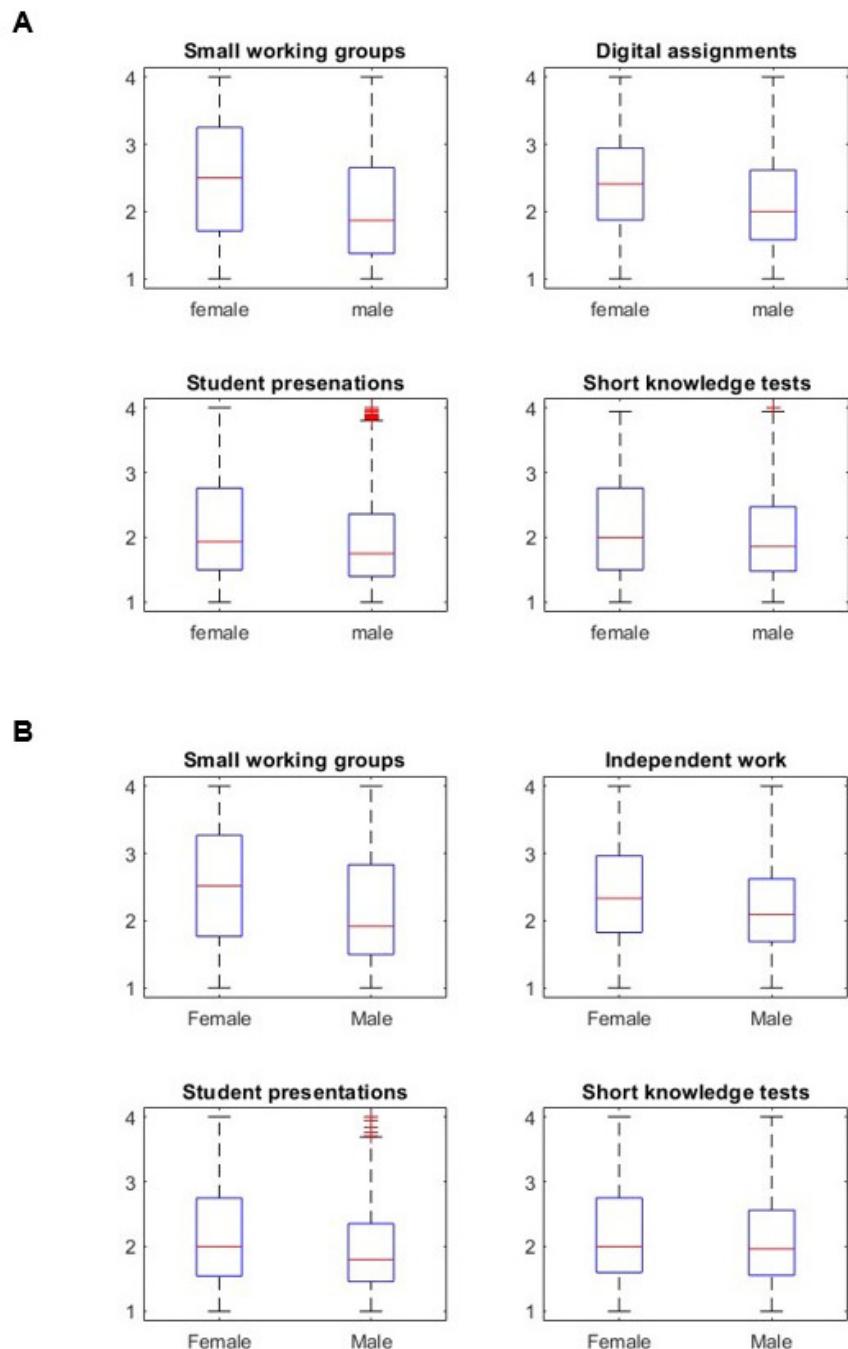
FIGURE 1
Use of interactive learning tools by female vs. male lecturers (small working groups / independent work during lessons/student presentations / short knowledge tests). 1 = Never used, 4 = Used very frequently. **(A)** Stands for year 2021−2, **(B)** stands for year 2022−3.

and those that made little or no use of such methods—shows that both variables are statistically significantly higher in the high-use/high-variety group ($p < 0.001$).

Figure 2 compares average scores for the two variables between the two groups. The comparisons were statistically significant ($p < 0.01$).

In sum, we found that greater use of interactive learning methods in F2F courses was associated with both higher satisfaction of the students with the course (expressed in overall class

evaluations), and higher perceived clarity of the teaching in the class. Interestingly, both measures were also higher in courses taught by female lecturers.[2] Most notably, greater use of a variety of interactive learning methods in F2F courses was associated with elevated satisfaction and perceived clarity of the teaching.

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2 Only the first of these analyses (on overall class evaluations) is presented in this paper. Details of the analysis on clarity of teaching by gender of the lecturer are available from the authors upon request.
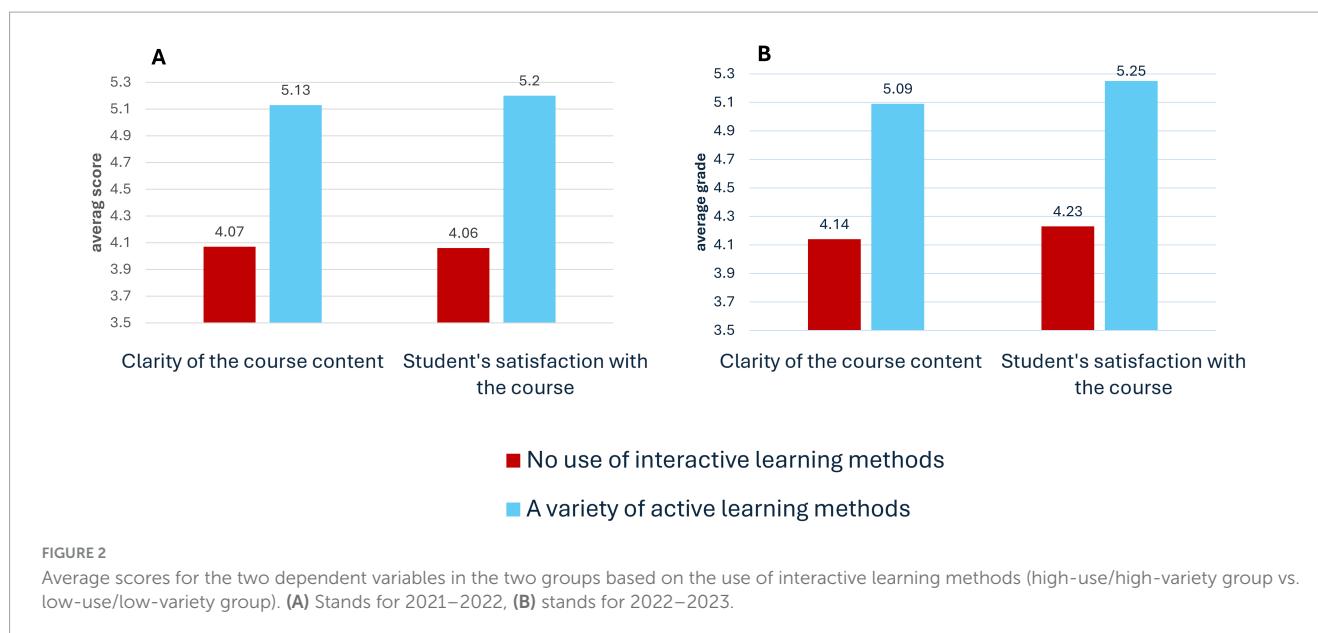
FIGURE 2
Average scores for the two dependent variables in the two groups based on the use of interactive learning methods (high-use/high-variety group vs. low-use/low-variety group). **(A)** Stands for 2021–2022, **(B)** stands for 2022–2023.

TABLE 6 Comparison of online and F2F classes between the years.

	Online and F2F 2021–22	Online and F2F 2022–23	F2F 2021–22 and F2F 2022–23
Evaluation score- Low use/low variety	0.012	0.0012	0.238
Evaluation score- High use/high variety	0.262	0.426	0.794
Clarity of course content- Low use/low variety	0.009	0.003	0.558
Clarity of course content- High use/high variety	0.567	0.124	0.36

6.2 RQ2: The online versus F2F environment

Table 5 presents a comparison between the findings of the online and F2F studies, including the student and class characteristics and the use of interactive learning methods.

As can be seen, the trends in the results align closely between the two modalities. Moreover, importantly, when considering the effect of using a variety of interactive learning methods, no statistically significant differences were found between F2F and online classes when the instructor made extensive and varied use of interactive learning methods. However, in classes with little or no use of interactive methods, we found statistically significant lower evaluations and lower perceived clarity of teaching in F2F compared to online classes. It is worth mentioning that no statistically significant differences were found between the results for F2F classes of 2021–22 and 2022–23. The p-values results can be found in Table 6.

7 Discussion and conclusion

Faculty in academic institutions consistently strive for excellence in teaching by exploring and discovering educational methods and approaches that will enhance student satisfaction and their evaluation of courses, thereby improving their skills (Ribeiro, 2011; Wilson et al., 2021). Numerous studies have highlighted the positive effects of active learning on student satisfaction and academic achievement across various educational settings, from traditional classrooms to online platforms (Summers et al., 2005; Rajabalee and Santally, 2021). Despite this well-documented benefit, research exploring the impact of a diverse array of active learning techniques specifically in online versus face-to-face (F2F) environments remains limited (Barnett-Itzhaki et al., 2023). Our study contributes to this area by demonstrating that a variety of active learning methods significantly enhances students' course evaluations and their perceptions of teaching clarity. Furthermore, our analysis reveals consistent patterns across all measured factors, underscoring the effectiveness of diverse teaching methods in both online and F2F settings (see Table 5).

Our analysis reveals consistent patterns across all measured factors, underscoring the effectiveness of diverse teaching methods in both online and F2F settings (see Table 5). The similar correlations between interactive learning methods and course evaluations/teaching clarity in both environments (r = 0.19 to 0.30 for F2F and r = 0.17 to 0.25 for online, as shown in Table 5) provide empirical evidence that active learning strategies are equally beneficial regardless of the mode of instruction. This consistency not only aligns with previous research highlighting the universal advantages of active learning (e.g., Summers et al., 2005; Freeman et al., 2014; Deslauriers et al., 2019; Theobald et al., 2020) but also extends these findings by demonstrating their applicability across different educational modalities. Specifically, our results support and expand on Freeman et al. (2014) meta-analysis, which found that active learning increases student performance in STEM disciplines, by showing

similar benefits in non-STEM fields and in both online and F2F contexts. The observed patterns in our study also indicate that student engagement and satisfaction are driven more by the pedagogical approach than by the physical or virtual nature of the learning environment. This finding is consistent with research by Theobald et al. (2020), who found that active learning narrows achievement gaps for underrepresented students across various STEM disciplines, suggesting that the benefits of active learning transcend specific learning environments. Furthermore, it is particularly valuable for educators and institutions as they continue to navigate the evolving landscape of higher education, which increasingly includes both online and traditional classroom settings. The consistency in our findings reinforces the importance of implementing varied and interactive teaching methods across all educational formats to enhance student learning experiences and outcomes.

One of the most significant findings from our research is that both evaluation scores and perceived clarity of teaching are notably lower in F2F classes compared to online classes when active learning methods are minimally used or absent. This discrepancy could be attributed to several factors. Primarily, traditional frontal teaching methods may cause frustration among students confined to a classroom setting, where distractions and noise levels are typically higher than in-home learning environments. Online learning, by contrast, often provides a quieter, more controlled environment that may be conducive to concentration and deeper engagement. Moreover, the ability to revisit recorded online sessions allows for repeated exposure to material, a benefit not typically available in F2F settings.

These observations suggest that the physical classroom environment can significantly impact the effectiveness of teaching methods, particularly when active learning strategies are underutilized. As such, this study not only reinforces the need for implementing a broad spectrum of active learning techniques but also highlights the environmental factors that can affect their success.

Despite the significant insights gained from this study, several limitations must be acknowledged. First, the data was collected from a single institution, which may limit the generalizability of the findings to other educational contexts or institutions with different demographics and teaching practices. Second, the study relied on student self-reported data from course evaluations, which may introduce biases related to individual perceptions and experiences. Additionally, while the study controlled for various factors, it was not able to account for all potential variables that could influence student evaluations, such as instructor experience or specific course content. Moreover, the transition from online to face-to-face learning environments during the COVID-19 pandemic may have introduced unique challenges and adaptations that are not fully captured in this study. Finally, the focus on a limited number of active learning methods means that other potentially effective interactive techniques were not explored.

Looking ahead, the implications of our findings open several avenues for further research. Future studies might explore how interactive methods influence student satisfaction and perceptions in hybrid or blended courses, which combine online and F2F elements. Additionally, qualitative research could provide deeper insights into how these methods specifically enhance the learning process across different settings.

In conclusion, our findings advocate for the integration of a wide range of active learning strategies to overcome the challenges often faced in traditional educational environments. By adopting varied and innovative teaching methods, educators can significantly improve the educational experience and outcomes for students in both online and F2F formats.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Faculty of Social and Community Sciences Institutional Review Board Approval. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

Funding

Acknowledgments

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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How higher education teachers see their professional identity

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An important dimension to understand the student learning process is the professional identity of teachers, which is conceptualized as a continuous process of construction and reconstruction. In this process, teachers define and assume their roles in a specific educational context that is characterized by tensions, adjustments, and transformations. This study focuses on understanding the professional identity of higher education teachers, a field characterized by constant evolution and demands. The personal characteristics of this identity are explored, including experiences and biographical representations, as well as its interrelationship with the institutional environment. Using a qualitative interpretive approach, six teachers recognized for their pedagogical innovation and educational commitment were interviewed. The results reveal outstanding motivation and responsibility in educational work, but also tensions between personal identity and the work context, reflected in the perception of low recognition and the importance of institutional leadership. The teachers show a critical and reflective view of their work, influenced by childhood experiences that impact their conceptions of educational justice and equity. To conclude, the common characteristics of professional identity in higher education highlight the need to integrate them into professional development. The article advocates for the design of more personalized training programs and the promotion of continuous learning among peers as key elements to strengthen this identity and improve pedagogical practice.

KEYWORDS

professional development, teacher identity, higher education, teaching identity, barriers

1 Introduction

The COVID-19 pandemic has highlighted the urgency of addressing new challenges in higher education. Among these challenges is the need to adopt more student-centered pedagogical approaches to promote participation, collaborative learning, and the practical application of knowledge. It has also highlighted the need to recognize the growing importance of 21st-century skills such as critical thinking, problem-solving, effective communication, and collaboration in today's job market. These aspects are especially relevant in the teaching-learning process in higher education (Ruiz-Bolivar, 2022). International organizations such as UNESCO (2022a, 2022b, 2024) have stressed the strategic and irreplaceable role of higher education in shaping more sustainable, resilient, and peaceful societies. In this context, universities face the challenge of anticipating the emerging demands of an ever-changing society (Waller et al., 2021; Alpízar et al., 2023; Sancho et al., 2018) with the aim of becoming educational spaces that respond to the needs of the 21st century.

These demands include, according to Martínez and Sánchez (2019), continuous training and pedagogical innovation, promoting student-centered teaching and, professional competencies including digital competencies, as indicated by Vishnevsky et al. (2021). Further, Kritt and Budwig (2022) highlight the relevance of constructivist pedagogical practices and the institutional changes necessary to support this transformation, emphasizing that teacher identity must evolve in line with these new demands.

Similarly, it is essential to address the conflicts and tensions that prevent teachers from advancing their innovative pedagogical practices. Conflicts related to higher education institutions include lack of time due to administrative overload, poor institutional support, and lack of incentives for innovation (Siekkinen et al., 2020). There is also resistance to change, both at the institutional level and among teaching colleagues, as well as rigid policies that inhibit experimentation with new teaching methods (Dugas et al., 2020). The lack of adequate continuing education programs and limited interdisciplinary collaboration also limit teachers' ability to develop and apply new teaching methodologies (Cuadra-Martínez et al., 2021). It is crucial to address the tensions derived from resistance to change and teachers' work overload, as Fernández and Díaz (2020) point out, to ensure an effective transition towards new educational practices. On the other hand, Ruiz and Hernández (2021) and Fahara and Torres Tobías (2019) highlight the need for institutional policies that support teacher well-being and encourage interdisciplinary collaboration. These are key elements to overcome these challenges and adapt to contemporary demands in the educational field.

In this way, it is expected that universities will improve staff professional development considering certain aspects. Key among them is professional identity, which is an essential field of study for higher education, and which contributes to improving educational quality, promoting professional development, strengthening relationships with students, encouraging educational innovation, and promoting teacher well-being (Canaza, 2020). In a constantly evolving world, universities strive to maintain and protect their traditional privileges and financial resources. However, this effort is counteracted by increasing pressure from society itself, including the need to develop study programs that are relevant and updated, that prepare students to face the challenges of the world of work, and that contribute to economic and social development. Further, universities are expected to promote innovation and cutting-edge research that addresses pressing global problems such as climate change, public health, and social inequality (UNESCO, 2022b).

These demands strain the identity of university teachers by challenging established practices and beliefs and generating pressure to adapt to a constantly changing educational environment. Teachers may struggle to reconcile these demands with their own professional identity and their most recognized functions associated with teaching, research, and management (Zabalza-Beraza and Zabalza-Cerdeiriña, 2022).

The way in which these functions are carried out will be determined, or rather influenced, by the different dimensions of a teacher's professional identity: (a) the professional aspects connected to the demands and parameters in which teacher professional identity is built from its profession and specific knowledge, the main dilemmas in this regard, and their training needs; (b) the personal aspects related to the type of personal involvement and commitment typical of the teaching profession, teachers' life cycles, and conditions affecting them

such as personal problems, satisfaction, expectations, and beliefs; and (c) the labor aspects related to contractual conditions, selection and promotion systems, incentives, and working conditions (Zabalza-Beraza and Zabalza-Cerdeiriña, 2022; Gregory et al., 2019; Olszewski, 2023).

In addition, teacher identity in its general and specific definitions is modified throughout professional life: it is constructed and reconstructed (Beijaard, 2019). For example, Trautwein (2018) addressed the development of teacher identity by exploring the changes in the identity of eight academics enrolled in an extensive teacher development program and concluded that the development of identity is fundamental for a teacher and that this can change over time. Other studies (Beijaard, 2019; Noonan, 2019) concluded that each profession develops its own professional identity – it is not unique – and in the same way as Trautwein (2018) points out, it evolves over time as teachers gain experience, face new challenges, and reflect on their practice. In other words, teachers develop new skills, adopt new pedagogies, or redefine their values and beliefs throughout their professional career.

This article is based on a qualitative study that explores teacher professional identity, using in-depth interviews that allow us to understand teachers' experiences and perceptions. A qualitative approach is appropriate for this analysis since it seeks to understand how personal and professional experiences, as well as the institutional context, are related in the construction of teacher identity. The study will be guide by the following research questions: (1) how do personal experiences and family context shape teaching identity? (2) how does the institutional environment affect teachers' perception of their professional identity? and (3) what individual, professional and institutional aspects are key to understanding teaching identity in Higher Education and how do they contribute to professional training?

The article will first address the personal characteristics of teachers' professional identity, which are constituted by biographical representations and experiences in their personal lives, and how these are connected to their professional performance (Hargreaves, 1994; Alonso et al., 2015). Secondly, the study will investigate the relationship between these personal experiences and, in particular, the institutional environment in which teachers operate. The perception of their work environment will be delved into, considering how feeling valued and recognized affects their vision of their professional career, as suggested by Van Lankveld et al. (2017). Finally, the study will use a multidimensional approach to examine the intersection between individual, professional and institutional aspects, following the approaches of similar studies (Kritt and Budwig, 2022; Beijaard, 2019; Cuadra-Martínez et al., 2021; Peri et al., 2023), as well as the contribution to professional training.

1.1 Definition and key aspects in the construction of professional identity

Professional identity is understood as a mixture of professional models, relational and biographical processes are anchored in what teachers interpret and internalize from emotionally charged educational experiences from the preschool stage to the exercise of the teaching profession.

Most of the research carried out on professional identity establishes a strong link between personal and professional aspects

(Alonso et al., 2015; Trede et al., 2011; El Atmani and Madrane, 2023). Personal events and experiences are linked to the teachers' professional performance (Beijaard, 2019; Noonan, 2019; Van Lankveld et al., 2017). In other words, the construction of teachers' identity construction occurs in a diversity of contexts which could affirm or produce conflicts regarding the assumed identity (Ávalos and Sotomayor, 2012).

In the field of higher education, various studies have indicated that the development of teachers' professional identity is intrinsically linked to a variety of factors ranging from childhood experiences to family and social influences. According to Pérez and Rivera (2021), play during childhood and family models can have a pivotal role in the development of a vocation and interest in teaching.

The construction of a teacher's professional identity is also shaped by their initial training, individual psychological characteristics, and sociocultural factors as pointed out by Cuadra-Martínez et al. (2021), Vanegas-Ortega and Fuentealba-Jara (2019), and Olave (2020). This initial training covers both formal education and the specific training necessary to perform the teaching role, which includes the acquisition of pedagogical knowledge, teaching skills, and practical experiences in educational environments.

The aforementioned elements not only influence teachers' perception of teaching and learning but also affect their values and the way they approach their professional work. Further, individual psychological characteristics such as personality and motivations play a fundamental role in shaping a teacher's professional identity.

Similarly, sociocultural factors such as the sociopolitical context and social expectations exert a significant influence on teachers' perceptions and practices. For example, pressure to provide quality education in environments where social advancement through education is valued can influence teachers' decisions and actions.

The construction of teachers' professional identity according to Hargreaves (1994) involves the integration of technical and emotional aspects of teaching with their personal experiences. This view is supported by studies such as Bara et al. (2018) and Day et al. (2006), who argue that the development of professional identity arises from the interaction between the individual experiences of teachers and the social, cultural, and institutional context in which they operate.

In this sense, as Serrano and Pontes (2016) mention, the development of a teacher's professional identity acquires meaning through interactions with other individuals during the exercise and evolution of their professional life. These interactions are critical in shaping teachers' perceptions, values, and practices and in influencing their ever-changing professional identity.

1.2 Relationship between teacher professional identity and pedagogical practice and reflective processes

Reflection is essential for the professional development of teachers. According to Schön (1992), this activity allows them to articulate their knowledge and beliefs about teaching, giving them greater control over their actions in the classroom and the ability to make changes. Reflection can be carried out individually or through feedback from colleagues as well as through individual and collaborative practical investigations (De Vries et al., 2014; Beauchamp, 2015).

The relationship between the personal and professional identity of a teacher is closely linked to reflective processes that enable the reconfiguration of their pedagogical practice (Vanegas-Ortega and Fuentealba-Jara, 2019; Marín et al., 2019). These processes imply a critical review of one's own experiences, values, beliefs, and actions. In the context of teaching, teachers can reflect on how their personal and professional identities are intertwined in their pedagogical work. Therefore, a reflective approach requires teachers to develop the ability to reflect through strategies such as self-observation, case analysis, reflective journal writing, collaboration, continuing education, and action research.

This reflective approach allows teacher education to be approached from broader perspectives that include values, attitudes, and emotions, as well as the development of professional identity, decision-making, analysis of ethical dilemmas, and the review of one's own viewpoints (Sellars, 2012; Vanegas-Ortega and Fuentealba-Jara, 2019). Reflection is crucial for teacher professional development as it facilitates the transformation of teaching paradigms as teachers engage in activities related to their professional growth (De Vries et al., 2014) such as mentoring, learning communities, and spaces for reflection on teaching (Ávalos, 2007; Schön, 1992; Shulman, 2016). These activities prompt teachers to review, adapt, and improve their pedagogical approaches in order to promote meaningful and effective learning for all students.

2 Methods

The research is framed within a qualitative methodology (Schreirer, 2012) at the levels of data collection and in the structuring of the data analysis. This research used a cross-sectional and exploratory design (Creswell and Poth, 2016) that began with the description of a phenomenon, in this case professional identity in higher education, to then delve into its interpretation.

2.1 Participants

The study focused on Higher Education teachers who were selected by the Centre for Innovation in Education of the university under study. This centre, renowned for its work in the continuous improvement of educational quality, identified these teachers as highly motivated, committed, and innovative individuals in their pedagogical practice. Their ability to implement creative and effective strategies to improve the teaching and learning process within the university context was valued. Below is a description of the participants, whose names have been pseudonymized to protect their identities (Table 1).

2.2 Data collection

In-depth interviews were used as described by Kvale and Brinkmann (2015). This qualitative methodology stands out for its ability to explore and understand the diversity of human experiences. Through open and reflective dialogue, researchers can gain a deeper understanding of the phenomena studied. The interviews were conducted using a previously prepared protocol that addressed relevant topics. The aim was to generate an environment of trust that

TABLE 1 Description of the participants.

Name	Profession	Subjects	Qualifications
Antonia	Physics and mathematics education	- Electricity - Electronics - Applied mathematics II	- Teaching diploma EDUSUP - Master's degree in teaching
Rocío	Social worker	- Formulation of social projects - Poverty and social exclusion - Social responsibility and citizen participation	- Master's degree in Psychology with Community Social Psychology
Roberto	Social worker	- Gerontology - General sociology - Introduction to sociology - Formulation of social projects	- Master's degree in Leadership - Teaching diploma
Jorge	Mathematics education	- Mathematics in different levels	- Master and PhD in Mathematics
Ernesto	Agricultural engineer	- Vegetables - Cereals - Potato production	- Bachelor's degree in agriculture - Master's degree in agriculture - Teaching diploma
Raúl	Electrical civil Engineer Mathematics education	- Methodology - Evaluation - ICT	- Master's degree in Curriculum - Teaching diploma - Master's degree in Higher Education

would allow the interviewees to respond honestly to the questions posed (Taylor and Bogdan, 2000).

The interviews were conducted in person using a conversation format stimulated by the interviewer and with a pattern of flexible questions, leaving spaces to address topics that had not been predetermined (Corbetta, 2007). The interviews were digitally recorded and later transcribed in their entirety.

For the interview protocol, various topics were considered. Firstly, it was considered that the interpretation process could be guided by relevant theoretical frameworks such as the professional identity theory proposed by Beijaard et al. (2004) and Beijaard (2019). This conceptual framework offers a solid perspective to understanding how professionals in the field of higher education develop and negotiate their identity in their educational work. Some topics that were addressed were:

- Family influences: Aspects of your career or life story which mark and influence your professional work.
- Academic training and experience: Evaluate the teacher's academic training, including their academic degrees and expertise, as well as their previous experience in teaching and in the specific field of study.
- Aspects related to motivation and satisfaction.
- Work conditions
- Characteristics of the work environment where you work as a teacher
- Teacher reflection: as a critical process whereby teachers explore and evaluate their teaching practice.

2.3 Analysis techniques

To analyze the interview data, we followed an approach recommended by Sancho-Gil and Hernández-Hernández (2019) and

Creswell and Poth (2016), who suggest that the interpretive phase involves the analysis of qualitative data to identify patterns, themes, and significant relationships related to professional identity in higher education.

Content analysis was conducted following Schreirer (2012), for its ability to systematize and code qualitative data in a rigorous manner. This method allowed us to identify emerging patterns and themes in the interviews, as well as examining the context, providing a deeper understanding of teachers' professional identities.

The following steps were followed: (a) open coding of the transcribed interviews identifying *a priori* and emerging categories and codes; and (b) comparison of codes to identify relationships between them as well as the collection of common themes. This allowed the relationships to be described and interpreted to produce a preliminary analysis of the data. For this study, open coding was first applied. This involved breaking down the textual data into meaningful units and assigning them codes that represented key themes or concepts. These codes responded to *a priori* categories, adjusting the codes as the data was studied more deeply. The second step was code comparison where the identified codes were grouped and analyzed to discover common relationships and patterns. This process allowed us to identify emerging themes and understand how the different codes interact with each other. The coding matrix is presented below (Table 2).

Regarding ethical considerations, all participants were provided with a document explaining the study and identifying who was conducting it and their institutional affiliation. In addition, the participants were asked to sign a consent letter which indicated who they could contact if they had further questions or concerns.

3 Results

Several areas and aspects that they consider fundamental to their professional identity. Among these highlights are:

TABLE 2 Coding matrix.

A priori themes	Code	Emerging themes	Finding
Family influence	Mother's role Work ethics	Commitment and duty to educational tasks	Intersection of family life with teaching work
Effort, discipline, and meritocracy	Personal experience Hard work Autonomy	Persistence and determination	
Professional ethics and educational values	Social justice Equity Vocation	Critical view of education	
Commitment to continuous professional development	Continuous development Training from constructivist approaches Active methodologies	Continuous development	Continuous development for pedagogical innovation
Student development	Motivation and enthusiasm Skill development Creativity and self-criticism Active methodologies	Development of skills in the student	Commitment to the comprehensive development of the student
Teacher reflection	Learning from good and bad teachers Assessment of pedagogical practices Self-reflection Adaptation of methodologies	Pedagogical experiences approached from self-reflection The importance of self-reflection in teaching practice	Intersection between teaching reflection and pedagogical practice
Tensions in the workplace	Little time for educational tasks Low recognition Lack of institutional support Working conditions Leadership and trust	Little time to carry out educational tasks and low teacher recognition Importance of institutional support for teacher development	Tensions and problems faced in the workplace

Own elaboration.

3.1 Intersection of family life and teacher duties

Below are the three emerging categories representing the relationship between family life and professional duties.

3.1.1 Commitment and duty to educational tasks

For teachers, the construction of their professional identity intersects with their personal lives, with the family context being relevant and influential in the exercise of their professional activity. It is possible to identify a cultural aspect at the level of family structure, where a preferred view of gender and its associated roles (father and mother) have allowed them to strengthen the commitment and duty with the educational tasks they carry out in higher education.

> …My mother was a very hardworking, my mother worked and never gave up on us, always attentive to everything that happened to us. She wasn't a tactile mother, I mean, "come here my little son," a cuddle. No, mum said, "you have to study when you have a test, you start studying today" and in some way that got us all on track, all the children… (Rocío, Social Work teacher).

> I am the third of six siblings and I think that the influence that helped the whole family, all the siblings, was mum, because dad went out to work, so mum read us stories, she made us learn all the basic functions very early … (Roberto, Social Work teacher).

3.1.2 Persistence and determination

The most important element of the quote below for teacher identity is the influence of personal experiences and individual effort in the development of the teacher's professional identity. Ernesto recognizes that his life has been marked by hard work and constant effort, which has contributed to forging his identity as a professional. His view highlights the importance of personal commitment and dedication in the development of teaching identity, highlighting persistence and determination as fundamental traits in the process of training and professional growth.

> …I feel that my life has not been easy, it has been a lot of effort. Although it is true that, not as much as my father and many people today, but it has been like, (…) work, with a lot of work, that is, I think that today I am the result of a lot of work, it is very difficult for me (…) but I keep trying, I keep trying, a little obsessive in terms of personality… (Ernesto, Agronomy teacher).

The following quotation highlights the importance of autonomy and authenticity in the formation of the teacher's professional identity, as well as the influence of family experiences in academic and professional decision-making.

> My eldest sister had studied law and my second eldest sister studied social work, and I took the university entry test, I did well but not as well as I wanted, I must have gotten about 680, 690 [out of 850] at

that time, but it was enough for me to apply for law, for example, which was kind of what my dad wanted and at the University of Concepción, but I did not want to because of my sister's experience in law, I did not like it… (Antonia, Electrical Engineering teacher).

3.1.3 Critical view of education

There are two participants with initial teacher training and two social workers who indicate that the motivation to become teachers is related to the concept of justice, which suggests they have a critical view of education and equity.

…the other thing that motivates me has to do a little with the issue of justice, from what I was telling you… you have to be as fair as possible with the students and not discriminate against anyone… (Rocio, Social Work teacher).

Antonia's statement below about her wanting to become a teacher since she was a child suggests a connection with the teaching vocation, learned through play in her first experiences during childhood, which manifested in her games.

I always had the intention, since I was little girl, I wanted to be a teacher and for me the topic of being a teacher was always a game, we played when we were kids and everything… (Antonia, Electrical Engineering teacher).

3.2 Continuing development for pedagogical innovation

A commitment to continuous learning is a central characteristic of the participants' professional identity, as they recognize the importance of keeping up to date with the latest educational trends and teaching methodologies.

I am always updating myself; I have done a diploma, a masters, and courses that have allowed me to hone my training as a teacher… (Antonia, Electrical Engineering teacher).

Because I think that someone who works in education or wherever they work, one always has to be innovating and updating, looking for different tools… (Roberto, Social Work teacher).

3.3 Commitment to the comprehensive development of the student

The main finding in relation to emphasis on student development is the importance that teachers accord to motivation and commitment in their educational context. Roberto and Jorge below highlight the need to generate enthusiasm and motivation among their students, as well as the need to develop skills and habits necessary for learning. Further, one of the interviewees emphasizes creativity, self-criticism, and self-confidence as fundamental elements in teaching. Both teachers stress the teachers' passion and commitment to offer quality education and promote the comprehensive development of their students.

Well, first I have to find a way to make the students get excited about the specialty, acquire all those study habits, and school habits that they did not acquire in secondary school or primary education, and on the other hand try to level them up, from the viewpoint of mathematical tools, writing, communication. So, in the face of all that I believe that us teachers (…) do something different, because one could actually do more things, but looking for a new method is for that, the motivation that students will learn (Roberto, Social Work teacher).

…a very, very strong commitment to students; there is a certain amount of creativity that suddenly escapes us, I do not know where that comes from, very creative, self-critical, we are not at the top, we are always going up, we are never at the bottom, nor at the top, just going up. There is play, what we are doing is fun, it is entertaining, I do not want to bore anyone, very strong extrinsic and intrinsic motivation, a lot of self-confidence, the eternal survivor of everything (Jorge, Mathematics teacher).

3.4 Intersection between teaching reflection and pedagogical practice

Below are the two categories that represent the intersection between teaching reflection and pedagogical practice.

3.4.1 Pedagogical experiences approached from self-reflection

These discourses emphasize the importance of reflecting on one's own experiences as students and teachers, and how these can influence professional development and the continuous improvement of educational practice.

Jorge, a mathematics teacher, highlights that even the least effective teachers can provide valuable lessons by showing how certain practices should not be carried out. This suggests that experiences with different types of teachers can help educators reflect on their own practice and identify areas for improvement.

They teach you how not to do things. Less effective teachers can provide valuable lessons by showing how certain practices should not be done (Jorge, Mathematics teacher).

Similarly, Raúl, another mathematics teacher, shares a similar opinion about learning from both good and less effective teachers. He highlights that even from teachers who are not considered good, valuable lessons can be learned about how not to do things.

Look… I even learned from the bad teachers and it's very true, from the good teacher, you obviously learn a lot from them and from the bad teacher too. They teach you how you do not have to do things (Raúl, Mathematics teacher).

Finally, Rocío, a Social Work teacher, reflects on how experiences with dull lecturers during her time at university influenced her own pedagogical approach. Although she acknowledged that she sometimes finds herself repeating teaching patterns that she criticized, she also notes that these experiences

lead her to look for ways to improve her teaching practice for future classes.

> I felt that when I studied at the university, my teachers were so dull in some way, that I feel that I do not teach my students in the same way that I criticized, although sometimes I end up doing it, but at least I feel that it is not very useful, but at least I feel that when I end up repeating, I have to change it for another class (Rocío, Social Work teacher).

3.5 The importance of self-reflection in teaching practice

This section highlights the importance of a critical perspective towards teaching, which implies self-reflection of one's own pedagogical actions, and which is seen as an important element in professional development.

> … a rather critical view of our work or self-criticism of our own work, that is, when I leave a class, it is clear when I did it well, when I felt that the students were motivated, and when they were not. And I believe that that same criticism is what prevents you from being complacent, it is what allows you to look for new ways (Roberto, Social Work teacher).

The main finding here is the teacher's constant reflection and willingness to change their practice. Below, Ernesto displays a critical attitude toward his own teaching approach, questioning whether there are better ways to convey content to his students. His quotation highlights the importance of reflective thinking and willingness to adapt by teachers who constantly seek to improve their methodology and provide a more effective educational experience for students.

> But I question myself, I tell them, (…) I am teaching some content, I question myself when I see it in the second semester, I tell them "and will the kids understand this question, I wonder" and I say to myself, "what happens if I do it another way and I begin to reformulate myself, (…), what happens if I do it another way." And two things can happen to me, either for the worse or better, and they have not necessarily been better, I change it then, but… (Ernesto, Agriculture teacher).

Tensions and problems they face in the work context and that are related to their teaching work.

The view shared by most of the participants is that they face an adverse environment, which makes professional development difficult. They emphasize not having time for their lesson planning, little institutional support, and plenty of administrative work.

3.5.1 Little time to carry out educational tasks and low teacher recognition

The main finding here is the dedication and personal sacrifice that teachers, like Rocío, make in their work. Below, Rocío expresses how she invests a significant amount of time working on educational projects from home, even sacrificing time that she could spend with her family. Her quotation brings to the fore the teachers' commitment

and passion for their work, as well as the additional demands they face beyond their contracts. It also raises the need to recognize and value the additional effort that teachers dedicate to their work.

> I invest a lot of time, which I could perhaps invest in having a good time, in going out with my family, with my husband; I invest it in working on projects from home. If they paid me 3 days, three afternoons for working on projects, moving around, talking to teachers, taking a course to see how it works, networking, it would be wonderful, but currently we do the same thing, only at home with additional time to the paid one… (Rocío, Social Work teacher).

3.5.2 Importance of institutional support for teacher development

The data also highlights the importance of institutional support for the success of teachers and the effective development of teaching. Both Antonia and Roberto emphasized the need to have an institutional environment that provides the appropriate conditions so that teachers can carry out their work effectively. This includes the availability of resources, the recognition of teaching talent, and the implementation of methods that help alleviate the administrative burden, allowing teachers to focus on their pedagogical work. These comments stress the importance of a solid institutional infrastructure and a support system to promote the success of teachers in their educational work.

> One can have very good intentions, but there have to be certain conditions in the institution's ecosystem for that to be happen, it is essential (Antonia, Electrical Engineering teacher).

> I believe that institutional support is even more fundamental because talent is always there. But if there is talent without institutional support nothing is done. Invest in a method that frees the teacher from so much administrative work (Roberto, Social Work teacher).

3.6 Effective leadership that contributes to teacher confidence

Leadership, according to the participants, is a determining factor in the development and consolidation of teachers' professional identity. They stress the importance of leadership that supports their efforts in the implementation of pedagogical innovations and in the academic sphere.

Two participants stress how direct supervision positively influences their motivation and their ability to implement pedagogical innovations in the classroom. For them, leadership is defined by trust and autonomy among teachers, as well as believing in their own abilities. This implies that effective leadership fosters an environment wherein teachers feel supported and empowered to explore new educational practices, which will in turn contribute to better performance and greater commitment to teaching and learning.

> Today we have the leadership of a program lead that has encouraged and allowed me and Roberto to innovate. We have a program lead that has allowed us to advance, and I also feel that they have allowed us to create and trust in ourselves (Antonia, Social Work teacher).

4 Discussion

Qualitative analysis of the teachers' perceptions has provided valuable insight, showing how personal experiences, family values, and the institutional context influence their professional identity (Sancho-Gil and Hernández-Hernández, 2019; Zabalza, 2009; Zabalza-Beraza et al., 2018).

One of the key findings is the influence of family experiences and values on educational practice. The participants indicated that their commitment and sense of duty towards education are strengthened through family roles, such as the support and responsibility learned in the family unit. This highlights how specific family values not only shape the perception of teacher identity, but also directly affect the implementation of teaching methods. The existing literature, such as Ávalos and Sotomayor (2012), and Cuadra-Martínez et al. (2021), has addressed the influence of personal context on teacher identity, but the current study deepens our understanding of how these specific family values, such as work ethic and vision of social justice, influence their professional identity.

Regarding continuous training based on constructivist approaches, teachers highlight that this training is essential not only for their professional development, but also for their personal commitment to the continuous improvement of their teaching practice. Participation in courses and workshops that promote constructivist methodologies allows teachers to adapt to changes and enrich the teaching-learning process. In line with previous research (e.g., Ávalos, 2007; Cuadra-Martínez et al., 2021), the current study reveals that this training acts as an integral element in the professional identity of teachers, strengthening their sense of purpose and personal connection with teaching, which goes beyond simple technical updating.

Teachers' ability to reflect on their past experiences, both positive and negative, plays a crucial role in their professional development. This finding indicates that critical reflection not only improves pedagogical practice, but it also becomes an essential aspect of teacher identity – a finding reflecting Ávalos (2007) and El Atmani and Madrane (2023), who highlight the importance of teaching reflection.

The study also shows the pivotal role of work tensions in pedagogical performance. Teachers face challenges such as lack of time for lesson planning, lack of institutional support, and a significant administrative burden, all of which limits their ability to focus on teaching, overall affecting its quality. Previous literature, such as that of Siekkinen et al. (2020) and Dugas et al. (2020), have also shown how these tensions have a negative impact on educational quality.

Finally, leadership that supports teacher efforts in the implementation of pedagogical innovations and in professional development is essential to strengthen teacher identity. Although leadership has been recognized in previous literature, such as in the work of Day et al. (2006), the current study reveals that effective leadership not only supports professional development, but it also influences the construction of teacher identity, highlighting the need for leadership to go beyond managing teachers, but instead, inspiring and motivating them.

These findings show that a teacher identity based on reflection, motivation and commitment to teaching prevails despite an adverse institutional context. Teachers share common elements of commitment and satisfaction with their practice (Sancho-Gil and Hernández-Hernández, 2019; Sancho-Gil et al., 2022; Hernández-Hernández and Sancho-Gil, 2019). It is also important to highlight that the findings are in line with previous research documenting how personal, family, and professional dimensions are elements for the construction of teacher identity (Kritt and Budwig, 2022; Beijaard, 2019; Cuadra-Martínez et al., 2021; Peri et al., 2023).

5 Conclusion

The study enriches our knowledge about teacher identity by demonstrating how family experiences, continuing training, and critical reflection interact to strengthen teachers' professional identity. The study was based on a specific sample of teachers, which may limit the generalization of the findings to other educational contexts.

These findings highlight the complexity of teacher identity, which is not only developed in the educational environment, but it is also influenced by personal and social factors outside the school.

The study also offers a significant practical contribution by highlighting the need to implement policies and strategies that support teachers in their professional development. Evidence suggests that providing ongoing training based on constructivist approaches, as well as strong institutional support, can improve teacher effectiveness and satisfaction. Additionally, encouraging critical reflection and recognizing the extra effort teachers put into their work can strengthen their professional identity and commitment to teaching.

Universities should prioritize the improvement of teachers' professional development, focusing on professional identity as a fundamental factor. This attention not only improves educational quality, but also strengthens relationships with students, drives educational innovation and promotes teacher wellbeing. However, they face increasing pressure from society to adapt to a constantly changing educational environment, which generates tensions in university teaching identity. As this study reveals, although teachers show a positive perception of their professional identity, it contrasts with the institutional reality marked by tensions and conflicts. This discrepancy underscores the urgency of addressing institutional tensions to improve the work environment and well-being of teachers.

This study reveals how events and experiences in teachers' personal lives are intrinsically related to their professional work. In addition, it highlights the sense of vocation and commitment to teaching that teachers manifest, influenced by their family and personal experiences that have left a significant mark on their life trajectories.

This commitment manifests itself in a remarkable way even in adverse working conditions, where teachers face challenges in adopting new methodologies and dedicating attention to their students. This deep connection to teaching strengthens teacher identity by providing a clear sense of purpose, cultivating resilience in the face of challenges, shaping personal experiences, and motivating the adoption of new pedagogical practices.

Challenges in the institutional context, such as lack of recognition, work overload, and low valuing of leadership, can negatively affect both teachers' professional development and work experience. Exploring these difficulties could open up an interesting line of research.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CH: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft, Methodology. MA: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft. IR: Investigation, Project administration, Resources, Writing – review & editing. RV: Project administration, Resources, Writing – review & editing.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Academic performance as a driver for the development of reasoning for complexity and digital transformation competencies

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This study analyzed the relationship between academic performance and the development of transversal competencies of reasoning for complexity and digital transformation in higher education students. The Tec21 educational model of the Tecnológico de Monterrey was used as a framework for analysis. Data from 33,319 students were analyzed following a CRISP-DM methodology, first an exploratory analysis was performed on the data to recognize and understand the presence of competencies in the educational model. Machine Learning methodologies, including Random Forest and XGBoost, were then employed to identify the most influential curricular and co-curricular variables in the acquisition of studied competencies. The results revealed a significant correlation between academic performance and the acquisition of the competencies, highlighting that high grades are consistently associated with success in developing these competencies. This study extends the understanding of how competency-focused educational interventions can facilitate professional and personal development in a labor market that demands advanced skills and adaptability. The discussion focuses on the implications of these findings for formulating educational policies and pedagogical practices that prioritize both academic achievement and the comprehensive development of essential 21st-century competencies. From a broader perspective, our work is framed in the achievement of Sustainable Development Goal 4 Quality Education and is oriented to identify variables that boost the acquisition of 21st Century Skills in higher education contexts.

KEYWORDS

reasoning for complexity, educational innovation, higher education, digital transformation, academic performance, students, competency-based education performance, Tec21

1 Introduction

The effect of the pandemic in the organizational context has impacted the young population, both in terms of job stability and recruitment processes, making it difficult to choose competent candidates. It has been observed a 23% increase in post-pandemic unemployment rates among 18 to 24-year-olds, as well as a reduction in the earnings of those who remained employed, generating a discouraging perception among young people regarding their professional expectations, so that 40% face the future with uncertainty and up to 14% do so with fear (UN, 2021). On the other hand,

three-quarters of American companies have expressed difficulties in recruiting the right people for their vacancies, identifying critical thinking, problem solving, innovation and creativity in the number one missing soft skills (37%); followed by the ability to deal with complexity and ambiguity (32%), and communication skills (31%) (WEF, 2019). This reality highlights the pressing need for organizations to adapt their recruitment strategies and foster an environment that not only attracts but also nurtures the requisite soft skills among the younger workforces.

Consequently, in the field of higher education, leaders of international organizations have proposed guidelines that promote the construction of competencies known as 21st century skills, through the collaborative work of different nations. Such skills are framed within the Sustainable Development Goals (SDGs) of the 2030 Agenda and of these, SDG 4 (UN, 2022a) stands out, which aims to ensure quality, inclusive and equitable education, promoting learning opportunities that last throughout life for all people (Oficina Regional de Educación para América Latina y el Caribe, 2017; UN, 2022b). The skills of the 21st century arise from the emerging issues of the century in question. The World Economic Forum (2016a) states that to face the challenges imposed by the present, students need to acquire abilities that transcend traditional learning systems, so that it is possible to develop skills linked to technology and social and emotional learning that will be useful in the labor scenario. In this context, with the arrival of the so-called fourth industrial revolution or Industry 4.0, conceptualized from the implementation of smart technology, big data, artificial intelligence (AI), nano and biotechnology, the internet of things (IoT), among others, workers of the present and future need to develop new skills to keep pace with what organizations demand from them (Industrial Global Union, 2016; World Economic Forum, 2016b; Xu et al., 2022). Acknowledging the rapid onset of Industry 4.0, it becomes imperative for educational institutions to restructure curricula to encompass not only technology-oriented skills but also the social and emotional competencies that are crucial for students to navigate the multifaceted challenges of the current labor landscape and beyond.

For the development of 21st century skills in employees, it is necessary to first have an impact on the educational systems where the concept of Education 4.0 has emerged (González-Pérez and Ramírez-Montoya, 2022; Kennedy and Sundberg, 2020; Patiño et al., 2023). Ramírez-Montoya et al. (2022) state that education 4.0 derives from the adaptation of new technology based on teaching-learning systems to the changes that have arisen in higher education environments and to the challenges and complexity imposed by the present; where the integration of competencies such as complex thinking, and digital transformation becomes necessary in higher education institutions as a support for all their instructive processes (Miranda et al., 2021). As strategies for the development of transversal competencies and the promotion of a critical perspective of reality are implemented, it will be possible to minimize the negative effects that COVID-19 pandemic has generated in young people and contribute to a better training of students for their optimal performance, both in the educational and organizational contexts (Walsh et al., 2021; Rof et al., 2022).

2 Literature review

The 21st century skills are predictive of the challenges that may be imposed by the digital transformation of various social scenarios. Therefore, they prepare higher education spaces for the future needs

of a constantly changing population and provide future professionals with an awareness of the reality that transcends the physical teaching-learning environments (Fadel, 2008). Despite the efforts of higher education institutions to foster this type of competencies, there is widespread ambiguity regarding the teaching criteria for assessing performance and what is expected to be achieved in everyone, as well as uncertainty (UN, 2021) as to the degree to which these skills impact on the training and academic performance of students. Thus, it becomes essential for higher education institutions to establish clear, actionable criteria for teaching and assessing 21st century skills, ensuring that students are not only equipped with these competencies but also understand their tangible impact on academic and professional success in a digitally transformed society.

There are some actions that respond to these needs that can be implemented from higher education settings. Among such actions we can find fostering skills, supporting teacher specialization, and eliminating connectivity barriers (UN, 2021). Specifically, in this work we will focus on exploring the effect of some of the most relevant competencies recognized by UNESCO with the objective of knowing to what extent curricular variables enhance the competencies of reasoning for complexity, and digital transformation, together with their sub-competencies. Likewise, there's a need to know how the development of those skills itself may impact the academic performance of the students and, in turn, would impact in the near future over their performance in organizational contexts.

2.1 Complex thinking and digital transformation as transversal competencies in higher education

Complex thinking (also called reasoning for complexity) refers to the acquisition of multidimensional knowledge. This competency is composed of four sub competencies: critical thinking, systemic thinking, scientific thinking, and innovative thinking that allow higher education students to reach problem solving in diverse scenarios (Ramírez-Montoya et al., 2022). In general terms, critical thinking refers to the application, analysis, synthesis, and evaluation of information acquired or generated through processes of observation, experience, reflection, reasoning, or communication as guides for action. Systemic thinking is the reasoning necessary for university students to analyze and understand complex global phenomena. Innovative thinking refers to the creative capacity with a tendency to succeed, and scientific thinking is a higher order capacity that allows students to face the problems of today's world, through logical, analytical, systemic, inductive, and deductive problem solving (Suárez-Brito et al., 2022a,b). Therefore, the promotion of complex thinking within higher education is crucial, as it arms students with a multifaceted toolkit of sub competencies for analyzing and navigating the complex landscape of contemporary global challenges.

On the other hand, digital transformation refers to the creation of new paradigms in the changing relationships between individuals, industry, and society, supported by the Internet of things and digital technology. It is a global change of socio-economic relations within a cyber-physical world (Mikheev et al., 2021; Garcez et al., 2022; George-Reyes et al., 2023; Vázquez-Parra et al., 2023). For the student community and faculty, digital transformation in higher education improves scientific activity, teaching-learning processes

and their experience, as well as the flow of information due to the presence of distance courses and open access to educational resources (Bygstad et al., 2022; Mikheev et al., 2021). Digital transformation, therefore, catalyzes new interaction paradigms and socio-economic shifts in higher education, enhancing scientific activities, learning processes, and information accessibility through digital technologies among the most prominent are the Internet of Things (IoT), Cloud Computing, Virtual Reality, and 3D holograms.

2.2 Tec21 educational model

The Tec21 Educational Model, implemented by Tecnologico de Monterrey, is a transformative initiative designed to align education with the demands of the 21st century. It is characterized by four main pillars: Challenge-based Learning, flexibility in learning modalities, inspirational faculty, and an engaging university experience (Swain-Oropeza and Renteria-Salcedo, 2019; Olivares Olivares et al., 2021; Villanueva, 2018). This model contrasts with traditional educational approaches by emphasizing real-world problem-solving, interdisciplinary collaboration, and the integration of emerging technologies, as seen in its application to engineering education to meet Industry 4.0 needs (López et al., 2021). The model has been well-received by students, with surveys indicating a positive perception compared to traditional models (Medina et al., 2021). It also satisfies the requirements of a changing world by offering greater real-world connection and flexibility (Pérez and Campos, 2021). Likewise, during the COVID-19 pandemic, the model demonstrated resilience, with Student Evaluation of Teaching (SET) scores remaining stable or even improving, suggesting that the model's characteristics may have contributed to a successful transition to online learning (Campos et al., 2022). Thus, interdisciplinary learning as a main characteristic of this educational model, encourages the synthesis of ideas and techniques from various fields, leading to greater creativity and innovation; being especially important in industries that thrive on new ideas and cutting-edge solutions.

Tec21 model encompasses seven transversal competencies that aim to enhance the personal and professional development of students. These competencies are: (1) Ethical and Citizen Commitment, focusing on implementing projects that transform the environment and promote the common good with an ethical conscience and social responsibility; (2) Reasoning for Complexity, which integrates various types of reasoning in problem analysis, synthesis, and resolution, fostering continuous learning; (3) Communication, involving the effective use of different languages, resources, and communicative strategies according to the context; (4) Digital Transformation, encouraging the strategic use of digital tools to innovate and improve processes and products; (5) Self-Knowledge and Management, which involves building a personal and professional well-being project through lifelong reflection and resource integration; (6) Innovative Entrepreneurship, generating innovative, versatile solutions in changing environments that create value and positively impact society; (7) Social Intelligence, developing effective collaboration and negotiation environments in multicultural contexts, respecting and appreciating the diversity of people, knowledge, and cultures (Modelo Tec, n.d.; Villanueva, 2018). These competencies are designed to prepare students not only for professional success but also for personal growth and responsible citizenship.

Specifically, the competencies of Reasoning for Complexity and Digital Transformation within the Tec21 model distinguish themselves by focusing on critical and forward-thinking skills necessary for modern challenges. Reasoning for Complexity is characterized by its emphasis on integrating various forms of reasoning to tackle complex problems, promoting an interdisciplinary approach and continuous learning, essential for adapting to ever-evolving professional landscapes (Baena-Rojas et al., 2022, 2023; Ramírez-Montoya et al., 2022). This competency stands out by encouraging students to synthesize information from diverse fields, enabling them to develop comprehensive solutions that consider multiple dimensions of a problem. On the other hand, Digital Transformation is notable for its focus on the strategic adoption of digital technologies to innovate and enhance productivity and creativity in various domains. It emphasizes not only the use of digital tools but also the transformation of processes and methodologies to stay relevant in the digital age (Aditya et al., 2021; Teixeira et al., 2021; Ostmeier and Strobel, 2022). This competency is particularly distinct in its direct response to the digital economy's demands, preparing students to be proactive in leveraging technology for sustainable and impactful advancements. In sum, the Tec21 Educational Model exemplifies Tecnológico de Monterrey's commitment to a dynamic, responsive, and comprehensive approach to higher education, where students are equipped with critical, technical, and social skills that empower them to lead and innovate in a globally connected and digitally driven world.

The objective of the present study was to establish the relationships between the performance of transversal competencies of complex thinking and digital transformation and the variable of academic performance, measured as the average of the student's grades for the academic program in the academic period in which these competencies are promoted. The following research questions guide this study:

1 How are transversal competencies in complex thinking and digital transformation integrated and contribute to educational outcomes in a competency-based educational model in higher education?
2 What impact do students' academic achievements have on the development and performance of complex thinking and digital transformation skills in the context of higher education outcomes?

3 Method

This work pretends to explore the potential of data science, following CRoss-Industry Standard Process for Data Mining (CRISP-DM) methodology (Abbasi et al., 2016), in order to analyze student performance by using the result of students' assessment based on the defined attributes or learning outcomes, on the records described in previous section.

CRISP-DM is still the *de facto* standard for developing data mining and knowledge discovery projects. In particular, when data science projects become more exploratory the paths that the project can take become more varied, and a more flexible model is called for. Here, in the purpose of this project, we pretend to categorize, depending on the available data and the corresponding match within

objectives we defined, the experiments can deal with goal-directed and exploratory cases.

This methodology facilitates business and data understanding, data preparation, modeling, evaluation and deployment, ensuring that each phase contributes significantly to aligning with business objectives and extracting value from data. The iterative nature of CRISP-DM is ideal for big data projects, where accuracy in handling and analyzing complex data is crucial (Abbasi et al., 2016).

3.1 Data criteria and ethical considerations

In this work, we employed specific criteria to select and evaluate the data used. The primary indicators for academic performance included the final grades and GPA of students, while competencies were assessed through predefined metrics in the Tec21 educational model. These indicators were chosen based on their relevance and proven reliability in previous educational research (IFE Data Hub, 2023).

Ethical considerations were predominant throughout this research. We adhered to strict data privacy protocols to ensure the confidentiality of student information. Data were anonymized and stored securely, following ethical guidelines established by the Institute for the Future of Education (IFE)'s Educational Innovation collection of Tecnologico de Monterrey. We ensure that our research practices upheld the highest standards of integrity and respect for participant rights.

4 Results

The results section is organized according to the stages of the CRISP-DM methodology. For each stage, the methods applied to the information analysis and the consequent obtaining of results are detailed.

4.1 Business understanding

Within the framework of the proposal of the Tec21 Model, the aim is to complement educational resources with competencies through the subjects taught to promote comprehensive development of the student that facilitates their insertion into the market field. This approach covers technical requirements and various soft skills that allow the student to adapt to any situation that may arise in the present or near future, in an environment where technology and problem-solving acquire increasing relevance. Therefore, in Tec21, some courses are complemented with two relevant competencies that meet these objectives: Digital Transformation and Complex Thinking.

The analyzed dataset (IFE Data Hub, 2023) comes from the record of the first six academic periods of operation of the Tec21 Model from August 2021 to June 2023. The dataset records general information (e.g., age, gender, school) of students and their relationships with courses, competencies, and sub-competencies, generating repeated rows. Each student has a variable number of rows depending on the number of courses, the number of academic periods enrolled, and the number of competencies associated with each course. The "unique()" function algorithm for data frames from Pandas was used to find and

return the unique student elements in the dataset, obtaining 33,319 higher education students, of which 56.46% are men and 43.54% are women. They have an average age of 18.7. They come from 52 different countries, the majority (93.2%) being Mexican, followed by students from the United States (2.98%), and the rest distributed mostly through Latin American countries in order: Ecuador, Honduras, Guatemala, Venezuela, among others. Students are enrolled in five different schools according to the discipline: Architecture and Design (EAAD), Social Sciences and Government (ECSG), Humanities & Education (EHE), Engineering & Sciences (EIC), and Business (EN).

4.2 Data understanding

The data understanding phase initially focuses on the detailed analysis of each of the columns of the data set to discern its potential relevance to the study. This process involved a thorough evaluation to identify the possible values of each column and thus determine its usefulness. Data dictionary was consulted to obtain a general description of the information contained in each column or variable. It was ensured that all columns in the data set were present as documented, with no missing items, and that the data matched their descriptions. In those cases where the descriptions did not match the data found, an effort was undertaken to understand the nature of the data available.

Through this exhaustive analysis, 45 columns were identified within the data set, of which 26 are categorical and 19 are numerical. Of the numeric columns, 14 have float values, and 5 have integer values, covering a total of 583,073 rows. A detailed analysis was carried out for each categorical column, identifying the possible values they could assume. We observed columns with a limited number of possible values, such as student gender, which only includes Male and Female, and other columns, such as dates, which present a wide range of possible values. The Python programming language (Python Software Foundation, 2024) and the Dask library (Dask Development Team, 2024) were used to analyze the numerical variables. A descriptive statistics analysis was obtained that included the count of non-null values, the mean, the standard deviation, the minimum, the maximum, and the quartiles. The use of the Dask library was preferred over the Pandas library (McKinney, 2010) due to the large volume of data. Dask improves memory efficiency by processing data in chunks unlike pandas, which require loading the entire data set into RAM memory. This allowed us to run the analysis using a computer with fewer hardware resources.

4.3 Data preparation

The data preparation stage constitutes a crucial step in the analysis process, where the data set is subjected to a series of transformations to optimize it for subsequent modeling and evaluation. Initially, the data set was divided into two different subsets, each corresponding to one of the focal competencies of the study: 'Digital Transformation' and 'Reasoning for Complexity', using the column that describes the competencies as a separation criterion. Within each subset, special attention was paid to the variable that shows the level assigned to the student in said competence, which indicates with the terms 'Observed' and 'Not observed' whether the corresponding competence was

acquired or not, respectively. To facilitate subsequent analysis, these terms were coded numerically as 1 and 0.

Data preparation included a detailed assessment of the null values in each data set. During this analysis, we identified several columns with a high proportion of null values, the presence of which not only lacked relevance to our research objectives but also compromised the integrity of the remaining data set. Removing all rows containing null values would have resulted in a significant loss of valuable data in other columns. Since filling in these null values was not feasible due to their volume, and their relationship to our objective was nonexistent, we opted to discard such columns to preserve the quality of the other relevant variables. Subsequently, those columns with some unique identifiers such as 'student.id', columns with detailed descriptions such as 'subject.longName', and columns that represented uniqueness in all their values such as 'group.isLIFE' and 'group.isAcademicSupport' were removed. Finally, the acquired level column was segregated from the rest to prepare it for use in prediction.

4.4 Modeling and evaluation

In the modeling and evaluation stage, we created a data model corresponding to each of the research questions. Concerning research question 1, we identified the number of courses that promote the competency of complex thinking or digital transformation. We then grouped these courses according to the discipline where they are taught. Figure 1 shows the distribution of the number of courses where Complex Thinking or Digital Transformation competencies are involved according to academic

schools' different disciplines of knowledge. The results of this analysis revealed a greater incorporation of both competencies in the School of Engineering and Sciences (EIC). The rest of the schools present a similar number of courses where the two competencies of the present study are involved. This distribution reflects the emphasis and relevance that the Tec21 Model assigns to the competencies of Complex Thinking and Digital Transformation in the field of engineering, thus underlining its importance in the comprehensive training of students in this area.

Modeling and evaluation concerning research question 2 were performed through the application of machine learning models. Machine Learning methodologies were capable of providing insights into the relative importance of the different variables in the dataset. Special emphasis was placed on the identification of the most relevant characteristics (feature importance) that influence the obtaining by students of Complex Thinking and Digital Transformation competencies. Based on the data model, Random Forest RF (Schonlau and Zou, 2020), and XGBoost (Chen and Guestrin, 2016) techniques were applied to determine the variables that most influence the attainment of complex thinking and digital transformation competencies. Additionally, Logistic Regression (Bailly et al., 2022), and Support Vector Machine (SVM) (Cervantes et al., 2020) models were included to validate the predictive capacity of the analysis, comparing the relevance of the characteristics identified by the RF and XGBoost models. Data processing included the selection of potentially significant variables, such as student demographic information, course details, and previous grades, as well as the treatment of categorical variables and the normalization of numerical variables. The data set was divided into a ratio of 80% for training and 20% for testing, to evaluate the robustness of the models.
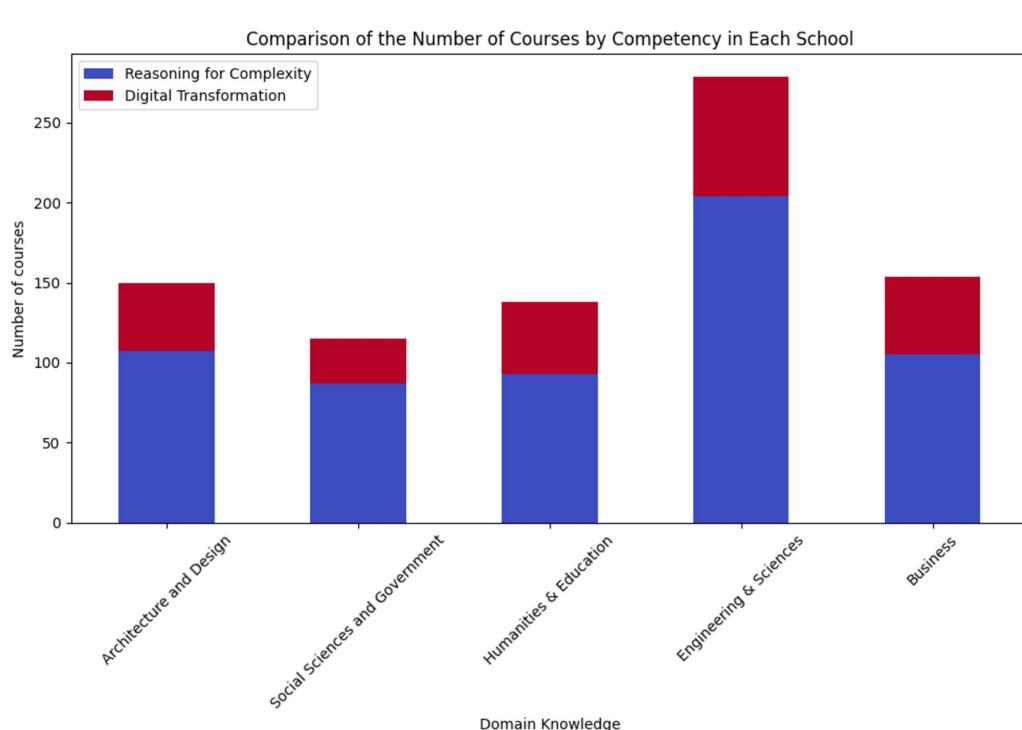

FIGURE 1
Number of courses containing complex thinking or digital transformation competencies among academic schools.

Results indicated that the student final_grade variable emerged as the most influential characteristic in obtaining proficiency, standing out considerably over the other variables in the Random Forest and XGBoost models. According to the data dictionary, final_grade corresponds to the student's final grade for the subject. In these models, the final_grade variable received approximately twice the importance of any other characteristic, with other variables such as semester GPA showing less relevance. This finding was consistent in both models, which reinforces their validity. However, it is important to highlight that a significant imbalance was observed in the dataset, with more than 90% of the records indicating obtaining Complex Thinking or Digital Transformation competencies. This imbalance could induce a bias in the models, predisposing them to predict obtaining such competencies more frequently due to the underrepresentation of negative cases. Despite this limitation, the models showed high performance in the precision, recall and F1 score metrics, for both the positive and negative classes, with a precision value ranging from 0.78 to 0.97, suggesting a capacity robust predictive within the context of the present imbalance.

To obtain a more detailed understanding of the impact of the final grade on the acquisition of specific competencies, Figure 2, shows box plots describing the difference between obtaining and not obtaining Complex Thinking and Digital Transformation competencies, using the final grade as a comparison variable. In the analysis of these visualizations, it was observed that students who managed to acquire the competencies consistently presented higher final grades. In the boxplots corresponding to the acquisition of competencies, the median and quartiles were substantially above the threshold of 70, thus highlighting the positive correlation between high final grades and the achievement of competencies. On the other hand, students who did not acquire the competence showed a distribution of scores that, although more varied, focused on a lower median, particularly in the Complex Thinking competence, where outliers below a numerical grade of 35 were observed.

Boxplots of Figure 2, revealed not only reinforce the premise that the final grade is a significant predictor for obtaining competencies but also show a general trend of lower grades associated with not obtaining competencies. Despite the presence of outliers and the wide distribution of qualifications for not obtaining Digital Transformation, the relationship between high qualifications and the acquisition of competencies remains robust. This finding underscores the importance of the final grade as a critical variable in the educational model and suggests that, despite the full range of grades, there is a distinctive division in the attainment of competencies based on academic performance.

An analysis was performed to estimate the probability of acquiring the competencies of Complex Thinking and Digital Transformation based on the score obtained in the final_grade variable. Table 1 shows the score ranges of the final_grade variable for the probability of obtaining each of the two competencies under study. Table 1 shows a segmentation of the range of scores into four categories: from 0 to 69, from 70 to 79, from 80 to 89, and from 90 to 100. The findings revealed an incremental pattern: for students with scores in the range of 0 to 69, the probabilities of acquisition were 46.63% for Complex Thinking and 44.80% for Digital Transformation. This percentage almost doubled for the next range of scores, with 83.20% for Complex Thinking and 89.67% for Digital Transformation in the range of 70 to 79. The upward trend remained consistent for the higher ranges, culminating in those with scores of 90 to 100 had, on average, a 98.64% probability of acquiring Complex Thinking and a 98.88% for Digital Transformation. These data suggest that there is a relationship between the final grade (final_grade variable) and the probability of obtaining a competency, indicating that higher academic performance may be associated with the achievement of competencies.
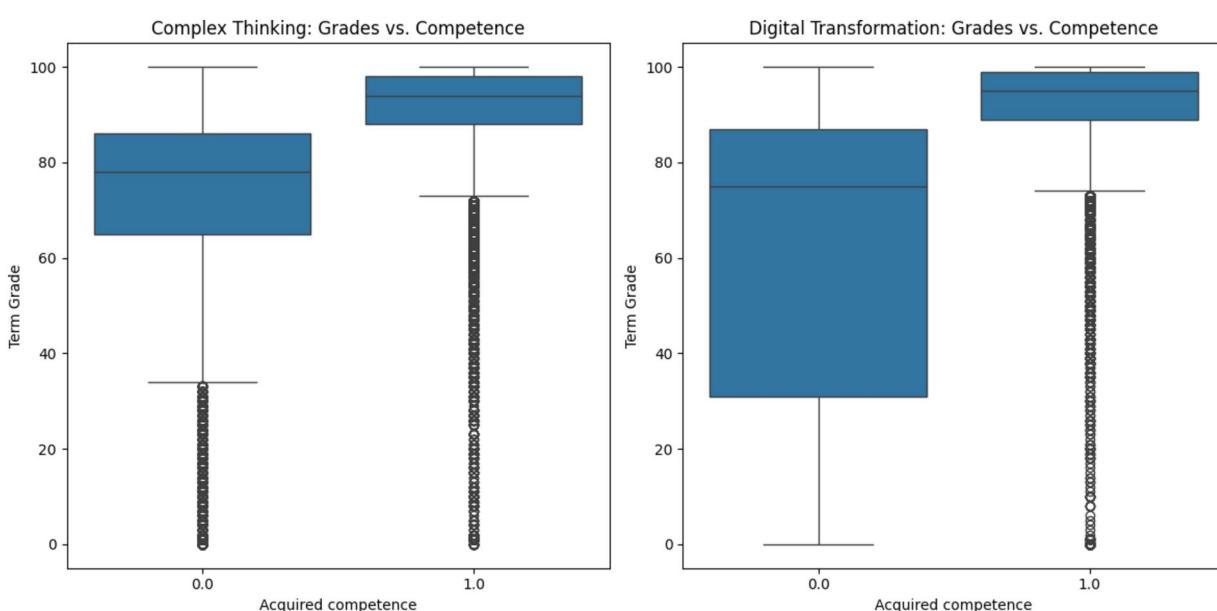

FIGURE 2
Boxplots distribution for final grade and acquisition of complex thinking and digital transformation competencies.

TABLE 1 Association between student's final grade ranges and the percentage of competency acquisition.

Grade range	Complex thinking	Digital transformation
0–69	46.63%	44.80%
70–79	83.20%	89.68%
80–89	93.44%	95.41%
90–100	98.64%	98.88%

4.5 Linking data to discussion

To substantiate our findings, we performed a comprehensive statistical analysis using Random Forest and XGBoost models. The final grades emerged as the most influential factor in acquiring competencies, as depicted in Table 1. This correlation aligns with our hypothesis that academic performance is a significant predictor of competency acquisition.

The box plots in Figure 2 further illustrate the distribution of final grades among students who acquired competencies versus those who did not. As shown, students with higher final grades were more likely to develop competencies, supporting our discussion on the impact of academic achievement on competency development.

These data points are critical in understanding the broader implications of our findings. They demonstrate a clear link between academic performance and the development of essential competencies, validating the criteria established for this study.

5 Discussion

A competency-based educational model has an independent relationship between grades received and competencies acquired. Table 1 shows that the higher the grade, the higher the probability of acquiring the Complex Thinking and Digital Transformation competencies. This relationship also implies that not all of the students who obtain one of the two competencies that are being studied will pass the course. Likewise, not all students who perform well acquire these competencies.

The modeling and evaluation related to the research questions were carried out through the application of automatic learning models, providing an adequate analysis. As shown in Figure 1, the distribution of courses containing the competencies of analysis was established and the presence of them was differentiated among Academic Schools that make up the Institution; unlike previous studies (Swain-Oropeza and Renteria-Salcedo, 2019), where the competencies were analyzed transversally without distinguishing the area of specialization of the participants. Data processing included the selection of potentially significant variables, as well as the treatment of categorical variables and the normalization of numerical variables, in order to assess the robustness of the models for each Academic School.

The educational model (Tec21) from which the data was obtained for the study is based on competencies. In Tec 21 there are two evaluation factors: on the one hand, the final grade and, on the other hand, the obtaining of the competencies associated with each course. These evaluation factors are independent. Thus, a student can pass

the course (when obtaining a final grade > =70/100) but not obtain the competencies. Similarly, a student might obtain the competencies but fail the course. Because competencies are not exclusive to a single course but are distributed in a group of courses, a student who did not achieve a competence will have the opportunity to achieve it in other classes. When a student accredits a level of competence through a course, this level is marked as achieved in the student's record of competencies and can no longer be reversed. If the student subsequently fails a previously achieved competence, the student does not have to reaccredit that competency. An analysis corresponding to obtaining competencies with valid results was performed, even with the limitation of the specific data analyzed in this study as seen in section 3.4. A careful selection of the analyzed database was carried out, highlighting the values of interest according to the CRISP-DM methodology (Abbasi et al., 2016). Thus, the models developed by analyzing the database, showed high performance in their accuracy.

The relationship between high grades for students and the acquisition of competencies is demonstrated analytically. Figure 2 shows the above statement. In Salas Velasco (2014), a proposed model for the development of competencies in their graduates is described by assuring that evaluation positively improves competencies with strong econometric evidence. Then, the premise that the final grade is a significant predictor for the attainment of competencies and its opposite effect at par is reinforced. However, results should be taken carefully, as the observed correlation does not necessarily imply causation. Further investigation is needed to fully understand the underlying factors and to confirm these findings across different contexts and populations.

An analysis was performed to estimate the probability of acquiring the competencies analyzed related to a more precise score range by the students. Table 1 shows the score ranges of the final variable for the probability of obtaining each of the two competencies under study. There are not many references that converse between grades and competencies, although (Chernikova et al., 2020) comments that diagnostic competencies are adequate for less advanced students, or that self-regulation levels are more effective for advanced students, there is no consistent analysis between grades for this level of students. The data in this paper support the idea that students' final grades are a significant indicator of their likelihood of achieving competencies, highlighting a direct correlation between high academic performance and the acquisition of competencies valued by the educational institution. This implies that students who achieve higher final grades are more likely to obtain the competencies that the educational institution deems important. It suggests that academic performance, as measured by final grades, is closely related to the attainment of key skills and knowledge that the institution aims to impart. Therefore, focusing on academic success could be a crucial pathway to ensuring students acquire these valuable competencies.

It's worth mentioning that final grades may also be influenced by various external factors such as teaching quality, assessment methods, and individual student circumstances, which could affect the generalizability of the results. For example, variations in teaching quality across different instructors or courses can lead to differences in grading standards and student performance. Similarly, assessment methods that favor certain types of learners over others can skew final grades, making them less reliable as

indicators of competency attainment. Individual student circumstances, such as socioeconomic status, health issues, or personal responsibilities, can also impact academic performance and, consequently, final grades. Given these complexities, a holistic approach that considers multiple factors is essential to draw more comprehensive conclusions.

6 Conclusion

This research has shown a significant relationship between academic performance and acquiring transversal competencies of complex thinking and digital transformation in higher education. These findings are consistent with previous studies highlighting the importance of outstanding academic performance as a predictor of a student's ability to develop critical and advanced skills needed in the digital age (e.g., Salas Velasco, 2014; Chernikova et al., 2020). Thus, our study not only reaffirms the observed correlation between final grades and the acquisition of competencies but also broadens the understanding of how curricular and extracurricular variables influence this process. The ethical considerations adhered to throughout the study ensure that these conclusions are drawn from a robust and ethically sound dataset.

By demonstrating how competency-based educational models, such as Tecnológico de Monterrey's Tec21 Educational Model, can positively impact students' professional and personal development, the results significantly contribute to the field of educational innovation. Through its focus on specific skills that are critical to the contemporary labor market, this empirical study provides a solid foundation for future educational theories and models that are responsive to these dynamics.

From a practical perspective, the results underscore the importance of designing educational interventions that focus not only on academic performance but also on the comprehensive development of competencies crucial in the contemporary labor market. This approach is especially relevant within the framework of Tecnológico de Monterrey's Tec21 educational model, which seeks to prepare students for academic success and outstanding performance in complex and changing professional contexts.

Limitations and future direction. A crucial aspect that emerges from this study is the variability in the influence of specific competencies on academic outcomes, considering additional variables and diverse educational contexts to further validate and expand upon these findings by keeping ethical aspects. Although a strong association was observed between high grades and the acquisition of competencies, it is necessary to recognize that not all high-achieving students achieve these competencies, suggesting the existence of other mediating or moderating factors in this process, such as personal motivation, teaching methods, and the learning environment. In addition, the prevalence of acquired competencies in our dataset could induce bias in the predictive models used, suggesting the need for future research to employ alternative methods to control these deviations and explore the underlying causes of these differences. Based on the limitations and findings of the study, it is recommended that future research explore the mediating and moderating factors that influence the relationship between academic performance and competency acquisition. In addition, it would be beneficial to investigate how different teaching methods and learning environments may affect the development of cross-cutting competencies.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The use of the data was restricted to academic and research purposes only. Requests to access these datasets should be directed to jose.molina@tec.mx.

Ethics statement

The studies involving humans were approved by Institute for the Future of Education, Tecnológico de Monterrey. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

JM-E: Conceptualization, Data curation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. PS-B: Conceptualization, Project administration, Writing – review & editing. BG-P: Formal analysis, Visualization, Writing – original draft. EL-C: Resources, Validation, Writing – review & editing. MG-M: Supervision, Validation, Visualization, Writing – review & editing.

Funding

Acknowledgments

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Cognitive motivational variables and dropout intention as precursors of university dropout

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Introduction: The intention to dropout and dropout is a problem still unresolved in higher education institutions.

Objective: To estimate the differences in the levels of engagement, motivation and academic satisfaction according to (a) intention to dropout and (b) students who remained with those who dropped out. Method: non-experimental designs were used. Two studies are reported, study 1 involved 3,256 students and study 2 involved 2,110 students. The Utrecht Work Engagement Scale Student Test, the Academic Self-Regulation Scale and the Academic Satisfaction Scale were used. The intention to dropout was measured with 3 items and the final dropout data was taken from the official register of students who dropped out of university.

Results: There are significant differences in the levels of engagement, autonomous motivation and satisfaction between the students who remained and those who dropped out of the university.

Discussion: Students who dropped out in the 3rd semester presented lower levels of academic engagement, motivation and academic satisfaction than those who remained. The intention to dropout and lower levels of these cognitive-motivational variables may contribute to the identification of students at high risk of dropping out. These results contribute to unveiling key variables for the educational transformation of Higher Education in the 21st century.

KEYWORDS

academic engagement, motivation, academic satisfaction, intention to dropout, dropout, university quitting, higher education, quitting

1 Introduction

Dropout from tertiary education is a relevant issue that can be evidenced in different regions of the world (Behr et al., 2021; Perchinunno et al., 2021; Delogu et al., 2024). This is no exception in the Latin American region (Acevedo, 2021; Arias et al., 2023; Heredia and Carcausto-Calla, 2024), which reports concern about dropout levels in universities. Specifically, in Chile, the figures shown in recent years confirm the importance of addressing this phenomenon (López-Angulo et al., 2023; Sáez-Delgado et al., 2021; Von Hippel and

Hofflinger, 2021). According to the Higher Education Information Service (SIES; for its acronym in Spanish), the dropout rate of students in Chilean universities has remained between 21 and 30% (SIES, 2017, 2019, 2020), with a decrease of 1.2% in the first year (SIES, 2023).

In this context, the specialized literature highlights that cognitive and motivational skills are required to respond to academic, social and institutional demands at the university stage (Long and Noor, 2023; López-Angulo et al., 2022; Lorenzo-Quiles et al., 2023; Sáez-Delgado et al., 2023). Overcoming these challenges can be complex despite having met the formal requirements for university entrance (Kocsis and Molnár, 2024). The causes for students dropping out can be categorized into individual, academic, economic, institutional, and cultural factors (Aina et al., 2022; Bernardo et al., 2022; de la Cruz-Campos et al., 2023). Within the individual factors are, among others, academic motivation, academic satisfaction, academic engagement and intention to dropout (Álvarez-Pérez et al., 2021; Bernardo et al., 2022; Litalien et al., 2019; Marôco et al., 2020; Truta et al., 2018).

Motivation refers to the energy that moves the person to act. It can be observed from one extreme with no motivation, through controlled force or regulation to the other extreme of autonomous motivation (Ryan and Deci, 2000). Controlled motivation alludes to external pressures or external control (Vansteenkiste et al., 2006). At an opposite extreme, motivation is delineated as autonomous to emphasize its basic characteristic of choice and psychological freedom; this motivation and sense of academic enjoyment are favorable for progress in studies (Corpus et al., 2020; Noyens et al., 2019) is facilitated by perceived support for one's decisions from one's teachers (Alrabai, 2021), is linked to superior academic performance (Manzoor et al., 2023) and less likelihood of dropping out (Yusof et al., 2023). Consideration of this motivation may prove valuable in predicting future university dropout (Wild et al., 2024).

When students can actively participate in the achievement of their goals, they experience higher levels of academic satisfaction (Sánchez-Cardona et al., 2021). In the academic context, satisfaction is understood as well-being and enjoyment of the experiences lived by the student (Diener et al., 2018); it can be influenced by aspects such as academic self-efficacy, the expectation of results, progress in the established goals and social support (López-Angulo et al., 2021; Mostert and Pienaar, 2020). It is associated with characteristics of the university center, with pedagogical practices developed by its teachers (Espinoza and McGinn, 2018) and to the intention to dropout during the period of university entrance (Bernardo et al., 2018).

Academic engagement is another aspect linked to success in university (Acosta-Gonzaga, 2023; Ayala and Manzano, 2018; Cobo-Rendón et al., 2022; Martínez et al., 2019). It is a positive state of mind and persistent satisfaction, disaggregated into vigor, dedication, and absorption (Schaufeli and Bakker, 2003). Vigor is the student's willingness to exert effort and persist in academic activities. Dedication is a desire for involvement in academic activities, enthusiasm, a sense of pride and inspiration, related to studies. Absorption is a condition of concentration and involvement in academic activities, associated with a loss of the notion of time, which makes the student persist in the task without being aware of the time spent in its realization (Liébana-Presa et al., 2014; Schaufeli and Bakker, 2003). Engagement is related to academic satisfaction (Fisher et al., 2021) and to university persistence (Álvarez-Pérez et al., 2021). In contrast, a lack of dedication (dimension of engagement) to studies

has been found to be a predictor of dropout intention (Truta et al., 2018).

The process of disengagement with the university career begins with an intention to dropout, understood as part of a decision-making process developed during the early stages of the university experience, associated with the students' probability of discontinuing their studies (Song et al., 2023; Muñoz-Inostroza et al., 2024). The dropout intention alludes to desires to dropout corresponds to cognitions of changing or abandoning the career or the university institution (Bean and Metzner, 1985; Mashburn, 2000). The presence of these thoughts associated with dropping out can facilitate the disengagement process and is considered an early warning of a possible dropout situation. The intention to dropout is more frequent in first-year students (Bernardo et al., 2018; Behr et al., 2020; Lorenzo-Quiles et al., 2023). Definitive dropout refers to the cessation of institutionalized academic activities, for three or more consecutive terms (Bean and Eaton, 2001; Tinto, 1982). It is evident when a student interrupts studies before finishing university and does not enroll for two consecutive years (Acevedo, 2021).

Obtaining early warnings of eventual dropouts can facilitate the adoption of actions or interventions to mitigate them (Sáez-Delgado et al., 2020). Previous research has identified a variety of factors that contribute to dropout, including individual, academic, economic, institutional and cultural factors. However, there is a gap in the literature regarding how cognitive and motivational variables can be changed through student-teacher interactions in the teaching-learning process (López-Angulo et al., 2023). This study seeks to fill that gap by focusing on variables such as academic self-efficacy, academic satisfaction, academic engagement, and intention to drop out, which are crucial and modifiable factors that can influence student retention (Sánchez-Cardona et al., 2021; Respondek et al., 2017). The proposed study is relevant because it addresses the critical problem of university dropout by analyzing cognitive and motivational variables that are modifiable through student-faculty interaction. This research not only has the potential to improve students' well-being and academic satisfaction by identifying key factors that influence their intention to drop out, but can also inform institutional policies and practices that promote a more favorable educational environment. In addition, reducing dropout rates has important economic implications, improving the efficiency of the educational system and reducing the costs associated with dropout. Ultimately, the study contributes significantly to scientific knowledge by providing a basis for future research and practical applications in higher education (Cela et al., 2024; Holland et al., 2020; Tinto, 2017). In the present paper, the main objective was to estimate the differences in cognitive-motivational variables such as academic engagement, motivation, and academic satisfaction in groups of students who reported intention to dropout in first year of their careers and in students who dropped out of university in the second year, for which were carried two studies.

2 Study 1

Study 1 was carried out in the first academic semester. It aimed to estimate the differences in levels of academic engagement, motivation and academic satisfaction according dropout intentions.

2.1 Design

The design was non-experimental, descriptive, cross-sectional study (Ato et al., 2013). It was conducted in the university setting, without manipulation by the researchers.

2.2 Participants

A total of 3,256 first-semester university students from the 2017 and 2018 enrolled cohorts participated, with an average age of 19.2 years (SD = 1.82 years), of these 1,638 were male (50.3%) and 1,618 female (49.7%). The students belonged to 6 universities in Chile different faculties: Faculty of Education, the Faculty of Social Sciences, the Faculty of Engineering and the Faculty of Physical and Mathematical Sciences.

2.3 Measuring instruments

2.3.1 Sociodemographic questionnaire

A questionnaire was designed to obtain information on age, sex, career and year of entry to the university.

2.3.2 Academic motivation

The Academic Self-Regulation Scale (Vansteenkiste et al., 2009) was used. It assesses autonomous motivation (e.g., "I study this career because it is fun") and controlled motivation (e.g., "I study this career because others expect me to"). A seven-alternative Likert-type response scale was used. In this research it presented a reliability index of α = 0.88 in the dimension of autonomous motivation and of 0.87 controlled motivation (or external pressure).

2.3.3 Academic satisfaction

The Spanish version of the Academic Satisfaction Scale was used. It evaluates the degree to which students feel satisfied in general with their studies (e.g., "I am satisfied with being in this career"). A Likert-type scale with seven alternatives was used. Of the original scale, a unifactorial structure and reliability indexes of α = 0.94 are reported. The Spanish version maintains the unifactorial structure with a reliability index of 0.85 (Medrano et al., 2014). In this research it presented a reliability index of α = 0.91.

2.3.4 Academic engagement

The Spanish version of the Utrecht Work Engagement Scale Student Test UWES-9 (Schaufeli et al., 2002) was used. It evaluates the degree of engagement to studies, and is composed of three dimensions: vigor (student's willingness to make an effort and persist during study, e.g., I feel strong and vigorous when I study or attend classes), dedication (desire to be involved in the academic activity, e.g., I am enthusiastic about my career) and absorption (state of concentration and involvement in the academic task, e.g., I am happy when I am doing tasks related to my studies). The internal consistency indices in this study were: academic engagement α = 0.90, vigor α = 0.82, dedication α = 0.84, absorption α = 0.78.

2.3.5 Intention to dropout

Three items were used: "I hope to complete my studies in this career," "I am thinking of changing careers," "Do you want to continue studying the same career? A Likert-type scale of seven alternatives was used (1 = totally disagree to 7 = totally disagree). The intention to dropout is the result of averaging the items (reversing the second item); an average score below 5 indicates intention to dropout. The internal consistency index was α = 0.82.

2.4 Procedure

The approaches for the development of social science research presented in the Singapore Declaration on Integrity in Research were taken into account. The students responded to the questionnaires after reading the informed consent. To obtain the results Student's t test was performed for independent samples. Compliance with assumptions and homogeneity of variances were checked with Levene's test; in cases where this was not met, a nonparametric test for independent groups was used.

2.5 Results of study 1

In order to respond to the objective of estimating the differences in cognitive-motivational variables such as academic engagement, motivation and academic satisfaction in groups of students who declared their intention to dropout in the first year of their degree, the first study identified students with intention to dropout of their first year of studies. Of the 3,256 students in the total sample, 358 were categorized as intending to dropout and 2,898 as not intending to dropout (see Table 1).

The results indicate statistically significant differences in all the variables considered, between the group with intention to dropout (1st semester) and the group without intention to dropout (Table 2). The students with intention to dropout presented lower scores for autonomous motivation, academic satisfaction and engagement than the group with intention to remain; however, the score for controlled motivation (or external pressure) is higher.

3 Study 2

Study 2 estimated differences in the levels of academic engagement, motivation and academic satisfaction between students who remained and students who had dropout in the 3rd semester.

3.1 Design

Was used quantitative approach with non-experimental design of kind longitudinal panel. Panel analysis involves following exactly the same people over the period of the study. The variables (academic engagement, motivation and satisfaction) were measured (in the first semester) and then (in the third semester) the students who dropout were identified.

3.2 Participants

A total of 2,110 students completed the second instrument measurement. The mean age of the participants was 19.3 years

TABLE 1 Descriptive statistics of cognitive and motivational variables in the first academic year.

Cognitive motivational variables	Types of groups	N	M	SD
Controlled motivation	Dropout intention	334	3.29	1.43
	Intention to remain	2,797	2.65	1.36
Autonomous motivation	Dropout intention	348	4.68	1.24
	Intention to remain	2,828	5.92	0.89
Academic satisfaction	Dropout intention	337	4.67	1.15
	Intention to remain	2,841	5.89	0.86
Academic engagement	Dropout intention	348	3.98	1.10
	Intention to remain	2,843	5.12	0.99
Vigor	Dropout intention	351	3.64	1.35
	Intention to remain	2,872	4.36	1.30
Dedication	Dropout intention	350	4.17	1.29
	Intention to remain	2,870	5.92	1.00
Absorption	Dropout intention	352	4.10	1.25
	Intention to remain	2,866	5.07	1.12

TABLE 2 Differences in cognitive motivational variables with respect to intention to dropout.

Cognitive motivational variables	Levene	t	df	p value	Mean difference*	Cohen's d
Controlled motivation	0.049	7.8	408.53	$p < 0.001$	0.64	0.39
Autonomous motivation	0	−18.15	392.32		−1.24	0.92
Academic satisfaction	0	−18.65	380.97		−1.21	0.96
Academic engagement	0.014	−18.38	418.67		−1.14	0.90
Vigor	0.294	−9.769	3,221		−0.72	0.17
Dedication	0	−24.39	401.31		−1.75	1.22
Absorption	0.014	−13.80	423.44		−0.96	0.67

*Negative values indicate lower scores in the group where the intention to abandon is present.

(SD = 1.83 years). The gender distribution was 1,116 males (53%) and 994 females (47%).

3.3 Measuring instruments

3.3.1 Sociodemographic questionnaire

A questionnaire was designed to obtain information on age, sex, career and year of entry to the university.

3.3.2 Academic motivation

The Academic Self-Regulation Scale (Vansteenkiste et al., 2009) was used. It assesses autonomous motivation (e.g., "I study this career because it is fun") and controlled motivation (e.g., "I study this career because others expect me to"). A seven-alternative Likert-type response scale was used. In this research it presented a reliability index of α = 0.88 in the dimension of autonomous motivation and of 0.87 controlled motivation (or external pressure).

3.3.3 Academic satisfaction

The Spanish version of the Academic Satisfaction Scale was used. It evaluates the degree to which students feel satisfied in general with their studies (e.g., "I am satisfied with being in this career"). A Likert-type scale with seven alternatives was used. Of the original scale, a unifactorial structure and reliability indexes of α = 0.94 are reported. The Spanish version maintains the unifactorial structure with a reliability index of 0.85 (Medrano et al., 2014). In this research it presented a reliability index of α = 0.91.

3.3.4 Academic engagement

The Spanish version of the Utrecht Work Engagement Scale Student Test UWES-9 (Schaufeli et al., 2002) was used. It evaluates the degree of engagement to studies, and is composed of three dimensions: vigor (student's willingness to make an effort and persist during study, e.g., I feel strong and vigorous when I study or attend classes), dedication (desire to be involved in the academic activity, e.g., I am enthusiastic about my career) and absorption (state of concentration and involvement in the academic task, e.g.,

I am happy when I am doing tasks related to my studies). The internal consistency indices in this study were: academic engagement α = 0.90, vigor α = 0.82, dedication α = 0.84, absorption α = 0.78.

3.3.5 Final dropout

Data was taken from the official register of students who dropped out of university.

3.4 Procedure

In addition to the above measures, the university was asked for information on the permanence of students in the 3rd semester. Based on this information, groups of students who remained and those who dropout were formed. Descriptive results were generated, and Student's t-test for independent samples was used to answer the objective.

3.5 Results of study 2

We identified 321 students who were withdrawn from their university career (15.2% of the study participants) (see Table 3).

The descriptive statistical analyses indicate that the levels of autonomous motivation, academic satisfaction and academic engagement of the students who dropped out were lower than those who remained in their studies, with controlled motivation (external pressure) being the only variable in which they obtained higher scores (see Table 3). The differences between the groups are statistically significant; additionally, it was identified that there were no statistically significant differences in controlled motivation (external pressure) (p = 0.09) (Table 4).

TABLE 3 Descriptive statistics of cognitive-motivational variables in students who dropout in the second academic year.

Cognitive motivational variables	Abandonment effective	N	M	SD
Controlled motivation	Yes	310	2.70	1.42
	No	1748	2.55	1.29
Autonomous motivation	Yes	314	5.42	1.21
	No	1745	5.84	0.96
Academic satisfaction	Yes	309	5.24	1.05
	No	1748	5.77	0.91
Academic engagement	Yes	203	4.57	1.13
	No	1,185	5.01	1.03
Vigor	Yes	206	3.87	1.35
	No	1,190	4.24	1.31
Dedication	Yes	205	5.17	1.36
	No	1,193	5.81	1.09
Absorption	Yes	205	4.64	1.23
	No	1,192	5.00	1.14

4 Discussion

The objective of this investigation was to estimate the differences in the levels of academic engagement, motivation and academic satisfaction (1st) according to the intention to dropout of first academic year students and (2nd) between students who remained and students who dropped out in the 3rd semester, that is, in the second year of his career. The main results are discussed below, and limitations, future lines of research and conclusions are specified.

4.1 Motivation

In first-year university students, there are statistically significant differences in the levels of autonomous motivation according to the intention to abandon their studies. Students with intention to dropout showed lower scores in autonomous motivation, this result confirms the findings of research that indicate that high autonomous motivation is associated with intention to stay in university (Fernández et al., 2024). This finding underscores the importance of fostering autonomous motivation to reduce dropout rates.

Motivation as a cognitive motivational variable is linked to social factors, and moderately stable motivation could be modified based on contextual factors such as the relationship with the teacher (Duchatelet and Donche, 2019; García-Ros et al., 2018). Therefore, it is pertinent to propose that it is possible to influence these variables through the interaction of students and teachers. In this case, the role of the teacher in the development of autonomy, competence and relationship can improve autonomous motivation and reduce the intention to dropout (Huéscar and Moreno-Murcia, 2017; Oriol-Granado et al., 2017).

This result corroborates those students who show greater interest in carrying out academic activities show more persistence in their development (Corpus et al., 2020). The results found in Study 2 are consistent with those of Study 1, observing that those who had abandoned their university careers presented lower levels of autonomous motivation than those who remained. The situations that occur in motivation at the beginning of the career have an impact on performance and the intention to change careers or to dropout of university altogether (Wild and Grassinger, 2023).

4.2 Academic satisfaction

High levels of academic satisfaction favor the intention to remain in the career. This result is in line with other research showing the relationship between academic satisfaction and intention to stay in university (Meštrović, 2017; Wilkins-Yel et al., 2018). Also, high life satisfaction is associated with academic success, specifically good performance, student engagement, academic self-efficacy, defined goals, and perceived lower stress; all of these are conditions that are not present in students with medium or low levels of satisfaction (Antaramian, 2017; Díaz-Mujica et al., 2022).

The results of this study indicate that students with high levels of academic satisfaction also presented high scores in academic motivation. This finding is consistent with previous research (Vergara-Morales et al., 2019) showing relationships between academic satisfaction and different levels of motivation: poor (r = −0.92), low (r = −0.66), good (r = −0.54), and high (r = 0.29).

TABLE 4 Differences in cognitive motivational variables with respect to effective dropout.

Cognitive motivational variables	Levene	t	df	p-value	Mean difference*	Cohen's d
Controlled motivation	0.005	1.67	404.54	p = 0.09	0.15	0.08
Autonomous motivation	0.000	−5.90	385.79	p < 0.001	−0.43	−0.30
Academic satisfaction	0.000	−8.27	392.90		−0.53	−0.42
Academic engagement	0.038	−5.19	262.94		−0.44	−0.32
Vigor	0.58	−3.64	1,394		−0.36	−0.10
Dedication	0.000	−6.38	251.41		−0.64	−0.40
Absorption	0.134	−4.07	1,395		−0.36	−0.11

*Negative values indicate lower scores in the dropout group.

Another study found that, the greater the satisfaction with the course, the greater the use of self-regulation strategies, the greater the students' engagement and the lower the intention to dropout (Bernardo et al., 2022). It is possible to affirm that students who are satisfied with their careers have sufficient motivation to develop academic activities in accordance with their interests, are motivated to learn, achieve good performance and remain in their careers.

4.3 Academic engagement

Students with the intention of dropping out in the first year presented lower scores in academic engagement and in each of its subcomponents (dedication, absorption, and vigor), with respect to students without the intention of dropping out. Students who start university with thoughts of dropping out have lower behaviors associated with dedication, sustained energy, and involvement in academic activities. Lack of dedication to university studies is a significant predictor of intention to dropout and definitive dropout (Llauró et al., 2023; Truta et al., 2018). The large effect size reported for the variable dedication ($d = 1.22$) is noteworthy, which is statistically possible (Sawilowsky, 2009), and suggests a significant difference in dedication between students with and without dropout intentions. This implies that students intending to dropout show significantly lower dedication compared to their peers.

Engagement is a positively related variable in students' academic life; an engaged student exhibits better academic performance (Qureshi et al., 2023; Tight, 2020), reports higher levels of hedonic well-being (Kaya and Erdem, 2021; Kryza-Lacombe et al., 2019) and good self-regulation skills (Ketonen et al., 2016). Research has consistently shown that a high level of academic engagement is associated with better academic outcomes and lower dropout intention (Myint and Khaing, 2020; Paloş et al., 2019). Encouraging student engagement from the beginning of university studies could be a protective element for continuation of studies.

This engagement is influenced by factors such as social support, positive coping strategies, and positive perceptions of teaching competence (Paloş et al., 2019). To reduce dropout rates, it is essential that universities develop strategies that foster students' academic engagement from the first year.

4.4 Strengths, limitations of the study and future lines of research

One of the main strengths of this research is the sample size, with 3,256 first-semester university students in Study 1 and 2,110 students in Study 2. A large sample size provides a robust basis for generalization of the results and increases the external validity of the study. Similarly, the inclusion of students from six different universities in Chile ensures a diversity in educational experiences and contexts, allowing for greater generalizability of the findings. The study focuses on critical cognitive and motivational variables such as autonomous motivation, academic satisfaction and academic engagement, which are essential for understanding the phenomenon of university dropout. This is one of the few studies that follows students over time and shows how cognitive and motivational variables influence not only intention but also dropout. This provides valuable information for the development of interventions aimed at improving these specific areas.

This study contributes to the understanding of the dropout phenomenon in higher education. However, among the possible limitations to be considered are the measurement instruments selected for data collection, given that these are self-report instruments and, therefore, the results should take into account the biases associated with this type of measurement. On this point, future studies could consider other data to analyze the dropout phenomenon, for example, learning analytics, available in the activity performed by students and teachers in institutional LMSs (Mella-Norambuena et al., 2023). Also, based on the evidence on the impact of teachers' encouragement of self-determined behaviors in students (Huéscar and Moreno-Murcia, 2017; Oriol-Granado et al., 2017); it will be of interest to explore in the future the behavior of the variables analyzed in the teacher-student interaction, with special attention to the way in which, through the teaching-learning process, the basic psychological needs of competence, autonomy and relatedness are satisfied in students.

5 Conclusion

(a) Students with intention to dropout present lower levels of academic engagement, autonomous motivation and academic satisfaction than students who reported intention to remain in their career; the latter, on the other hand, present higher levels of controlled motivation; (b) Students who dropped out of their careers in the 3rd

semester had lower scores for engagement, autonomous motivation and satisfaction from the beginning of their professional training than those who continued their studies; (c) The cognitive-motivational variables: autonomous motivation, academic satisfaction and academic engagement, together with the intention to dropout in the 1st semester of the career, can be used as indicators of future dropout of first-year students at the university.

This study provides specific result of the cognitive and motivational factors that influence dropout intention and actual dropout in university students. The findings suggest that improving autonomous motivation, academic satisfaction, and academic engagement may be key to reducing dropout rates and improving academic success in higher education. Higher education institutions should focus on improving students' academic experience to reduce dropout rates (Meštrović, 2017; Wilkins-Yel et al., 2018). Implementing support and counseling programs that increase satisfaction and motivation could be an effective strategy to keep students engaged in their studies. Programs that teach time management techniques, effort regulation, and study environment management can help students improve their academic performance and overall satisfaction. Similarly, academic purposes can be fostered as they provide meaning, motivation, and direction, acting as self-regulatory mechanisms for academic behavior (López-Angulo et al., 2024). Incorporating counseling and psychological support services into the curriculum and university life can provide students with the resources they need to manage stress and emotional challenges, which in turn can improve their academic satisfaction and reduce dropout intention. This includes providing a learning environment that supports autonomous motivation and offers robust academic and emotional support. Integrating activities that promote dedication, absorption, and vigor into learning experiences can help keep students engaged and reduce intent to dropout.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by ethics committee of the University of Concepcion Comité Ético Científico de la Universidad de Concepción. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer JV-M declared a shared affiliation with the author JM-N to the handling editor at the time of review.

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Enhancing multimodal literacy through community service learning in higher education

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This Curriculum, Instruction, and Pedagogy (CIP) article outlines the pedagogical design of a course that uses Community Service Learning (CSL) to foster undergraduate students' multimodal literacy development. The article draws on a social semiotics approach to learning and communication and aligns with progressive pedagogical designs that prioritize learners' active participation. The course syllabus, methodological procedures, and assessment strategies are described. CSL serves as a means for higher education teachers to embrace civic and social responsibilities, promoting values such as solidarity and generosity through their teaching. This article examines the challenges and benefits associated with CSL and offers insights to inspire higher education teachers to adopt pedagogical designs based on creativity, solidarity, and generosity.

KEYWORDS

digital literacy, multimodal literacy, community service learning, higher education, communication skills, social engagement

1 Introduction

The current global scenario requires citizens who critically exercise democracy (Landry and von Lieres, 2022), effectively communicate across differences (Shcherbyna et al., 2024), and build knowledge to promote the political, social, cultural, and educational development of their regions (Cevallos Borja et al., 2015). The education system must evolve from one that serves the industrial society to one that prepares learners to function in the knowledge society (UNESCO, 2013). Developed countries participating in the global knowledge economy have become dependent on the creation and exchange of intangible forms of production such as information, entertainment, services, and knowledge (Ruiz-González et al., 2015). Educational systems capable of producing individuals skilled in symbolic creation are strategic. A rapidly developing globalized technological society requires the new generation to be proactive, expressive, agile, self-disciplined, and creative (Singer, 2012).

However, educational reform should not be used to uphold neoliberal capitalist systems submissively. This is because not all the transformative potential in education is captured by neoliberalism, the flexible accumulation model of modern capitalism, or market demand (de Oliveira and Gallardo-Echenique, 2015). According to Kress (2011), determining how education can empower learners to live productive lives on individual and social levels is more essential than merely engaging learners to satisfy the requirements of the economic agenda. It should be noted that Kress' (2011) phrase "living productive lives" is related not to "the creation or consumption of products" but to achieving the sustainable development goals (SDGs) of "Health and Wellbeing" as part of the 2030 Agenda (Echegoyen-Sanz et al., 2024). This implies prioritizing human needs for personal fulfillment and emotional wellbeing as non-negotiable values that form the basis of

educational purposes. A compelling argument exists against the "commercialization" of creative, transformative, and innovative thinking, highlighting the need for the judicious use of creativity in education to achieve the SDGs in the 2030 Agenda (Craft, 2005; Craft et al., 2008).

Knowledge societies, Community Service Learning (CSL), multimodal literacy, and social semiotics are key terms relevant to the conceptual framework of this Instruction, and Pedagogy (CIP) article. Knowledge societies prioritize and value the ability to locate, generate, process, transform, distribute, and use information to create and apply knowledge for human advancement. They need a social vision incorporating solidarity, plurality, inclusion, and participation (UNESCO, 2005). CSL is an educational experience in which students take part in a planned service project that addresses needs in the community and then reflect on the experience to learn more about the course material, develop a deeper understanding of the discipline, and strengthen their sense of civic duty and personal values (Bringle and Hatcher, 2009). Multimodal literacy is a term that comes from a pedagogical approach (Kress, 2003, 2006; Jewitt and Kress, 2003; Jewitt, 2006, 2008) that questions traditional frameworks in the face of the challenges presented by the digital age. It draws on social semiotics, a theoretical framework that examines how meaning is created and communicated through social practices, focusing on the interplay between language, visual elements, and context (Kress and Van Leeuwen, 2001). Walsh (2010, p. 213) defines multimodal literacy as "… meaning-making that occurs through the reading, viewing, understanding, responding to, producing and interacting with multimedia and digital texts." A basic assumption of the multimodal literacy approach is that "both learning and sign-making are dynamic processes which change the resources through with the processes take place—whether as concepts in psychology or as signs in semiotics—and change those who are involved in the processes" (Kress, 2003, p. 40). How knowledge is represented, and the mode and media chosen is a crucial aspect of knowledge construction, making representation integral to meaning and learning more generally (Jewitt, 2008).

Educators embracing an awakened attitude are committed to fostering a peaceful present and future. They prioritize sustainable and equitable models of human development and recognize that learning transcends academic pursuits and encompasses spiritual and emotional growth by transforming learners' reality and interactions with others. This approach contrasts with education for reproduction, which assumes the stability of cultural and social forms (Kress, 2011). Many teaching practices rely on reproducing social and cultural forms, doing things the way they have always done, and expecting students to learn. Sullivan (2011) asserted that educators often conform to expectations by settling for monotony and perpetuating a prescriptive mentality that views learning as uniform and predictable.

Achieving social transformation requires pedagogical designs that depart from content reproduction-focused pedagogies. This CIP article presents the pedagogical design of a course that uses CSL to engage undergraduate students in multimodal literacy development. It provides information to inspire higher education teachers to embrace pedagogical designs based on creativity,

solidarity, and generosity. Higher education often serves neo-liberal economic models, educating students to meet market requirements. This CIP article is a scholarly invitation to higher education teachers to adopt pedagogical designs that educate students to question and ultimately transform the capitalist market system.

2 Pedagogical framework and principles

Theories of communication initially understood communication as a closed circuit between the sender and receiver, establishing a symmetrical relationship between the one encoding the message and the one deciphering it (Charaudeau, 2006). However, from a social semiotics approach, communication depends on interpretation and not on the initial creator of the message or its elaboration (Kress, 2019). Learners engage in semiotic work when actively interpreting their educational resources. Thus, according to Kress (2019), learning is a semiotic process involving transformative commitment based on global interest.

Progressive pedagogical designs prioritize students' active participation by considering it essential for effective learning (de Oliveira et al., 2015). Students can autonomously search for, select, and analyze information when guided and supported. Furthermore, they transition from passive consumers to active knowledge producers by sharing insights derived from interpretation processes through various modalities, such as verbal language, sound, and images (de Oliveira et al., 2009). To achieve this, higher education teachers must develop pedagogical designs that challenge students and provide them with contemporary analog and digital tools (de Oliveira and Gallardo-Echenique, 2015).

It is essential to foster students' multimodal development and enable their participation in knowledge societies, thereby mitigating the risk of marginalization. Archer (2014) considers a multimodal approach to have the potential to make classrooms more democratic and inclusive, thereby enabling marginalized students' histories, identities, languages, and discourses to be visible. Only by intentionally retreating from the excesses of a highly regulated, performance-based audit culture can emphasize creativity in higher education be promoted daily. In this regard, she argued that ideologically engaged multimodal creative learning is crucial in forming wise futures that ensure just and sustainable models of human growth.

When considering the role of creativity in education, it is relevant to consider that there are different rhetorics of creativity (Banaji, 2011), which fall into two paradigms: a paradigm of competition or a paradigm of collaboration (de Oliveira and Gallardo-Echenique, 2015). In a paradigm of competition, creativity is pivotal in economic production and enterprise. The socio-economic circumstances behind the educational interest in creativity receive special relevance (Shaheen, 2010). In this tradition, investment in creativity directly addresses the neoliberal need to restructure capital to generate new products and exploit intellectual property possibilities. In a collaboration paradigm,

researchers and educators deliberately approach education matters from a social and cultural perspective, satisfying the demands that place human needs for personal fulfillment and emotional wellbeing as non-negotiable values based on educational purposes.

The literature urges higher education teachers to promote creative semiotic work that opens alternatives to reinforcing capitalist neo-liberal structures. Tseris and Jamieson (2024) drew on creative pedagogies to support critical thinking, openness to learning, and engagement with multiple forms of knowledge in a mental health social work curriculum. They reported that students could embody analysis of power and knowledge with heightened confidence and enthusiasm for exploring multiple paradigms in mental health and engaging with more just and expansive possibilities in their future practice. Similarly, Mendelowitz and Govender (2024) explored the nuances of critical, imaginative, and affective entanglements by examining students' decisions to redesign advertisements and theorize their process. They found that students engaged within various combinations of creative-affective, critical-affective, and critical-creative moves across different assignments that required analysis and imagination, evoked emotions, and made a significant contribution toward doing literacies in transformative ways. de los Ríos (2022) explored a curricular unit that allowed young people to use new media technologies to tell important stories about themselves and their social worlds during heightened anti-immigrant sentiment in the United States. They demonstrated how Latinx young people contest racist narratives, reclaim their identity, and author new spaces for solidarity. In the learning experience, the students utilized podcasts to promote creativity and self-expression and connect personal experiences to broader pressing discourses about immigration, language, racialization processes, and resistance.

When planning and conducting pedagogical interventions, higher education teachers decide from various alternatives: they determine the content, presentation methods, activities, and learners' roles. Each decision reflects their identity and worldview. Additionally, these decisions provide students with cues for interpreting the information, although they do not dictate their responses. Students, too, actively select what they want to learn from the options provided, even if they choose not to participate. Their choices vary depending on their interests, maturity, and prior knowledge. Therefore, teaching and learning are design processes that inform learners' choices and adapt to their interests.

3 Social engagement

Multimodal composition pedagogy poses a paradigm shift in higher education (Olivier, 2021). This new pedagogy is warranted—grounded in the value of generosity rather than competitiveness (de Oliveira et al., 2015, 2016). From a methodological point of view, this new instruction paradigm promotes a student-centered model of teaching and learning, explores the potential of interactivity and the disjunction of time and space, and enriches the learning experience with different modes (de Oliveira et al., 2009). Social relations are established among teachers and students and knowledge is restructured based on solidarity. Co-creation practices become an opportunity space to re-image higher

education, question the status quo, and envisage a different kind of society (Wallin, 2023).

Students perceive community and solidarity pedagogies as innovative and value approaches that foster community-centered learning, interdisciplinary methods, and experiential education for tackling broader societal and economic challenges (Ciolan and Manasia, 2024). Freire (2008) states that educators must commit to the world by fostering humanization, responsibility toward others, and engagement in history. Solidarity and generosity underpin a pedagogy dedicated to social transformation and liberation from systems of domination. In this regard, Kioupkiolis (2023), Muñoz et al. (2022), Frankenberger et al. (2018), and Boucher (2016) illustrate how solidarity and generosity have been successfully integrated into educational practices, reinforcing a paradigm of transformative learning practices. Padrós-Cuxart et al. (2024) explored how educational transformative practices based on friendships, support, and solidarity can prove successful in settings beyond traditional educational environments, helping individuals to establish positive relationships that help them face challenges.

Freire (2008, p. 79) stated, "No one educates anyone, no one educates oneself: men educate each other mediated by the world." Similarly, Kress (2019) emphasized engagement as integral to the definition of learning, describing learning as a transformative commitment driven by individuals' focus and principles, which leads to the evolution of their semiotic/conceptual resources.

Freire (2002) argued that educators are pivotal agents of change. However, he emphasized that they must approach their actions with love. This facet of change is often rejected by proponents of change solely for the pursuit of wealth. According to Freire, love is the key to authentic change, manifested through a commitment to freedom achieved through dialogue and the transformation of all individuals subject to various forms of domination. He defined "love" as an essential education component, stating that "there is no education without love. Love involves fighting against selfishness. He who is not capable of loving unfinished beings cannot educate. There is no imposed education, just as there is no imposed love. He who does not love does not understand others; He doesn't respect them" (Freire, 2002, p. 8).

4 Learning environment and objectives

The activities outlined within the course framework presented in this CIP article affect the development of three transversal skills (CT) of the Rovira i Virgili University skills map:

CT1. Efficiently managing information and knowledge through the efficient use of ICT.
CT2. Critically, creatively, and innovatively solving problems within the field of study.
CT3. Demonstrating responsibility, initiative, and the ability to work independently and as a team.

This study aims to describe Multimodal Literacy, a component of the "Communicative Skills" course taught in the 1st year of

education degrees at the Faculty of Educational Sciences and Psychology of the Universitat Rovira i Virgili. It carries six European credits and serves as the first module of the 12-credit course. The degrees offered include Early Childhood Education, Primary Education, Double Degree in Early Childhood and Primary Education, Social Education, and Pedagogy. This module is structured with two theoretical and four practical credits, spread over 15 sessions within a 4-month timeframe. These sessions encompass various activities, including an introductory session, syllabus development sessions, group project presentations, and a final reflection and closure session. The course syllabus comprises five topics:

i)   Digital identity and intellectual property.
ii)   Multimodal literacy.
iii) New learning methods in the digital age.
iv) Assertive communication.
v)   Safe Internet practices and cyberbullying.

5   Theoretical sessions

The flipped-class methodology was used for theoretical sessions. On the virtual campus, students were assigned readings to complete at home. Face-to-face classes were dedicated to debating and exchanging ideas. The students took multiple-choice exams as a task associated with the theoretical sessions. These exams are designed to assess the reading and understanding of the mandatory texts and are conducted at the end of each of the five items on the syllabus.

6   Practical sessions

In practical classes, students performed group and individual activities that challenged them to translate their theoretical reflections into tangible outputs. Individually, students created an e-portfolio. In groups, they developed a project based on CSL. Students receive weekly work scripts through the virtual classroom forum, enhancing their autonomy as they navigate learning spaces like the University Learning and Research Resource Center. Many tasks require a quiet environment for completion, which the center provides.

7   E-portfolios

E-portfolios are digital collections of student work that showcase learning achievements, skills, and reflections, often used for assessment purposes. They promote semiotic work that favors transformative pedagogical approaches, allowing students to become content producers and not mere information consumers. They provide an appropriate platform for integrative learning that allows students to visualize the relationships between various concepts learned throughout the course and beyond (Thomas, 1998; Syzdykova et al., 2021). E-portfolios also provide opportunities for students to reflect on their learning experiences and assess how these experiences are linked to everyday practice (Alzouebi, 2020).

In their e-portfolios, the participating students must create four entries through guided reflections: (1) who I am, (2) who I would like to be, (3) my professional future, and (4) what I learned from the CSL experience. The E-portfolio is evaluated through co-evaluation, which is defined as students measuring the learning achievement of their classmates. This is part of the formative assessment in the teaching-learning process, as it regulates and improves students' learning. Three classmates evaluate each student and the e-portfolios of three classmates, with 85% of their grades corresponding to the average of the evaluations received by their peers and 15% corresponding to their grades as evaluators.

8   Community service learning project

CSL provides a dynamic source of innovative instruction by imbuing university students with responsibilities from a fresh perspective (Smith et al., 2013). As students' skills are used to benefit society, these duties take on a social role in addition to serving their own educational goals. Tijsma et al.'s (2020) analysis of the literature highlighted three essential steps in the implementation of CSL: (1) aligning course objectives and formats, (2) establishing a relationship with the community partner, and (3) defining a reflection and evaluation strategy.

The Universitat Rovira i Virgili maintains a catalog of CSL projects and entities. A "Social Project Market" is promoted by the university Social Commitment Office. Both activities allow the establishment of collaborations between university teaching staff and non-profit organizations to promote CSL projects within the framework of university courses.

In the framework of the Multimodal Literacy CSL project, students work in groups of four or five to create, in the order of collaborating with non-profit organizations, four communicative pieces:

- Infographic: The digital tools used are free online tools, such as Canva and Genially.
- Podcast: The digital tool used is Podcastle or another app that offers free access.
- Video: The software used is Shotcut, HitFilm, Clipchamp, or others with free access.
- Comic: The tool used is Pixton.

To perform these tasks, groups of students receive continuous and personalized guidance from the teacher of the Multimodal Literacy module and personalized tutoring from collaborating non-profit organizations. In the 2022–2023 academic year, the project involved six entities and 107 students, while in the 2023–2024 academic year, it involved 19 entities and 182 students. Service-learning projects must be validated at the university by the Academic and Teaching Policy Commission.

The non-profit organizations participating in the CSL project during the 2023–2024 academic year are listed in Table 1, along with a short description of their action areas.

The learning outcomes pursued in the Multimodal Literacy module are as follows:

- Conceptualize the process of literacy in a more complex way.

TABLE 1 Non-profit organizations participating in the multimodal literacy module CSL project during the 2023–2024 academic year.

Non-profit organization	Areas of action
Atzavara-arrels	Interculturality, social cohesion, and communicative action
AFANOC	Association of Family and Friends of Oncological Children of Catalonia
Una Finestra al Món	Defense and dissemination of the cause of the Sahrawi people
Ocell de Foc	Young people's mental health to promote autonomy and independence
Ennatura't	Outdoor physical activity, training, and health service
Esplai blanquerna	Promotion of an integrated and inclusive society
Fundació Topromi	Improving the quality of life of adults with intellectual disabilities
Fundació Onada	Training and work integration for people with disabilities
Center de Noves Oportunitats	Training and incorporation into the world of work and education for young people aged between 16 and 24 years who are not studying or working.
Papageno	Association of Professionals in Suicide Prevention and Postvention
APSAS	Association for Suicide Prevention and Survivor Care
ACPS	Catalan Suicide Prevention Association
Ecocolmena	Help take care of bees, wild pollinators and the environment
Complex Educatiu	Tarragona Educational Campus (CET)—space dedicated to the field of education
Cooperativa l'Escamot	Active mobility and local development
La Bastida	More empowered individuals, more cohesive communities, and a socially committed territory
Athena	Association of families of boys and girls and young individuals with high ability in the province of Tarragona and Terres de l'Ebre
Cooperativa El Far	Visibility of groups that usually do not have a voice
Cooperativa Fet Tàrreco	Training with a feminist and transformative perspective.

- Develop digital competence.
- Apply critical, logical, and creative thinking to demonstrate innovation capacity.
- Work independently with responsibility and initiative.
- Work in a cooperative team and share responsibilities.
- Advanced use of information and communication technology.
- Manage information and knowledge.
- Express oneself correctly and write in the official language of the university.

Assessment is done through hetero-evaluation (evaluation by the instructor) and co-evaluation strategies (peer evaluation). Students' learning outputs are evaluated using two hetero-evaluation and one co-evaluation strategy. The hetero-evaluation tasks are:

- Five multiple-choice examinations account for 30% of the course grade. At the end of each topic of the course syllabus, students take a multiple-choice exam to check their reading and understanding of the theoretical reference readings.
- The CSL Project accounts for 40% of the course grades. Groups of four or five students use any free online platform for web development; they create a webpage displaying the communication pieces created for the non-profit organization with which they have collaborated on their project.

Finally, the e-portfolios account for 30% of the course grade and are assessed using the co-valuation strategy described in Section 7. The Moodle "workshop" tool is used to assign random e-portfolios for evaluation and automatic calculation of qualifications. A rubric is used to guide the peer evaluation, which allows for generating a quantitative grade to which students can add qualitative comments to offer more information to their evaluated peers. The rubric is shared with the students at the beginning of the course to make them aware of the evaluation criteria and strategies.

9 Results to date

The Social Commitment Office of the Universitat Rovira i Virgili uses a survey to assess the validated CSL experiences. In the 2022–2023 academic year, ∼107 students participated in the Multimodal Literacy Project, yielding 84 responses. During the 2023–2024 academic year, ∼182 students participated in the project, resulting in 145 responses. The groups comprised first-year students aged 18–21 years. In 2022–2023, the average overall satisfaction with the Multimodal Literacy course was 9.14, with a deviation of 0.8 (Cronbach's Alpha: 0.61; Table 2). However, despite efforts to expand the number of entities for personalized attention, the average overall satisfaction dropped to 8.04 with a deviation of 1.54 in the 2023–2024 academic year. Communication challenges and differences in work rhythms with some non-profit organizations posed difficulties for some students. Consequently, their experiences varied, with more negative evaluations in some cases. The increase in participating non-profit organizations also heightened the potential for unpredictable situations, which created tension in adhering to the academic calendar.

The satisfaction survey ends with a non-mandatory open-ended question where the participants can make clarifications, observations, or suggestions. Most responses in this field positively assessed the 2022–2023 and 2023–2024 academic year teaching experiences, highlighting different aspects of its implementation. The students highlighted a wide range of topics, including how much they enjoyed the course methodology, how much it enriched their personal and professional lives, and how much they felt their communication and digital abilities had improved. Consistent with the findings of Bringle and Hatcher (2000) and Ribeiro et al. (2023), CSL exhibited the potential to promote

TABLE 2 Assessment survey of the multimodal literacy course CSL project.

Assessment dimension	2022–2023 M	SD	2003–2024 M	SD
Tasks developed by the students				
I have done the proposed tasks.	9.91	0.29	9.59	0.41
The tasks done have had a direct relationship with my academic training.	9.18	0.64	8.35	0.80
I have put into practice the knowledge acquired throughout my studies.	9.18	0.56	8.24	0.84
The CSL experience has been a training supplement.	9.55	0.51	8.7	0.75
Relationship with the university faculty and the organization				
I have received information, communication, and support from the university teaching staff.	9.0	0.48	8.69	0.68
I have received supervision and support from an external non-profit organization in the development of tasks.	9.14	0.99	8.38	1.01
General assessment of the CSL experience	9.14	0.80	8.04	1.54

students' holistic development beyond academic content and integrate the development of specific and generic skills while students provide a service to the community. Drawing on a socio-cognitive perspective of critical discourse analysis, five semantic macrostructures can be elicited from the student responses: (i) Satisfaction and Enjoyment; (ii) Personal and Professional Growth; (iii) Challenges and Difficulties; (iv) Critical Awareness and Social Responsibility; and (v) Methodological Effectiveness. Semantic macro structures refer to the overall, global meanings of discourse: "They are mostly intentional and consciously controlled by the speaker; they embody the subjectively most important information of a discourse, express the 'overall' content of mental models of events (…)" (Van Dijk, 2009, p. 68). Below are examples of observations that highlight students' subjective experiences. The original quotations were either in Catalan or Spanish; a translation is provided.

9.1 Satisfaction and enjoyment

Many students expressed high satisfaction with the course methodology and the overall experience, indicating that the course was enjoyable and engaging. The students highlighted the dynamic nature of the learning process and the enjoyment derived from collaboration with non-profit organizations.

"This experience has been able to enhance my ability with digital and editing platforms in a very positive way. I have learned to make comics, to create a web page and its sections... It has been an enriching experience in general even though the entity has not been able to keep up with everything we were doing, I really enjoyed carrying out this work." (Academic year 2023–2024)

"I value the experience very positively, since knowledge has been acquired in a very dynamic way. The learning has been very enriching and being able to collaborate with an entity that can use your work is a source of pride." (Academic year 2022–2023)

"It's an activity that is very good because it leaves the traditional and is dynamic. We learn to work in a team, new technological resources, and new knowledge." (Academic year 2023–2024)

"I think that the CSL experience has been a very pleasant and profitable opportunity to train and learn about a very unknown and invisible problem. It has been a very original way of learning, using the students' creativity and motivating them day after day and task after task. I would have liked this experience to have been longer and to have had more time to get to know the problem and the organization in depth. However, I think it has served me well for my professional future." (Academic year 2023–2024)

9.2 Personal and professional growth

Students noted significant personal enrichment and skills development beyond academic content, such as digital competencies and teamwork. The following quotes are evidence of students' reflections on how the course impacted their views on life and their professional aspirations.

"It has been a very good experience with which I have learned many aspects of life and how to see life." (Academic year 2022–2023)

"It was a very enriching task. We had contact with another entity all on our own, with the support of teaching professionals from the URV (Universitat Rovira i Virgili) and the educational complex, we carried out work to promote the cultural heritage of the city from Tarragona." (Academic year 2023–2024)

"An experience to awaken consciences." (Academic year 2023–2024)

9.3 Challenges and difficulties

Some students reported challenges related to communication and coordination with non-profit organizations, which affected their experiences. This semantic macro structure highlights the complexities of managing CSL projects and the impact of these challenges on student satisfaction. An aspect that hindered students' experience was the need for improved communication with non-profit organizations. These organizations typically display enthusiasm for a project when it is presented to them a few months before its start date. However, when it is time for students to seek answers from these organizations, challenges may arise. Most associations lack professionalization, which indicates that

volunteers tend to work during their free time. Meeting students' support needs could prove challenging as the project progresses. This is evidenced by the quotes below:

"I really liked the experience, we had problems when receiving information from the entity but even so, I have learned a lot from the activity and I think it is a very complete and creative way to learn the concepts." (Academic year 2023–2024)

"Very enriching experience, although communication with the organization has been difficult at times." (Academic year 2022–2023)

"The participation and support from the external entity have been somewhat missed, but I understand that these are complicated dates, and they have not been able to participate as we expected." (Academic year 2022–2023)

"The little support from the entity has made the task difficult." (Academic year 2023–2024)

Owing to the additional complexity of the ongoing entity evaluations, students occasionally felt that the time allotted to the activities was insufficient.

"More time to carry out this work since it entails obtaining feedback from the entity that in many cases was not available." (Academic year 2022–2023)

9.4 Critical awareness and social responsibility

Several responses indicated that the course fostered a critical understanding of social issues, particularly through engagement with specific communities, such as the Saharawi people. This semantic structure highlights the role of the course in promoting civic engagement and social awareness among students.

"I am very grateful to the subject of Communication Skills for allowing us to get closer, discover and work with 'Una Finestra la Món' (A Window on the World). We have been able to learn about the unjust situation that the Saharawi people have been living in for years and we have been able to help the association through the creation of various materials. In summary, it has been a very enriching experience that has allowed us to have a more critical view of the world." (Academic year 2022–2023)

"It was a different experience, since we had to work with an entity. The entity we chose was very interesting, since I learned a lot and was able to listen to the experience of a volunteer, which called my attention a lot." (Academic year 2022–2023)

9.5 Methodological effectiveness

The students' responses suggest that the teaching methods employed effectively facilitated learning. The following quotes indicate that the pedagogical strategies contributed to students' positive experiences and learning outcomes.

"It has been a very positive experience and has contributed significantly to my academic training, as it has brought us a little closer to what our work could be in the future." (Academic year 2022–2023)

"The APS experience seemed very interesting and important to me, since, thanks to this project, I was able to learn more about the foundation with which we collaborated, very related to my future work, and we were able to see how they work and with what values they do it. In addition, we learned in a dynamic and fun way by performing the various communicative pieces." (Academic year 2023–2024)

10 Discussion and lessons learned

As described in this study, the teaching experience is complex, requiring considerable labor and preparation hours. These complexities increase with the additional planning, management, coordination, and adaptability needed for CSL, simultaneously involving large groups and numerous non-profit organizations. Institutional support is essential for successfully implementing, assessing, and certifying CSL. This support must be combined with a strong commitment to advancing innovative and significant teaching methods in higher education, a passion for teaching, and a dedication to students. This does not refer to romantic love, but rather, as Freire (2008) conceptualized, love is a commitment to freedom through dialogue to transform the reality of those under some form of domination. In this context, CSL enables students to commit to humanizing individuals and taking responsibility for humanity and history. In this project, the students were invited to humanize themselves by examining the world views of the participating non-profit organizations:

- The social cohesion activities promoted by Atzavara-arrels;
- The comprehensive psychosocial care for children and adolescents with cancer and their families offered by Afanoc;
- The dissemination activities of the cause of the Saharawi people, the history and present of oppression carried out by Una Finestra al Món;
- The support, active and individualized listening to people who are unwell implemented by Ocell de Foc and la Bastida;
- The awareness projects around the human need to defend the environment promoted by Ecocolmena and to integrate ourselves in it in a healthy way promoted by Ennatura't;
- The work for the social and labor integration of people with disabilities and the socio-labor insertion of people in a situation of social vulnerability laid by Fundació Onada, El Far, and Fundació Topromi;
- The projects for the promotion of an integrated and inclusive society with special attention to people and sectors with greater risk of exclusion by offered Esplai Blanquerna;
- The activities of attention to persons at risk of suicide, their relatives, and the support to bereavement by suicide extended by Papageno, APSAS, and ACPS;
- The pedagogical projects of Center de Noves Oportunitats and the Complex Education;
- The clean and safe urban mobility proposal promoted by Cooperativa l'Escamot;
- The guidance and support activities for families with high abilities offered by Athena;
- Cooperativa Fet Tàrreco implemented the feminist business model.

As can be seen, the values of the participating non-profit organizations reflect in practice the solidarity and generosity that inform the theoretical framework of the pedagogical design presented here. These are the values of pedagogical approaches committed to social transformation and liberation from domination situations. The non-profit organizations keep continuous and individualized contact with the groups. They instruct the students about the importance of their projects while presenting them with different forms and strategies of social resistance and improvement. Additionally, its critical perspective toward the communicative pieces created by the students offers an assessment by real end users of the students' semiotic work, resulting in a much richer learning experience. In some cases, non-profit organizations require students to make frequent changes in their communication pieces to transmit their projects and values more accurately. In these cases, the students revised their work until they reached a satisfactory result for both parties. This demanded resilience from the students and became an opportunity to accept constructive criticism proactively and with greater humility.

Apart from my traditional role as a university professor, which I perform in theoretical and e-portfolio activities, I have become a mediator in the CSL more closely related activities. On the one hand, I must correctly communicate to the non-profit organizations the expectations they may have of 1st-year students enrolled in the Faculty of Education. On the other hand, I convey to students that these are users who come from the real world, not the protected environment of our classroom. Understanding and meeting their needs requires communication skills that far transcend those related to technology management, even though these are necessary.

Notably, this teaching experience demonstrated that it is expedient for each non-profit organization to work with one or, at most, two groups of students. Furthermore, considering unforeseen events, it must be ensured that the participating non-profit organizations can respond to the demands of the students whenever possible. An assignment sheet was created for the 2023–2024 academic year to guide students and reduce their demands from these organizations effectively. This sheet required each non-profit organization to explain: (1) what message it wants each of the communication pieces to transmit, (2) the target audience of the pieces, (3) contacts (emails or telephone numbers) of informants or interviewees, if any, and (4) reference documents needed for the task. While this assignment form adds an extra task for non-profits before the project commences, it effectively reduces student demands during the project.

However, it is crucial to balance between prior planning and allowing students to be creative. Excessive guidance can stifle creativity. In this video, for example, a group of students worked with AFANOC, an association supporting families of children with cancer, and staged a dispute between cancer through self-composed music and dance. The semiotic work in this piece transcends digital skills, garnering empathy from the non-profit organization and posing a deep sensitivity in communicating its message. The cap seen at the end of the video is used as a fundraiser by the entity to offer accommodation, among other things, to families who come from centers far from the hospitals specializing in pediatric cancer. These hospitals are located in large cities and are very expensive to rent. In the particular case of this video, the non-profit organization made a very open request to the students: "Present AFANOC. Create awareness around pediatric cancer. Create involvement with AFANOC." The group of students united individual capacities not usually evoked in a traditional approach. The students examined their capabilities, feelings, and knowledge to determine how to fulfill the non-profit organization's request. In the video, the students transmitted their newly developed vision of the relationship between the effects of cancer, a family facing pediatric cancer, and the non-profit organization that offers support to the family.

While the case above details a success, some students may not know how to investigate their abilities and sometimes do not see the reward in doing so. In these cases, a more elaborate task orientation and individualized tutoring by the teacher can help develop the work. However, it is necessary to acknowledge that there are no formulas to achieve the balance between planning and openness that favors creativity. Very creative works are not the norm but rather the exception. However, I argue that it is important to create the conditions so that they can happen because of the learning experience they entail. In the present experience, telling students explicitly and repeatedly that they are expected to be innovative and creative informs them that this is an important aspect of their work, but it does not ensure that all groups will make the effort, and many will fail to do it successfully. Students are told that the non-profit organization's demands are proposals and that the non-profits will listen to them if they have creative counter-proposals. While students need guidelines to follow the tasks and calendar, the CSL experience, as described in this study, requires flexible spaces and times to ensure that the organization does not hinder creativity.

In practice, this flexibility translates into presenting both students and non-profit organizations with a work calendar permissive with each of the four partial work deliveries but very strict with the deadline of the final format delivery that consisted of a webpage presenting all the communicative pieces created by each group of students. This poses challenges for teaching management. During the 2023–2024 academic year, ~182 students participated in the project. Thirty-eight groups were working with 19 non-profit organizations. This involved delivering 152 communication pieces, each reviewed once, twice, and sometimes many times by the non-profit organization until the final result was satisfied. Being strict with a delivery date for each communicative piece was incompatible with the coordination and creation challenges students faced in the proposed tasks. To overcome these difficulties, from the beginning of the course, the students had at their disposal the ideal calendar for the partial deliveries of the communicative pieces and the irrevocable deadline for the presentation of the groups. The day of the exhibition was the deadline for the final delivery of all communication pieces in their final format. In groups of up to 20 students, the procedures described here only mean flexibility and extra patience from the higher education teacher. When we talk about groups with up to 100 students, as is the case of the degrees of Social Education and Pedagogy described in this CIP, the challenges are exponential, always in direct proportion to

the satisfaction experienced with their results on personal and academic levels.

The broader implications of CSL on students' personal, academic, and professional development are well-documented in disciplines as diverse as medicine (Nauhria et al., 2021), nurse education (Marcilla-Toribio et al., 2022), Computer and Information Science (Yamamoto et al., 2023), music education (Chiva-Bartoll et al., 2019), and teacher education (Khan and VanWynsberghe, 2020). In line with previous studies, the project described here shows that students noted significant personal enrichment and the development of skills beyond academic content, reported experiencing broader life views and impact on their professional aspirations, expressed high levels of satisfaction with the methodology, and developed a critical understanding of social issues. Fluid communication among all parts and calendar flexibility were the main challenges identified in the project. I hope this CIP will encourage the academic community to engage in pedagogical designs that re-image higher education, question the status quo, and envisage a society that puts creativity, solidarity, and generosity at the heart of the learning process.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

Funding

Acknowledgments

Conflict of interest

The author declares that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Perception of the learning climate and its prediction of wellbeing in psychology students at a Chilean university

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Autonomy-supportive environments have been identified as predictors of students' wellbeing and engagement. This paper aimed to examine the perception of learning climate and its predictive ability in the multidimensional wellbeing of university students. An associative and predictive approach was adopted, carried out through a cross-sectional study that included 295 students from a Chilean university. Participants completed a learning climate questionnaire and the PERMA-Profiler. Results indicated that students reported moderately high levels of wellbeing in general, with the dimensions of positive relationships, engagement, and purpose showing the highest scores. Regarding learning climate, responses indicated a mostly positive perception, with scores above the midpoint on the scale. No significant differences were found in wellbeing or perception of learning climate according to academic year. However, a significant interaction effect between gender and learning climate was found for overall multidimensional wellbeing, $F(1, 286) = 4.67$, $p = 0.032$, $\eta^2 = 0.016$. Men in the high learning climate group showed higher wellbeing than women, while women in the low climate group outperformed men in the same group. Additionally, significant gender differences were observed in the engagement dimension, $F(1, 286) = 11.23$, $p < 0.001$, $\eta^2 = 0.033$, with men in the high learning climate group reporting higher engagement, and women in the low learning climate group showing higher engagement than their male counterparts. Perception of learning climate explained a significant amount of the variance in all dimensions of wellbeing. These findings highlight the importance of promoting learning environments that foster autonomy and teacher support, and suggest that the learning climate may have different impacts on wellbeing depending on gender.

KEYWORDS

subjective wellbeing, psychological wellbeing, autonomy support, higher education, flourishing

1 Introduction

During their university years, young people experience situations that enable them to train and become professionally competent. They also could develop positive aspects related to their personal growth and motivation. Some students encounter difficulties in academic performance, which result in wellbeing issues and success in their university careers (Appleseth et al., 2023). The literature on higher education suggests that teacher autonomy support can promote educational success and student motivation (Okada, 2023). Therefore, the goal of educational institutions is to allow students to thrive in terms of classroom functioning, engagement, social development, and wellbeing (Ryan et al., 2023). The key to achieving this is providing conditions that allow students to satisfy their needs for autonomy, competence, and relatedness, which has subsequent benefits for learning and wellbeing (Howard et al., 2024).

Wellbeing is a construct studied from various perspectives. One is the hedonic perspective, which emphasizes overall life satisfaction, including domains such as work, academics, and relationships (Diener and Ryan, 2009). From this perspective, wellbeing can be described as the subjective evaluation that individuals make of their life experiences and the emotions associated with them (Passeggia et al., 2023). Therefore, it refers to subjective happiness, enjoyment, and pleasure in life (Auyeung and Han Mo, 2019).

Another perspective that has studied wellbeing is eudaimonia, which involves personal growth, purpose, and orientation toward self-realization (Ryan and Deci, 2006; Ryff, 1989). In this perspective, psychological wellbeing is considered a multidimensional construct associated with elements of engagement, meaning, and life achievements (Auyeung and Han Mo, 2019; Barra Almagia, 2012; Passeggia et al., 2023). Thus, psychological wellbeing can be explained as the positive functioning of individuals with their environment and high levels of satisfaction in various life spheres (Ryff and Keyes, 1995).

This study considers the PERMA model of wellbeing formulated by Seligman (2018) to address the construct. This theoretical perspective explains wellbeing as a multidimensional construct with eudaimonic and hedonic components, including positive emotions (P), engagement (E), relationships (R), meaning (M), and accomplishment (A). In the general population, PERMA components have been positively associated with overall satisfaction, job satisfaction, and positive effects, and negatively associated with negative effects (Cabrera and Donaldson, 2023). In the university student population, the components of PERMA have been associated with autonomy, resilience, flourishing, physical health, vitality, and character strengths such as curiosity, love of knowledge, gratitude, and love (Coffey et al., 2016; Leontopoulou, 2020).

Other perspectives consider wellbeing to include both interpersonal and intra-individual dimensions. The former refers to relationships with others, while the latter points to self-referent attitudes such as personal growth, self-beliefs, and experiences of mastery (Burns, 2017). In the Ibero-American context, PERMA has been analyzed among university students concerning interpersonal and intra-individual variables, finding significant associations between PERMA components and growth mindset, positive affects,

social interactions, overall life satisfaction, academic performance, secure attachment, university life adaptation, happiness, and indicators of physical and mental health. Conversely, negative relationships were found with academic anxiety, fixed mindset, and negative affect (Chaves et al., 2023; Cobo-Rendón et al., 2021; Umucu et al., 2024; Yang et al., 2024).

1.1 The role of autonomy support in promoting wellbeing and engagement in educational setting

Wellbeing has been associated with the satisfaction of basic psychological needs such as autonomy, competence, and social relationships (Mayerhofer et al., 2023; Pineda-Espejel et al., 2023). This association is addressed by the Self-Determination Theory proposed by Deci and Ryan (2000, 2002), a theoretical perspective that posits that these basic psychological needs—autonomy, competence, and relationships—need to be met to promote optimal functioning and, consequently, wellbeing.

Additionally, the theory proposes that basic psychological needs can be satisfied in interpersonal contexts that promote autonomy, enable the perception of competence through effective interaction with the environment, and foster significant social relationships (Deci and Ryan, 2000, 2002). Therefore, the type of educational context can influence students' wellbeing. However, individual and interpersonal factors, and even the type of culture—whether individualistic or collectivist—should be considered to understand wellbeing, along with differences between men and women within the same culture (Barra Almagia, 2012).

In this study, we delve into the basic psychological need for autonomy, understood as having the capacity for choice, associated with volition and self-perception that one's behaviors originate from one's own decisions (Ryan and Deci, 2017). Autonomy support, understood as the extent to which the environment enables individuals to perceive that they make decisions instead of being coerced (Grolnick, 2003). In Reeve (2016) study, applied the concept of autonomy support to teachers' motivational styles in the classroom and defined six essential aspects of teaching that support autonomy: (a) considering students' perspectives; (b) revitalizing internal motivational resources; (c) offering explanatory rationales; (d) using informational and non-pressuring language; (e) acknowledging and accepting negative affect; and (f) being patient. In summary, autonomy support refers to instructional efforts that satisfy students' need to be initiators of their behaviors (Reeve, 2016). Educational psychology research thus highlights the role of teachers in supporting students' motivation.

Autonomy has been studied concerning wellbeing and learning among university students (Holzer et al., 2021; Howard et al., 2021; Leow et al., 2023; Nalipay et al., 2020). On one hand, it has been found in motivational profiles of university students that those grouped in a profile with higher levels of learning autonomy also exhibited higher levels of academic satisfaction (Vergara-Morales et al., 2019). Additionally, it has been identified that increasing perceived autonomy support is linked to increased autonomous

motivation, with findings consistent in the opposite direction—when there is a high increase in autonomy control by the teacher, students' motivation and satisfaction diminish.

Linking constructs, autonomy support is strongly associated with the dimensions of the PERMA model (Seligman, 2018). In this case, autonomy support fosters the emergence of positive emotions in students, as it helps them develop greater perceived competence and intrinsic value toward learning activities (Berweger et al., 2021). Studies have shown that when students perceive an environment that respects their autonomy, they experience more positive emotions and a reduction in negative emotions such as stress or frustration (Meng-Ting Lo, 2021). In terms of engagement, autonomy support is closely related. According to Jiang and Tanaka (2022), students who perceive a high level of autonomy support, through the satisfaction of their psychological needs, show greater academic engagement and satisfaction with university life. This engagement is not only emotional but also behavioral and cognitive, involving active participation in the learning process. Within the same framework, another study investigated whether students' classroom engagement, in addition to being influenced by teachers' motivational styles, could also predict changes in those styles. The results showed that autonomy-supportive teaching predicted increases in student engagement across all its dimensions. Additionally, students' agentic engagement at the beginning of the semester also predicted increases in perceived teacher autonomy support, suggesting that active student engagement can influence teachers' teaching styles (Matos et al., 2018).

In the case of positive relationships within the classroom, both among peers and with faculty, these relationships foster student wellbeing. Autonomy support is linked to improved interpersonal interactions, providing an environment where students feel valued and recognized, which strengthens their support networks and sense of belonging (Wu and Xindong, 2024). This perception of support fosters healthier relationships and reduces feelings of isolation. Autonomy support is also related to a greater sense of purpose associated with wellbeing. Students who find meaning in their studies, such as those in counseling programs, tend to show higher wellbeing and greater perceived competence (Hurst and Prescott, 2021). An environment that fosters autonomy promotes meaningful and purposeful learning, motivating students to establish deeper connections between their academic goals and personal lives. Finally, academic achievements in this context are also influenced by autonomy support. A meta-analysis by Okada (2021) found that perceived autonomy support has a positive impact on academic performance and a moderate to large influence on students' autonomous motivation. Therefore, an environment that supports self-direction allows students to manage their own learning more effectively, which translates into better academic outcomes.

Autonomy support, has also been studied among university students, who are regularly exposed to deadlines, stressful situations associated with academic events and evaluations, and even competition with peers for better grades, situations that can impact their perception of autonomy. Research shows that autonomy support from parents, friends, and romantic partners is linked to university students' subjective wellbeing (Ratelle et al., 2013). Indeed, when students perceive high levels of these three sources of autonomy support, they report higher wellbeing levels.

In the academic context, it has been found that students who perceived support from their teachers and a high sense of autonomy reported greater engagement with their studies, which indirectly influences their wellbeing (Luruli et al., 2020). Certainly, an important relationship has been found between autonomy support from teachers and the satisfaction of students' basic psychological needs, as well as a decrease in anxiety and an increase in the likelihood of participation and adaptive beliefs regarding evaluation, implying self-regulated learning processes (Cho et al., 2023).

Similarly, the value of teacher support in predicting academic satisfaction has been corroborated, suggesting that autonomy support serves as a nutrient to satisfy basic psychological needs, with adaptive consequences in terms of increased participation, confidence, and student engagement, contributing to a positive relationship with intrinsic motivation (Huéscar Hernández et al., 2022). On the other hand, qualitative studies have documented that when students perceive low freedom, autonomy, competence, and relationships, anxiety ensues along with a perception of low capacity to act according to certain external demands (Tymms and Peters, 2020).

In the experience of international students, the willingness of instructors to create autonomy-supportive learning environments, that is, learning environments oriented toward responding to students' autonomy needs, allowing them to participate in classes, generating confidence in that participation, and the possibility of connecting with peers, has been explored (Cho et al., 2023). One of the strategies that enabled the perception of autonomy was the discussion of topics that students perceived as interesting and that promoted class participation, highlighting those teachers previously considered the most relevant topics for learning quality. It is important to note that these learning environments are structured; they are not unlimited opportunities for decisions or freedoms. Thus, it has been established that when students perceive they have the freedom to act autonomously and competently within a meaningful context, it brings benefits to their wellbeing.

1.2 The learning climate and autonomy support on university students' wellbeing and academic outcomes

In the educational context, the importance of the perception of autonomy as element related to self-regulated learning for the wellbeing of university students has also been emphasized (Hoque et al., 2023). In light of this, in the field of Science, Technology, Engineering and Mathematics (STEM), courses have been designed with strategies oriented toward motivational beliefs and learning skills, through tutoring strategies that encourage autonomy, peer relationships, and learning confidence (self-efficacy), achieved through the opening of possibilities in the choice of thematic areas of interest autonomously by the student, working in small groups, and well-established materials with various learning integration activities, to promote student wellbeing (Mayerhofer et al., 2023).

However, evidence contrary to the literature has been found, as a study in China found that perceived student autonomy in the classroom was inversely related to life satisfaction (Chen et al., 2017). The explanation was related to first-year students who had

just graduated from high school, where they were under a teaching style very oriented toward controlling student autonomy, which could affect their satisfaction upon entering university, where they encountered a learning environment that encouraged decision-making, freedom, and autonomy, which was perceived as a stressful situation for students in the adaptation process.

Another object of study in literature is the learning climate. Recent studies have explored the learning climate, specifically the type of learning climate that can be associated with a surface approach to learning among students. In this regard, it is observed that a controlling learning climate style does not enable the perception of autonomy in students, adding to uncertainties in the learning environment, which can frustrate the satisfaction of students' basic psychological needs, compromising their meaningful learning and wellbeing (Englund et al., 2023).

In this case, the learning climate, according to self-determination theory, can be either controlling or supportive, depending on how teachers manage their interactions with students. This concept encompasses elements such as the emotional and social atmosphere in which students learn, and how that atmosphere affects their motivation and engagement (Reeve, 2009). A positive learning climate is characterized by an environment that promotes engagement, emotional support, and relationship-building between students and the teacher. According to previous studies, the learning climate refers to the overall environment in which students learn, including social and emotional interactions among them and with the teacher. Sulla et al. (2023) emphasize that this climate is strongly influenced by interpersonal synchrony and teacher support, which foster critical thinking, decision-making, and problem-solving through collaborative learning. An effective learning climate should encourage shared regulation of learning, where students actively engage in knowledge construction and in managing the social and emotional challenges that arise during group learning (Hadwin et al., 2018). Thus, the learning climate can directly influence both wellbeing and academic outcomes (Sulla et al., 2023).

The learning climate, understood as the social and pedagogical environment that prevails in educational settings, plays a fundamental role in promoting student wellbeing. Various studies have established that pedagogical practices, particularly those that support autonomy, not only enhance intrinsic motivation but are also key predictors of student wellbeing. Research has shown that autonomy support, a practice in which educators encourage independent decision-making, has a positive effect on student wellbeing. Su and Reeve (2011) observed that when teachers adopt an autonomy-supportive approach, students experience higher levels of intrinsic motivation, which in turn improves their overall wellbeing. This occurs because a positive learning climate is established, where students not only feel more motivated to learn but also experience greater satisfaction in their school activities, contributing to a healthy emotional environment.

In this case, autonomy support is a more specific concept and refers to the teacher's actions that promote students' self-determination, that is, their ability to make decisions and be active agents of their own learning. Autonomy support is manifested when teachers adopt a teaching style that allows students to feel they have control over their actions by offering choices, listening to their opinions, and encouraging personal initiative (Deci et al., 1981). This type of support fosters intrinsic motivation, as students

perceive that their interests and needs are acknowledged and valued. Sulla et al. (2023) indicate that teachers can facilitate socially shared regulation of learning through strategies that promote autonomy, such as offering scaffolding, temporary supervision, and reflective questioning, allowing students to take ownership of the cognitive and emotional regulation skills necessary for academic success.

Similarly, Jiang and Tanaka (2022) pointed out that autonomy support also has a significant impact on psychological wellbeing. The fact that students feel empowered in their decisions and academic tasks creates an environment where autonomy is not just an educational practice, but a tool to promote wellbeing. This is consistent with self-determination theories (Deci and Ryan, 2000), which suggest that when the psychological needs for autonomy, competence, and relatedness are met, individuals achieve higher levels of wellbeing. Likewise, studies such as those by Soenens and Vansteenkiste (2010) and Neufeld and Malin (2020) have highlighted that the perception of autonomy in the learning environment directly impacts school satisfaction and emotional wellbeing. These studies conclude that an environment that facilitates autonomy, competence, and positive relationships generates a more satisfying educational experience, contributing to a more balanced and positive emotional state. Additionally, Gutiérrez and Tomás (2019) emphasized the relationship between perceived autonomy support and academic performance, indicating that student wellbeing not only improves their subjective wellbeing experience but also influences their engagement and performance in the classroom, reinforcing the integral role of the learning climate in wellbeing. Therefore, when the learning climate provided by the teacher is oriented toward promoting autonomy, it becomes a key predictor of student wellbeing. Teachers' promotion of autonomy is a critical factor that must be considered in creating educational environments that not only foster academic success but also promote the overall wellbeing of students.

For this reason, online psychological interventions have been designed to improve the wellbeing of university students, with proven effects in reducing depressive symptoms and increasing wellbeing, flourishing, positive emotions, and the need for autonomy (Auyeung and Han Mo, 2019). It was identified that these last two constructs act as active elements of post-intervention changes, specifically explaining that the need for autonomy is a psychological mechanism associated with general health and inversely with depression, which could be sensitive to positive psychology interventions, highlighting the importance of the need for autonomy as an essential element in identity formation.

The relevance of this study lies in exploring factors that are under-researched in the Ibero-American literature, such as the learning climate from a perspective of managing the need for autonomy in educational contexts and its impact on university students' wellbeing, delving into its hedonic and eudaimonic elements from the multidimensional perspective of PERMA. Similarly, continuing to delve into the psychological processes involved in study retention and reducing students' intention to drop out of their careers, previous research has indicated that constructs related to satisfaction, engagement, autonomy, and wellbeing are related to dropout (Bernardo et al., 2022; Jeno et al., 2023; Marôco et al., 2020). Moreover, it seeks to understand how teaching methodologies impact the satisfaction of students' basic

needs and, in effect, how self-perceived autonomy in learning processes influences wellbeing.

This study aims to deepen the university student's experience, generating data that can address current training challenges. Therefore, the objective of this research is to examine the perception of the learning climate and its predictive capacity on the multidimensional wellbeing of university students. The hypothesis system guiding this study is as follows:

H1: There are differences in the learning climate and the multidimensional wellbeing of students according to the academic year.

H2: There are differences between the learning climate and the multidimensional wellbeing of students according to gender.

H3: There are differences in multidimensional wellbeing in students with high and low perceptions of the learning climate.

H4: The perception of the learning climate predicts the multidimensional wellbeing of university students.

2 Materials and methods

2.1 Design

A predictive associative methodology (Ato et al., 2013) was chosen to examine the perception of the learning climate and its predictive capacity on the wellbeing of university students. Consequently, this research is framed as a cross-sectional study, as only one measurement of the variables of interest was taken. This study was cross-sectional since the data were collected at a single point in time (Hernández Sampieri et al., 2014).

2.2 Participants

Responses from 295 university students majoring in Psychology (71 males, 219 females, 5 preferred not to say) from a Chilean university were analyzed. The average age was 21.35 years (SD = 2.93). Table 1 shows the distribution of participants according to academic year. Additionally, 71.89% indicated that this was their first experience in higher education. An accidental non-probability sampling method was used, based on the availability of students present in the classrooms at the time of questionnaire administration. Assuming a 95% confidence level (α = 0.05) and a statistical power of 80% (1-β = 0.80), the expected effect size for the analyses was estimated. In the case of t-tests and ANOVA, the required sample size depends on the effect size expected to be observed. Since this study compares groups based on variables such as gender and academic year, a sample of 295 participants is adequate to detect small to moderate effect sizes (Cohen, 1988).

TABLE 1 Description of participants by year of university entry.

Year of entry	Frequency	Percentage
2019	33	11.2
2020	78	26.4
2021	102	34.6
2022	82	27.8
Total	295	100.0

2.3 Instruments

2.3.1 Learning climate

The Learning Climate Questionnaire (LCQ; Williams and Deci, 1996) consists of 15 items responded to on a Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). This questionnaire assesses the degree to which participants perceive their leader (e.g., professor, coach) promotes their autonomy. Higher scores indicate greater autonomy support from the professor. It is a unifactorial questionnaire with adequate psychometric properties for use in university students (S-Bχ^2/df = 2.17, S-Bχ^2 = 195.49, df = 90, RMSEA = 0.058, CFI = 0.99). Item factor loadings ranged from 0.25 to 0.81, all significant. The reliability of this scale has been α = 0.93 (Matos Fernández, 2009).

2.3.2 PERMA profiler

The PERMA-Profiler is an instrument designed to assess wellbeing in multiple dimensions based on the PERMA theory. It consists of 23 questions addressing five key aspects of wellbeing: positive emotions, engagement, relationships, meaning, and achievement. Additionally, it incorporates items contrasting with negative emotions, feelings of loneliness, and health perception. Participants respond on a Likert scale from 0 to 10. Psychometrically, the five-dimensional structure has been confirmed in its original version (RMSEA = 0.06, SRMR = 0.03, CFI = 0.97, TLI = 0.96, χ^2 = 10.606, DF = 80) (Kern et al., 2015). In terms of reliability among university students, internal consistency values range from α = 0.73 to α = 0.90 for individual dimensions and from α = 0.92 to α = 0.94 for the complete scale (Kern et al., 2015). In the Chilean validation, the factorial structure of the instrument was maintained (RMSEA = 0.054, CFI = 0.94, TLI = 0.95, χ^2 = 411.953, DF = 80) with reliability indices ranging from α = 0.40 to α = 0.87 for dimensions and α = 0.91 for the total scale (Cobo-Rendón et al., 2020).

2.4 Procedure

This study is part of a larger project titled "Academic Emotions, Wellbeing, and Autonomy Support as Predictors of Adaptation and Intention to Drop Out in University Life," evaluated by the Ethics Committee of the University of Development, Chile. The researchers contacted the authorities of the Faculty of Psychology to explain the study details and obtain approval to administer the questionnaires in their courses, ensuring a high response rate. Some researchers personally attended classrooms to inform students about the study and request their participation. Then, students

were invited to complete the questionnaires via QR codes after reading and signing an informed consent. The average response time was 15 min, and no incentives were offered for participation. This research was evaluated and approved by the Ethics Committee of the University of Development on October 4, 2022.

2.5 Data analysis plan

The collected data were stored in a Google form for management. Descriptive and central tendency analyses were conducted on the variables of the learning climate and wellbeing with their dimensions. The reliability of the responses was evaluated using Cronbach's alpha coefficient and McDonald's omega coefficient. Inferential analyses (Student's t-tests and ANOVA) were performed to examine differences in the scores of the variables of interest according to gender and academic year. Linear regression analysis was conducted to identify the predictive capacity of the perception of the learning climate on multidimensional wellbeing and its dimensions. The fulfillment of statistical assumptions for the use of these tests was verified. The data were analyzed using JASP 0.16 and Power BI.

3 Results

Below are the results of the evaluation of the learning climate and wellbeing of university students to address the objective of this work, which is to examine the perception of the learning climate and its predictive capacity on the wellbeing of university students.

When evaluating the average wellbeing scores, it was found that the highest scores were in the dimensions of positive relationships, followed by engagement and purpose, respectively. The dimensions of positive emotions, perception of achievement, and perception of health were averaged around 4, indicating a medium level on the response scale. Overall, there is a medium-high level of wellbeing concerning the analyzed responses. Regarding the perception of the learning climate, it scored above 4, with most responses falling in the middle range of the scale. Table 2 presents descriptive statistics on the scores of the dimensions of wellbeing and the perception of the learning climate.

3.1 Learning climate and student wellbeing according to academic year and gender

When evaluating the students' responses with the aim of addressing the hypotheses related to significant differences in the scores of the learning climate and wellbeing based on academic year and gender (H1 and H2), the analyses performed did not reveal statistically significant differences in the perception of the learning climate or in student wellbeing based on these criteria. Independent t-tests by gender did not reveal significant differences in any of the evaluated dimensions (see Table 3), and in the case of ANOVA analyses by academic year, neither the perception of the learning climate nor any of the evaluated dimensions of wellbeing (positive

TABLE 2 Descriptive statistics on perception of learning climate and wellbeing.

Dimensions	Min	Max	M	SD
Positive emotions	1.33	7.00	4.978	1.308
Engagement	1.00	7.00	5.154	1.023
Positive relationships	1.00	7.00	5.339	1.281
Purpose	1.00	7.00	5.098	1.419
Achievement	1.00	7.00	4.960	1.283
Health	1.00	7.00	4.706	1.534
Negative emotions	1.00	7.00	4.135	1.220
Multidimensional wellbeing	1.07	7.00	5.106	1.102
Learning climate	1.33	7.00	4.458	1.375

Min, minimum; Max, maximum; M, mean; SD, standard deviation.

emotions, engagement, relationships, purpose, and achievement) showed significant differences (see Table 4).

3.2 Results of the interaction between learning climate levels and gender on wellbeing and its dimensions

The analysis of the interaction between learning climate levels and gender revealed significant effects and trends close to significance in several wellbeing dimensions. In the case of positive emotions, although a significant interaction between learning climate and gender was not found, $F(1, 286) = 3.16$, $p = 0.077$, $\eta^2 = 0.010$, the results showed a trend toward significance. Men in the high learning climate group had a higher mean in positive emotions (M = 5.47, SD = 1.21) compared to women (M = 5.29, SD = 1.10). In the low learning climate, women had a higher mean (M = 4.53, SD = 1.27) than men (M = 4.08, SD = 1.70).

Regarding the results in the engagement dimension, the interaction between learning climate and gender was significant, $F(1, 286) = 11.23$, $p < 0.001$, $\eta^2 = 0.033$. Men in the high learning climate group had a higher engagement mean (M = 5.63, SD = 0.86) compared to women (M = 5.36, SD = 0.75). However, in the low learning climate, women showed higher levels of engagement (M = 4.86, SD = 1.13) than men (M = 4.22, SD = 1.35). This suggests that the interaction between learning climate and gender has a considerable impact on engagement.

For the positive relationships dimension, although the interaction between learning climate and gender was close to significance, $F(1, 286) = 3.58$, $p = 0.060$, $\eta^2 = 0.011$, it did not reach the conventional level. Men in the high climate (M = 5.64, SD = 0.99) had a slightly higher mean in positive relationships than women (M = 5.62, SD = 1.12). However, differences between men and women in the low climate were not significant, although men had slightly lower scores (M = 5.05, SD = 1.40).

In the case of the purpose dimension, the interaction between learning climate and gender was not significant, $F(1, 286) = 3.115$, $p = 0.079$, $\eta^2 = 0.009$, although a trend toward significance was observed. In the high climate, men (M = 5.79, SD = 1.19) had

TABLE 3 Evaluation of differences by participants' gender in the perception of learning climate and wellbeing dimensions.

Dimension	Gender	N	Mean	Standard deviation	Standard error	t-value (df)	p-value
Learning climate	Male	71	46.178	14.451	0.1715	1.027 (288)	0.305
	Female	219	44.247	13.553	0.0916		
Positive emotions	Male	71	50.000	15.317	0.1818	0.051 (288)	0.959
	Female	219	49.909	12.249	0.0828		
Engagement	Male	71	51.549	12.381	0.1469	−0.057 (288)	0.955
	Female	219	51.629	0.9446	0.0638		
Positive relationships	Male	71	52.207	13.225	0.1570	−1.009 (288)	0.314
	Female	219	53.973	12.679	0.0857		
Purpose	Male	71	52.254	15.510	0.1841	0.808 (288)	0.420
	Female	219	50.685	13.780	0.0931		
Achievement	Male	71	50.516	13.173	0.1563	0.615 (288)	0.539
	Female	219	49.437	12.749	0.0861		
Health	Male	71	48.592	14.818	0.1759	0.862 (288)	0.390
	Female	219	46.788	15.484	0.1046		
Negative emotions	Male	71	40.610	13.759	0.1633	−0.583 (288)	0.560
	Female	219	41.583	11.667	0.0788		
Multidimensional wellbeing	Male	71	51.305	12.472	0.1480	0.118 (288)	0.906
	Female	219	51.126	10.558	0.0714		

Degrees of freedom 288.

higher purpose scores than women (M = 5.41, SD = 0.86). In the low climate, women (M = 4.66, SD = 1.16) outperformed men (M = 4.13, SD = 1.61).

Regarding the achievement dimension, no significant interaction between learning climate and gender was found in this dimension, $F(1, 286) = 0.634$, $p = 0.427$, $\eta^2 = 0.002$. However, the descriptive results showed that men in the high climate (M = 5.45, SD = 0.93) had slightly higher scores than women (M = 5.31, SD = 0.86), while in the low climate, women (M = 4.39, SD = 1.16) outperformed men (M = 4.26, SD = 1.30) (see Table 5).

For the additional dimensions of the PERMA Profiler, in the case of the health dimension, the interaction between learning climate and gender was not significant, $F(1, 286) = 0.039$, $p = 0.843$, $\eta^2 < 0.001$. Men in the high climate (M = 5.18, SD = 1.36) and women in the same group (M = 5.03, SD = 1.36) did not show substantial differences. Similarly, in the low climate, the means between men (M = 4.22, SD = 1.54) and women (M = 4.15, SD = 1.68) were very similar. Finally, for negative emotions, although the interaction between learning climate and gender was not significant, $F(1, 286) = 2.600$, $p = 0.108$, $\eta^2 = 0.009$, the descriptive results indicated that men in the high climate (M = 4.08, SD = 1.49) had slightly higher negative emotions than women (M = 3.96, SD = 1.12). In the low climate, women (M = 4.46, SD = 1.27) reported higher levels of negative emotions compared to men (M = 4.03, SD = 1.70) (see Table 5).

Regarding the results for the multidimensional wellbeing variable, a significant interaction was found between learning climate and gender, $F(1, 286) = 4.671$, $p = 0.032$, $\eta^2 = 0.016$. Men in the high climate (M = 5.60, SD = 0.93) had higher multidimensional wellbeing scores compared to women (M = 5.41, SD = 0.86). In the low climate, women (M = 4.66, SD = 1.16) outperformed men (M = 4.22, SD = 1.30), highlighting the influence of the learning climate on the perception of multidimensional wellbeing by gender. In this case, the results show that the interaction between learning climate and gender has a significant impact on the dimensions of engagement and multidimensional wellbeing, with trends in other dimensions such as positive emotions, purpose, and positive relationships. Women and men respond differently to the learning climate in terms of wellbeing.

3.3 Differences in wellbeing among students with high and low perception of learning climate

To address the hypothesis regarding differences in wellbeing among students with high and low perceptions of the learning climate (H3), participants' responses were initially divided into two groups, "high" and "low." This dichotomization of learning climate perceptions was based on the cutoff points derived from the response scale used, providing empirical justification for this categorization. Specifically, the lower average response values (1 to 3.99) were grouped as low perceptions, while the higher average response values (4 to 7) were considered high perceptions. Since the response scale ranged from 1

TABLE 4 Descriptive statistics and ANOVA for learning climate and wellbeing dimensions.

Dimension	Academic year	N	Mean	Standard deviation	F (df)	Sig. (p)
Learning climate	2019	33	44.646	13.416	0.026 (3, 291)	0.994
	2020	78	44.376	12.680		
	2021	102	44.876	14.466		
	2022	82	44.407	14.204		
	Total	295	44.588	13.756		
Positive emotions	2019	33	50.909	11.064	0.157 (3, 291)	0.925
	2020	78	49.103	13.630		
	2021	102	49.967	13.919		
	2022	82	49.756	12.415		
	Total	295	49.785	13.087		
Engagement	2019	33	52.626	0.8155	0.509 (3, 291)	0.676
	2020	78	50.855	0.9691		
	2021	102	51.046	11.745		
	2022	82	52.398	0.9533		
	Total	295	51.548	10.238		
Positive relationships	2019	33	53.838	10.708	0.233 (3, 291)	0.873
	2020	78	53.932	11.606		
	2021	102	53.627	13.716		
	2022	82	52.398	13.671		
	Total	295	53.389	12.817		
Purpose	2019	33	54.040	13.611	0.916 (3, 291)	0.434
	2020	78	51.923	14.086		
	2021	102	50.261	14.949		
	2022	82	49.756	13.566		
	Total	295	50.983	14.195		
Achievement	2019	33	52.424	10.351	0.972 (3, 291)	0.406
	2020	78	49.487	12.860		
	2021	102	50.033	14.060		
	2022	82	48.049	12.092		
	Total	295	49.605	12.838		
Health	2019	33	5.020	1.236	0.780 (3, 291)	0.506
	2020	78	4.791	1.566		
	2021	102	4.588	1.573		
	2022	82	4.646	1.566		
	Total	295	4.706	1.534		
Negative emotions	2019	33	4.283	0.917	2.468 (3, 291)	0.062
	2020	78	3.816	1.270		
	2021	102	4.235	1.244		
	2022	82	4.256	1.216		
	Total	295	4.136	1.221		
Multidimensional wellbeing	2019	33	5.277	0.939	0.341 (3, 291)	0.796
	2020	78	5.106	1.085		
	2021	102	5.099	1.237		
	2022	82	5.047	1.012		
	Total	295	5.106	1.103		

Dimension	Learning climate level	Gender	Mean	Standard deviation
Positive emotions	High	Male	5.47	1.21
	High	Female	5.29	1.10
	Low	Male	4.08	1.70
	Low	Female	4.53	1.27
Engagement	High	Male	5.63	0.86
	High	Female	5.36	0.75
	Low	Male	4.22	1.35
	Low	Female	4.86	1.13
Positive relationships	High	Male	5.64	0.99
	High	Female	5.62	1.12
	Low	Male	5.05	1.40
	Low	Female	5.05	1.40
Purpose	High	Male	5.79	1.19
	High	Female	5.41	0.86
	Low	Male	4.13	1.61
	Low	Female	4.66	1.16
Achievement	High	Male	5.45	0.93
	High	Female	5.31	0.86
	Low	Male	4.26	1.30
	Low	Female	4.39	1.16
Health	High	Male	5.18	1.36
	High	Female	5.03	1.36
	Low	Male	4.22	1.54
	Low	Female	4.15	1.68
Negative emotions	High	Male	4.08	1.49
	High	Female	3.96	1.12
	Low	Male	4.03	1.70
	Low	Female	4.46	1.27
Multidimensional wellbeing	High	Male	5.60	0.93
	High	Female	5.41	0.86
	Low	Male	4.22	1.30
	Low	Female	4.66	1.16

(Strongly disagree) to 7 (Strongly agree), this dichotomization consistently reflects a differentiation between students who expressed agreement or disagreement with the statements related to the learning climate. Subsequently, an independent samples t-test analysis was conducted to identify differences in wellbeing levels between the two groups. This analysis revealed differences in all levels of wellbeing. Students with a high perception of the learning climate exhibited more positive emotions, engagement, positive relationships, and achievements than those

who reported a low perception of the learning climate, resulting in higher total wellbeing and health perception scores. It was also identified that students with a low perception of the learning climate had higher scores of negative emotions (see Table 6).

Upon analyzing the percentages of students with high and low perceptions of the learning climate according to the dimensions of wellbeing, we found that a high perception of the learning climate is associated with higher levels of positive emotions, engagement, relationships, meaning, achievement, and health. Conversely, a low perception is associated with lower levels of wellbeing. Specifically, the greatest difference between high and low perceptions of the learning climate was identified in the dimension of Engagement, with a difference of 80.34%. This suggests that individuals' engagement is the dimension most affected by climate perception and, therefore, can be considered the most relevant in this context (see Figure 1).

3.4 Predicting the perception of learning climate on university students' wellbeing

To address hypothesis H4, which posits that the perception of the learning climate predicts university students' wellbeing, the correlation levels between the scores of wellbeing dimensions and the perception of the learning climate were initially evaluated. Statistically significant associations were identified in all wellbeing dimensions with the perception of the learning climate. The strongest associations were found in the purpose dimension and total wellbeing. The weakest associations were found in the positive relationships and health perception dimensions. Inverse associations were identified between the perception of the learning climate and negative emotions (see Table 7).

To estimate the effect of the perception of the learning climate on wellbeing dimensions, simple linear regression analyses were conducted for each wellbeing dimension (dependent variables). The results obtained are presented in Table 8, which reports the results of each regression model.

The regression model results showed that the perception of the learning climate explains 22% of the variance in positive emotions, with the model being statistically significant [$F(1, 294) = 82.784$, $p < 0.001$]. For the prediction of the wellbeing dimension engagement, a statistically significant model was also identified [$F(1, 294) = 76.670$, $p < 0.01$], explaining 20% of the variance. A similar result was identified in the prediction model for the positive relationships dimension, which was statistically significant [$F(1, 294) = 62.237$, $p < 0.001$], explaining 17.5% of the variance. The identified prediction model for the purpose dimension was statistically significant [$F(1, 294) = 101.332$, $p < 0.001$], explaining 25.7% of the variance. For the wellbeing dimension achievement, a statistically significant prediction model was identified [$F(1, 294) = 93.082$, $p < 0.001$], explaining 24.1% of the variance. Finally, for multidimensional wellbeing, a statistically significant prediction model for the perception of the learning climate was identified [$F(1, 294) = 119.482$, $p < 0.001$], explaining 29% of the variance (see Table 8).

TABLE 6 Descriptive statistics on wellbeing scores concerning groups with high and low perceptions of the learning climate.

Wellbeing dimensions	Perception of learning climate	N	M	SD	Std. error mean	t	df	Sig
Positive emotions	Low	114	4.403	1.378	0.129	6.094	204.850	0.000
	High	181	5.340	1.123	0.083			
Engagement	Low	114	4.722	1.201	0.112	5.566	173.712	0.000
	High	181	5.427	0.782	0.058			
Positive relationships	Low	114	4.900	1.431	0.134	4.556	194.985	0.000
	High	181	5.615	1.094	0.081			
Purpose	Low	114	4.374	1.51825	0.142	7.127	192.455	0.000
	High	181	5.554	1.14138	0.084			
Achievement	Low	114	4.348	1.36712	0.128	6.634	197.558	0.000
	High	181	5.346	1.06363	0.079			
Health	Low	114	4.149	1.64026	0.153	5.161	293	0.000
	High	181	5.057	1.35439	0.100			
Negative emotions	Low	114	4.380	1.17150	0.109	2.761	293	0.000
	High	181	3.981	1.22913	0.091			
Multidimensional wellbeing	Low	114	4.547	1.19407	0.111	7.005	189.257	0.000
	High	181	5.457	0.87783	0.065			

N, number of participants per group; *M*, mean; *SD*, standard deviation; Std. error mean, standard error of the mean; *t*, *t*-test value; df, degrees of freedom for the *t*-test.
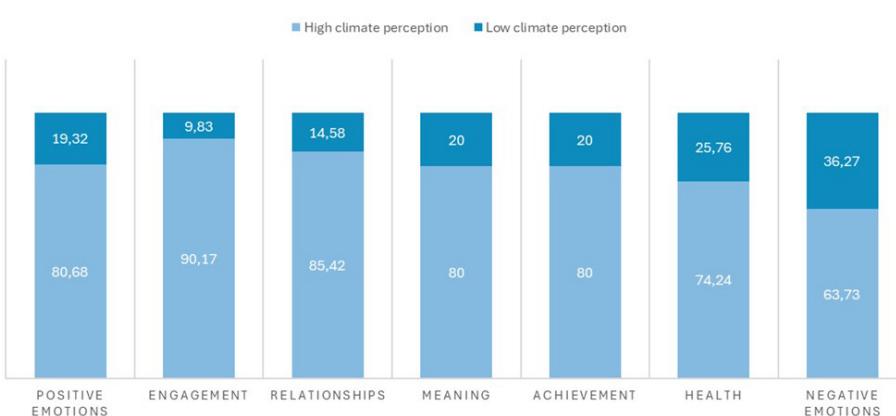
FIGURE 1
Frequency distribution of the categories of high and low climate perception according to wellbeing dimensions.

4 Discussion

Wellbeing has been studied from various perspectives, notably hedonic and eudaimonic. The hedonic perspective focuses on subjective life satisfaction and positive emotional experiences (Diener and Ryan, 2009; Passeggia et al., 2023), while the eudaimonic perspective emphasizes personal growth, purpose, and self-realization (Ryan and Deci, 2006; Ryff, 1989). Seligman's PERMA model (2011) combines both perspectives, describing wellbeing as a multidimensional construct that includes positive emotions, engagement, relationships, meaning, and accomplishment. This study aimed to evaluate the predictive capacity of the perception of the learning climate on the multidimensional wellbeing of university students. After reviewing the results, it is possible to affirm that significant results were found.

Firstly, it was observed that students, in general, reported a medium-high level of wellbeing. The dimensions of positive relationships, engagement, and purpose were the ones that received the highest scores. These results are encouraging, as the literature suggests that this level of wellbeing may be indicative of high overall life satisfaction, as well as autonomy and resilience in students (Cabrera and Donaldson, 2023; Coffey et al., 2016; Leontopoulou, 2020). Specifically, a high level in the positive relationships dimension is associated with components such as

TABLE 7 Pearson correlation between learning climate and wellbeing.

Dimensions	1	2	3	4	5	6	7	8
Learning climate	1							
Positive emotions	0.469**	1						
Engagement	0.455**	0.691**	1					
Positive relationships	0.419**	0.660**	0.543**	1				
Purpose	0.507**	0.833**	0.683**	0.648**	1			
Achievement	0.491**	0.774**	0.667**	0.599**	0.842**	1		
Health	0.367**	0.614**	0.458**	0.559**	0.595**	0.582**	1	
Negative emotions	−0.194**	−0.243**	0.066	−0.123*	−0.176**	−0.104	−0.104	1
Multidimensional wellbeing	0.538**	0.914**	0.807**	0.796**	0.929**	0.897**	0.650**	−0.144*

$*p < 0.05$, $**p < 0.01$.

TABLE 8 Regression models of learning climate perception on wellbeing.

Dependent variable	Scale	Unstandardized coefficients		β	t	sig	R	R^2
	B	SE						
Positive emotions	(Constant)	2.988	0.229		13.048	0.000	0.469	0.220
	Perception of autonomy support	0.447	0.049	0.469	9.099	0.000		
Engagement	(Constant)	3.644	0.181		20.175	0.000	0.455	0.207
	Perception of autonomy support	0.339	0.039	0.455	8.756	0.000		
Positive relationships	(Constant)	3.600	0.231		15.609	0.000	0.419	0.175
	Perception of autonomy support	0.390	0.049	0.419	7.889	0.000		
Purpose	(Constant)	2.766	0.242		11.409	0.000	0.507	0.257
	Perception of autonomy support	0.523	0.052	0.507	10.066	0.000		
Achievement	(Constant)	2.917	0.222		13.165	0.000	0.491	0.241
	Perception of autonomy support	0.458	0.047	0.491	9.648	0.000		
Multidimensional wellbeing	(Constant)	3.183	0.184		17.288	0.000	0.538	0.290
	Perception of autonomy support	0.431	0.039	0.538	10.931	0.000		

SE, standard error.

secure attachment and adaptation to university life, while it is negatively related to academic anxiety (Chaves et al., 2023; Cobo-Rendón et al., 2021; Umucu et al., 2024; Yang et al., 2024). In turn, a high level of engagement is related to a high level of perceived autonomy among students (Luruli et al., 2020), while a high level of purpose is associated with academic experiences that involve participation in community or cultural activities (Kovich et al., 2023).

For the dimensions of positive emotions, perception of accomplishment, and perception of health, were located at a medium level on the response scale. In this case, it is important to highlight that positive emotions are a fundamental variable for the wellbeing of young people, having positive effects on the rest of the dimensions (Ye et al., 2024), so the presence of medium or high scores is of interest to evaluate in the educational context.

Regarding the medium level of the perception of accomplishment dimension, this was identified at a medium level on the scale, making it relevant to evaluate this score in this scenario. This is because some students might not experience their training as attractive or challenging, which could hinder academic success and increase wellbeing (Kovich et al., 2023).

4.1 Learning climate and student wellbeing according to academic year and gender

In the statistical analyses conducted, no significant differences were identified in the perception of the learning climate and

wellbeing according to academic year or gender (H1 and H2). In the case of the learning climate, these findings are consistent with other research on university students where no differences were found between men and women. It appears that the perception of the learning climate is not differentiated according to the gender of the students (Navarro Huaringa et al., 2022) The results obtained are consistent with the central finding presented by Mammadov and Schroeder (2023), who observed in their systematic review that the samples analyzed showed a higher percentage of women compared to men, with 52.7% female representation and approximately 68% of the samples being predominantly women. These authors explain that, although some studies did not find significant differences in learning outcomes based on gender, others suggest that women may benefit more from affective relationships with teachers and support for their autonomy. This suggests that the social and emotional context may influence how students, especially women, respond to educational support.

However, the results regarding academic year contradict other studies, where differences were found in the perception of the learning climate between first and second-year students (Yüce, 2023). Thus, the perception of teacher support for student autonomy varies according to the different academic demands present at various levels of education.

Regarding wellbeing, studies on student samples report the existence of positive and significant differences in favor of women in positive emotions and relationships and a significant difference in favor of men in meaning and achievements (Hejazi et al., 2021). In terms of aspects of psychological wellbeing, gender differences have also been identified; men tend to report higher levels of autonomy than women, while women report higher levels of personal growth in terms of wellbeing (Barra Almagia, 2012). Despite not identifying differences, empirical evidence highlights the importance of understanding the specific needs and strengths of each gender, which can contribute to creating more inclusive and effective environments for the personal and academic development of all students.

4.2 Interaction between learning climate levels and sex on wellbeing and its dimensions

The analysis of the interaction between learning climate levels and sex revealed that, in terms of engagement, men in a high climate showed higher levels than women, while in low climates, women outperformed men. This finding suggests that the learning climate significantly influences student engagement, varying by sex.

To interpret the results on engagement in relation to learning climate and sex, it is essential to consider the research by Mammadov and Schroeder (2023), which highlights the importance of the learning climate in students' motivation and engagement. This study suggests that a positive educational environment can foster greater involvement in academic activities. The finding that men in high climates exhibit higher levels of engagement can be explained by the notion that positive climates, characterized by strong emotional support and effective interpersonal relationships, may align better with male learning expectations and styles. The literature suggests that men may

respond favorably to contexts that promote competence and recognition, which could explain their higher engagement in positive climates. These results are consistent with the conclusions of Nishimura and Joshi (2021), who indicate that autonomy support provided by authority figures significantly impacts the satisfaction of basic psychological needs, which in turn influences students' academic performance and emotional wellbeing. This context is key to understanding why men in high climates showed superior levels of engagement; an environment that promotes autonomy may resonate more with their educational expectations.

Additionally, it has been documented that the desired degree of autonomy may differ between boys and girls, affecting their ability to demonstrate self-directed learning (Mammadov and Schroeder, 2023). Likewise, Mammadov and Schroeder (2023) suggest that women may experience variations in their motivation and engagement depending on the type of support received, implying that a more personalized approach could be essential to maximizing their involvement in educational contexts. The observation that women outperform men in low climates indicates that they may respond more favorably to environments where more emotional or individualized support is provided, which is consistent with literature suggesting that women value interpersonal relationships more in their educational experience. Finally, Mammadov and Schroeder (2023) emphasize that gender differences in engagement may be influenced by contextual factors, suggesting that to optimize the engagement of all students, it is essential to create an inclusive learning climate that adapts to the specific needs of each group. This reinforces the need to implement educational strategies that consider these differences to foster greater engagement and wellbeing among all students.

4.3 Differences in wellbeing among students with high and low perception of learning climate

Significant differences in wellbeing were observed between those with high and low perceptions of the learning climate. Students with a high perception of the learning climate showed higher levels of positive emotions, engagement, positive relationships, and achievement, as well as better health perception compared to those with a low perception.

This relationship may be because interpersonal contexts, including the educational context, play an important role in satisfying basic psychological needs, promoting autonomy, and perceived competence, and the establishing of meaningful social relationships among students (Deci and Ryan, 2000, 2002). Therefore, a high perception of the climate indicates that students perceive the educational interpersonal climate as satisfying their basic psychological needs. Conversely, a low perception of the learning climate may indicate that students do not perceive the educational context as facilitating autonomy, which in turn hinders overall and academic satisfaction (Huéscar Hernández et al., 2022; Vergara-Morales et al., 2019).

This is relevant in the educational context, as wellbeing is a key construct for successful learning (Mayerhofer et al., 2023; Pineda-Espejel et al., 2023). Indeed, research has shown that when there is a high learning climate, students tend to be more engaged

with their academic activities, have greater interest in learning and developing new skills, and show higher academic engagement (Navarro Huaringa et al., 2022).

4.4 Predicting the perception of learning climate on university students' wellbeing

It was found that the perception of the learning climate was significantly associated with all the wellbeing dimensions studied, with the strongest association being with the purpose dimension. In the PERMA model, purpose is considered the belief that one's life is valuable and a sense of connection to something larger than oneself (Kern et al., 2015).

According to these results, the type of climate fostered in the classroom predicts the student's perception of the meaning of their life in this aspect. Similarly, these results align with previous evidence where the learning climate reflects a wide variety of activities developed within the school experience, through which teachers can create, acquire, and transfer knowledge and engage in learning behaviors with students (Shoshani and Eldor, 2016). Methodologies such as tutoring, the availability of elective subjects, and small group work favor autonomy in university students, which in turn is positively associated with wellbeing (Mayerhofer et al., 2023).

Linear regression analyses revealed that the perception of the learning climate explained a significant portion of the variance in all the wellbeing dimensions studied, with percentages ranging from 20 to 29%, depending on the specific wellbeing dimension. These findings suggest that the perception of the learning climate plays an important role in the wellbeing of university students and that a more positive perception of the learning climate is associated with greater wellbeing across multiple dimensions. This highlights the importance of promoting a positive and supportive learning environment to improve the overall wellbeing of university students. When academic terms focus on the individual, students perceive themselves as the center of their learning, fostering intrinsic motivations to make decisions about their education. This maximizes their autonomy and has a positive impact on their wellbeing and social empowerment (Tymms and Peters, 2020).

These observations underscore the relevance of students' learning experiences and how these can influence their engagement and perception of achievements, demonstrating the importance of the environment in shaping learning experiences by teachers (Sakız, 2017). Therefore, these findings suggest that a positive and supportive learning environment is crucial for student wellbeing. Promoting a learning climate that satisfies the needs for autonomy, competence, and relationships can significantly enhance wellbeing. Educational institutions should consider strategies to improve the learning climate, which could include training for teachers in autonomy-supportive practices and fostering positive interpersonal relationships within the educational environment.

Teacher support practices correlate positively with desired outcomes for students, including wellbeing and, consequently, performance (Howard et al., 2024). Autonomy-supportive teaching involves taking students' perspectives, encouraging the use of participatory practices that offer choices to develop learning at their own pace, and incorporating students' interests, perspectives,

and feelings during the development of their learning experiences (Collie et al., 2024). These practices should also be explicit, as students who perceive teachers' expectations and motivation are more likely to be motivated and develop an interest in learning (Escalante Mateos et al., 2021).

Thus, the reported findings contribute to the development of research on wellbeing in the educational context. Among the strengths of this study is the use of the PERMA model for measuring wellbeing, as this theoretical approach offers a comprehensive and multidimensional view of wellbeing, allowing a perspective on the eudaimonic and hedonic elements of this construct in university students. Therefore, the findings of this research indicate that the perception of a learning climate that prioritizes autonomy contributes to the multidimensional wellbeing of university students, covering various dimensions such as positive emotions, engagement, relationships, purpose, and achievements. This result aligns with Self-Determination Theory and supports previous studies that emphasize how autonomy support fosters the emergence of positive emotions in students, which is related to a greater perception of competence and intrinsic value toward learning activities (Berweger et al., 2021; Meng-Ting Lo, 2021).

In terms of engagement, it is evident that this aspect of wellbeing is predicted by a high perception of autonomy support. By meeting their psychological needs, students display greater academic engagement and higher satisfaction with their university experience. This connection has also been linked to improved learning outcomes (Jiang and Tanaka, 2022; Mammadov and Schroeder, 2023; Matos et al., 2018).

Regarding interpersonal relationships, the results suggest that autonomy support is closely tied to enhanced interactions among students. This type of environment allows students to feel valued and recognized, which strengthens their support networks and sense of belonging (Wu and Xindong, 2024). Autonomy support is also associated with a greater sense of purpose in students. Those who find meaning in their studies, such as counseling students, tend to exhibit higher wellbeing and a greater perception of competence (Hurst and Prescott, 2021). An environment that promotes autonomy fosters meaningful and vocational learning, motivating students to establish deeper connections between their academic goals and personal lives.

Finally, academic achievements are also predicted by autonomy support. A meta-analysis conducted by Okada (2021) revealed that perceived autonomy support has a positive effect on academic performance and a moderate to large impact on students' autonomous motivation. Therefore, an environment that encourages self-direction allows students to manage their own learning more effectively, which translates into better academic outcomes. These findings underscore the importance of an autonomy-centered learning climate in promoting the overall wellbeing of university students.

Similarly, evaluating the perception of the learning climate in relation to these dimensions provides greater clarity on which aspects of wellbeing are impacted by the development of educational interpersonal contexts. It is also crucial to consider the cultural characteristics present in university teaching, as cultural norms and values can significantly influence how students perceive autonomy, engagement, and their overall wellbeing. Understanding these cultural factors is essential for creating learning environments

that are not only supportive but also culturally responsive, thereby enhancing the effectiveness of educational practices in diverse university settings.

Among the limitations of this study, the results were obtained through self-report questionnaires, which may introduce response biases. Additionally, there was a gender bias in the sample, with a larger proportion of female participants (75%). This gender imbalance could have influenced some of the findings, particularly in dimensions such as engagement and positive emotions, where women generally reported higher scores in certain conditions. Future research should aim to include a more balanced gender representation to better understand potential gender differences in the perception of the learning climate and wellbeing outcomes.

Another important limitation is the high correlation observed between the dimensions of wellbeing, which may have masked individual predictions in the regression analyses. This high interrelatedness among wellbeing dimensions suggests that the use of more advanced analytical techniques, such as Structural Equation Modeling (SEM) or multiple regression analyses with all dimensions included as predictors, could provide a more detailed understanding of how each dimension uniquely contributes to the overall prediction of wellbeing. Finally, the study was conducted with students from a specific field of study at a single university in Chile, limiting the generalizability of the results to other educational contexts or disciplines.

Therefore, future research should extend the investigation to other regions and cultures to evaluate the generalizability of the findings, as well as examine whether there are significant differences in the perception of the learning climate and wellbeing among different subgroups of students (e.g., by faculties, levels of study, socioeconomic context). Additionally, understanding the mechanisms through which the learning climate influences wellbeing can help design more precise interventions, and how variables such as self-efficacy, intrinsic motivation, and social support may play crucial roles in success at this stage. From the teachers' perspective, it is suggested that future research focus on exploring the factors that favor teachers providing support and creating a motivating learning climate.

5 Conclusion

The results revealed that, although students generally reported a medium-high level of wellbeing, those with a more positive perception of the learning climate experienced significantly higher levels of wellbeing in various dimensions, such as positive emotions, engagement, positive relationships, and achievements. While it was not possible to identify differences in the perception of the learning climate and wellbeing among student groups based on academic year and gender, it was evident that the perception of the learning climate was significantly associated with all dimensions of wellbeing, with the strongest association being with the purpose dimension. Linear regression analyses confirmed that the perception of the learning climate explains a significant portion of the variance in all the wellbeing dimensions studied, with percentages ranging from 20 to 29%. Future research should delve into the factors that foster motivating learning climates and teaching practices that support the wellbeing of university students.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Comité de ética, Universidad del desarrollo. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Flipped classroom in physiology education: where are we and where are we heading?

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Flipped classroom (FC) is considered a student-centered teaching method that improves internal active learning of students and their acquisition of knowledge and skills. Among many medical majors, physiology is quite important as a bridge between basic and clinical principles. However, the complex and abstract nature of physiology causes learning stress to students. As the use of FC is widespread across various majors and principles with beneficial effects, analyzing its application in physiology is important to comprehensively evaluate its effectiveness and advantages, as well as disadvantages, and to improve the specific procedures of FC conduction. This article reviews the research on FC utilization in physiology education and summarizes its effectiveness and feedback from both educators and learners, serving as a guideline to facilitate and promote the development of FC in physiology education.

KEYWORDS

flipped classroom, physiology, active learning, education, medicine

1 Introduction

How can we improve the efficiency of learning? How to evoke a positive learning attitude? Active learning is considered an important skill, reflecting students' self-driving and self-management abilities (Möser et al., 2023). Since the proposal of the concept of a classification system for educational objectives at the annual meeting of the American Psychological Society in 1948, testing specialists have tried to develop better methods to evaluate the learning effect of students not only through examination scores but also in relation to their occupational performance. Soon after the proposal, taxonomy of educational objectives, including six major categories, inspired diverse theoretical research methodologies, demanding evaluation based on internal evidence and external criteria (McFarlane, 1981). Unlike teacher-centered traditional lectures, which is also called lecture-based learning (LBL), diverse student-centered learning methods, including flipped classroom (FC) (Yang et al., 2023), problem-based learning (PBL) (Tripp et al., 2023), team-based learning (TBL) (Mulugeta and Zemedkun, 2023), and case-based learning (CBL) (Sawang et al., 2023), have been explored and developed to improve student's internal active learning and their acquisition of knowledge and skills (Xiao et al., 2023). Among these methods, the FC is a relatively novel teaching method that involves an inverted classroom, online tools, and a shift in learning objectives from recalling knowledge to applying skills and abilities in practice, as well as a transition from teacher-centered to student-centered learning strategies (Betihavas et al., 2016).

On the other hand, medical professionals need to both memorize and apply an expanding body of medical knowledge to meet the evolving requirements of healthcare. Stimulating the

active learning attitude of medical students at different learning phases will facilitate the learning processes in terms of competency and knowledge and benefit patients finally (So et al., 2023). In the medical curriculum, physiology is a core and basic component, related to normal physiological mechanisms occurring continuously. However, the context of physiology is relatively complex for students, posing a great challenge to educators in terms of improving students' critical thinking and self-directed learning skills, as well as their active engagement in the learning processes (Haramati, 2000). The combination of pre-class online lectures or materials and the offline FC provides a flexible and feasible model for students to understand this difficult subject, while allowing educators to supervise student's learning needs and behaviors (Zhang et al., 2019). Since the introduction of this teaching strategy, the FC has been used in physiology education across different majors and academic phases. This study aimed to investigate the attitudes of educators and learners, as well as to reveal the effect of FC application. It focused on the utilization of the FC in physiology education, aiming to lay the foundation for its potential to improve students' active learning in physiological education and provide theoretical evidence for the extensive application of the FC in basic medical education.

2 The characteristics and research of physiology education

As an important branch of biology, physiology is one of the most important basic courses in medical colleges, functioning as a bridge between basic theory and clinical practice. This discipline of physiology studies the normal physiological phenomena, structure, and function of the human body at cellular, tissue, organ, and organ system levels and investigates the homeostasis regulation, interaction, and physiological changes between the human body and the environment under normal circumstances. As a basic course, physiology involves the knowledge of biochemistry, physics, biology, and so on. Before starting the physiology course, students are advised to prepare this background knowledge to gain a deep understanding of physiology, which benefits the learning of subsequent disciplines closely related to clinical practice (Li et al., 2023). In a survey conducted by the program directors of neonatal-perinatal medicine (NPM), physiology was identified as the best to lend itself to a standardized national curriculum with the highest prioritization, followed by core scholarly knowledge, pharmacology, and ethics (French et al., 2018). Therefore, physiology plays an important connecting role in the understanding, evaluation, treatment, and prevention of diseases, which is critical for clinical medical staff in daily medical work.

However, the content of physiology is vast and abstract. Importantly, students may sometimes feel bored during physiology lessons. It is difficult for students to understand and master the knowledge of physiology in a short time, let alone apply it (Surapaneni, 2023). Stimulating students' interest in physiology and further improving the quality and efficiency of the teaching process in physiology classrooms are urgent challenges for all physiology educators. Meanwhile, the shift from knowledge transmission to competency-based curricula in medical education also requires training for physiology instructors in active-learning methodologies. In India, a series of the International Union of Physiological Sciences workshops on physiology education techniques were conducted to

address previous issues, presenting case-based learning, problem-based learning, and the flipped classroom as potential methodologies for improving active learning attitudes (Chandran et al., 2020).

It has been pointed out that research has the potential to deal with a spectrum of issues relevant to physiology education at all academic levels, such as helping physiologists improve their teaching skills (Modell, 1989). Kline et al. designed an experimental approach based on a question not typically addressed in general textbooks of physiology and conducted a sandwich course through a pre-lab interactive tutorial for reviewing, a lab experiment for solutions, and a post-lab tutorial for analyzing. With this sandwich course, a kind of preliminary FC, upper-level science students gained a better understanding of a complex renal response regarding homeostasis, the main concept of physiology (Kline et al., 2000). To foster critical thinking in students during physiology learning, Abraham et al. developed a clinically oriented physiology teaching (COPT) strategy for undergraduate medical students. They found that the implementation of COPT improved student performance in examinations and received positive feedback (Abraham et al., 2004). Other teaching tools, such as asynchronous online discussions and collaborative projects (Taradi and Taradi, 2004), an applied supplemental course (Richardson and Birge, 2000), Quantitative Circulatory Physiology (QCP), a mathematical model of integrative human physiology (Abram et al., 2007), a peer-to-peer escape room activity (Carrasco-Gomez et al., 2023), Anki, a free and open-source flashcard program utilizing spaced repetition for quick and durable memorization (Levy et al., 2023), and physiology quiz competition (Mistry et al., 2023), have proven to be useful in teaching physiology for memory retention and/or critical thinking.

It has been reported that the previous background in elementary physiology did not offer an advantage for learning an upper-division physiology course (Richardson, 2000), indicating the importance of the teaching process in facilitating the understanding of physiology for medical students. Interestingly, Gilkar et al. demonstrated that during learning physiology, incorporating buzz sessions into lectures is liked and preferred by both learners and educators. These sessions help enhance communication, reasoning skills, and collaborative learning among students (Gilkar et al., 2023). To offer students the opportunity to engage in the learning process, Baashar et al. used an Audience Response System (ARS) integrated into anatomy and physiology lectures. This significantly improved session quiz scores and allowed students to actively engage and participate in the teaching process by responding to questions and receiving instant, anonymous feedback from educators (Baashar et al., 2023). These findings suggest that suitable interactive teaching methods and efficient interaction between educators and learners can facilitate the learning process of students, stimulate their interests, activate their inner eagerness for knowledge, and improve their retention of knowledge accordingly. The process of the FC involves a series of planned interactions and the collection of student responses, which help engage students in the physiological learning process.

3 The description of the flipped classroom

The flipped classroom (FC), also known as the inverted classroom, was first introduced by two high school chemistry teachers, Bergmann and Sams, who uploaded their teaching videos on the internet in 2007.

In the same year, the Khan Academy was founded, offering online teaching services for the first time, which drew increasing attention to reversing traditional education (Parslow, 2012). Although the main purpose of all teaching methods is to impart knowledge to students, the FC is different from traditional education in terms of its teaching form and focus.

In LBL, the educator prepares the lecture using PowerPoint, videos, and textbooks for 2–3 class hours each time, transmitting knowledge to students during class. However, in the FC, the educator must prepare learning materials for students' self-learning before class. During classroom interaction, the educator guides the designed processes, encourages the participation of students, and provides additional explanation, while learners share their pre-class learned knowledge in groups and participate in question/answer sessions. Even after FC teaching, online interaction continues regarding homework and learning feedback (Figure 1).

Since the launch of Khan Academy, online learning materials have rapidly prospered and developed, with platforms such as Medscape,[1] XuetangX,[2] CMOOC,[3] and YouTube[4] contributing to medical education (Mahajan et al., 2019). All these online videos and courses can be used as supplementary materials for the FC, including pre-class materials for students, which facilitate the design and implementation of the FC. It

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1   www.medscape.com
2   www.xuetangx.com
3   www.cmooc.com
4   www.youtube.com

is widely accepted that the FC can promote active learning in students and lead to increased academic performance in science, particularly among undergraduates. Even students who choose to skip classes and focus only on the final examination benefit from the FC. However, the workload in the FC may diminish the interest of students if there is insufficient time for pre-class and post-class activities. To summarize the previous use of the FC in physiology education, the following section will discuss its application across different majors.

4 The application of the FC in physiology education

4.1 Clinical undergraduate students

Clinical medicine students encounter a wide range of patients with diverse diseases and clinical manifestations. The nature of clinical medicine dictates that its medical education focus on the integration of theoretical knowledge and practical skills, while also training students to solve clinical problems. In clinic teaching, case analysis and discussion are commonly used to provide students with appropriate exposure to real patients and diseases, helping them understand and analyze clinical problems and develop their clinical thinking and decision-making skills (Hoang and Lau, 2018; Jagpal et al., 2022). However, for basic subjects such as physiology, the clinical background of students is often quite limited, which can hinder their ability to think critically about clinical problems, although mastering basic knowledge should be the core part.

FIGURE 1
Schematic diagram of the traditional lecture versus the flipped classroom.
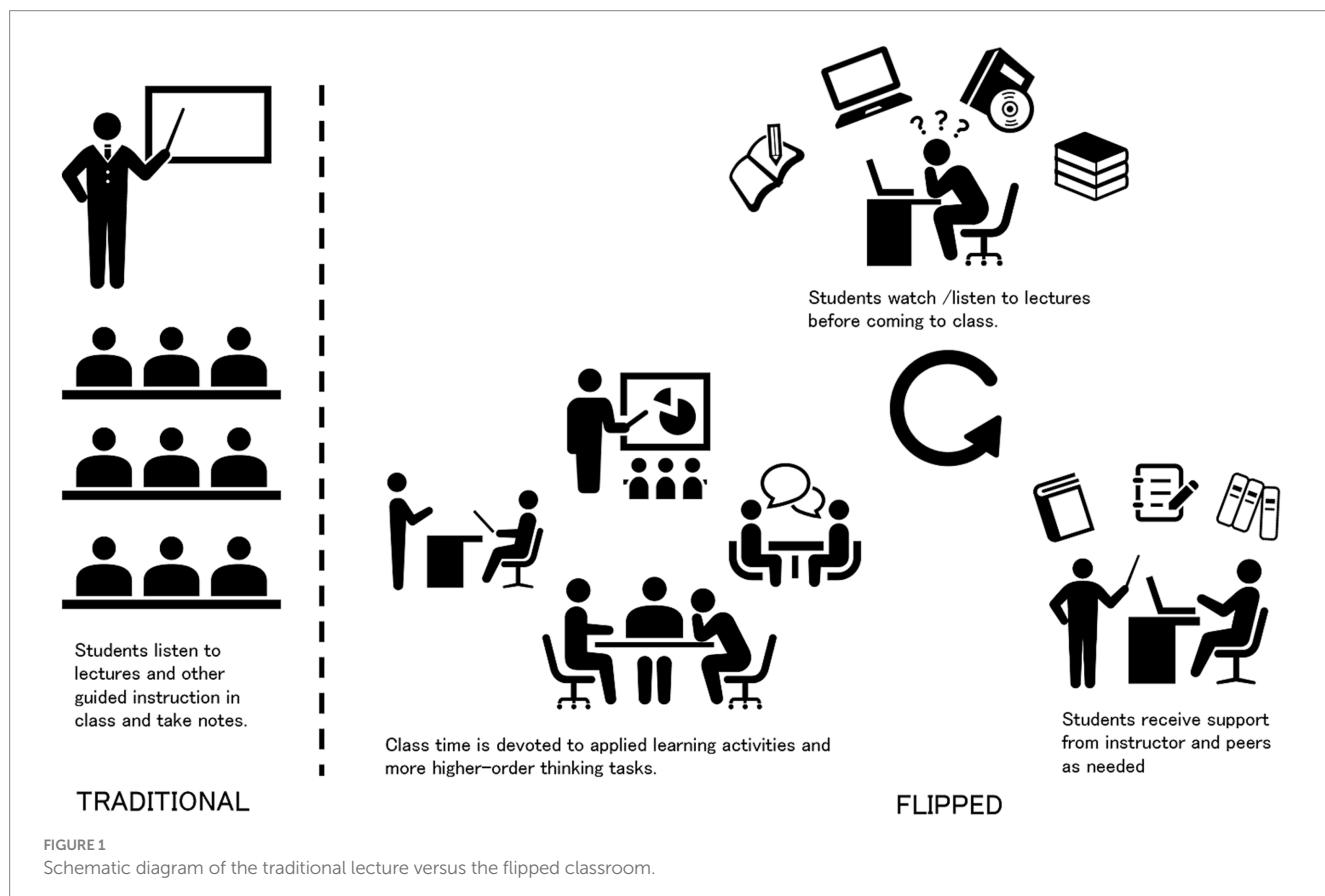
To improve the interests and learning outcomes of students, the reform of medical education has progressed rapidly, including the adoption of the FC. Zhang et al. developed a Small Private Online Course (SPOC) with "simple and practical" videos of less than 10 min, an extension of a Massive Open Online Course (MOOC) for physiology education. The videos consisted of concept introductions and explanations, classical examples, and a summary for systematic learning of each topic. The application of the SPOC in an FC teaching model for clinical undergraduate students revealed significantly increased test scores, along with 87.8% student satisfaction with the SPOC-based FC approach (Zhang et al., 2019). Even when divided into four grades, this three-step learning process—'pre-class self-study, in-class knowledge internalization, and after-class ability extension'—improved the percentage of students achieving high post-class scores. This improvement may be linked to the increased learning efficiency of the SPOC-based flipped classroom (FC) compared to traditional textbook learning (Zhang et al., 2019). Lu et al. used the "Xueyin Online" platform to collect students' regular performance data from the FC and traditional lecture groups, and they also evaluated their examination scores (Lu et al., 2023). The results were similar to those obtained in previous research, showing that improved learning effectiveness of students in physiology courses was correlated with their regular performance.

Another study in India also confirmed the improved effectiveness of physiology learning, with an increase in mean post-test scores in the FC group compared to the CBL model, under a competency-based undergraduate curriculum (Kumar et al., 2022). Even when the online FC model was conducted without face-to-face interaction between teachers and students, the learning effectiveness of physiology education was significantly improved by the FC model for high-achieving students (Xu et al., 2023). Liu et al. modified the process of the FC and implemented a partially flipped physiology classroom (PFC) with 71 students majoring in clinical medicine. Interestingly, students in the PFC group achieved significantly higher scores on the deep learning approach, while students in the traditional lecture group achieved high scores on the surface learning approach, indicating that the PFC model enhanced the motivation for deep learning in physiology education (Liu et al., 2024). Even among underachieving students, the mean post-test score was significantly higher than the pre-test score, and approximately 39% of students strongly agreed that the FC teaching model provided adequate and relevant materials that were easy to learn, while many students strongly believed that the FC teaching model facilitated their understanding of the subject (Shireesha et al., 2024).

For individual physiological systems, as well as gastrointestinal and renal physiology, the final exam scores improved with the flipped methodology. However, the improvements were not significant for repeaters, compared to new students with similar prior knowledge and English proficiency (Sánchez et al., 2020). Interestingly, although the improvement in examination results was significant in the flipped groups with new students, there were no significant differences in stress levels between the groups, measured by awakening salivary cortisol and self-perceived stress scores. The stress during physiology learning was proposed to be consistent across all students, regardless of the methodology used, reflecting the considerable stress experienced during the learning process of physiology (Sánchez et al., 2020). Another study conducted in Iran confirmed that the FC method improved the learning and performance of medical students

in the gastrointestinal physiology course (Seidi et al., 2024). Similar results were found among Indian medical undergraduate students learning cardiovascular physiology (Prabhavathi et al., 2024). However, educators should pay more attention to the specific factors related to learning stress, as this may help students better adapt to physiology learning.

While the previous investigations focused on the short-term effect of the FC in physiology courses, Ji et al. designed a quasi-experimental study with two random classes, a traditional lecture as the control group and FC teaching as the experimental group, to evaluate both the short- and long-term effects of the FC (Ji et al., 2022). The physiology courses were all conducted in the fourth semester using different teaching methods, while the results were evaluated based on the examination scores from basic courses and clinical courses in the fourth through seventh semesters. The FC improved the students' learning effectiveness, as evidenced by a high average score in physiology, but had no effect on the other three basic courses in the same semester. However, for the basic and clinical courses in the fifth through seventh semesters, the final examination scores were significantly higher in the experimental group than in the control, except for the surgery pandect. These findings indicate the promising potential of the FC in physiology education to enhance the learning effectiveness of students, not only in physiology courses but also in follow-up medical courses (Ji et al., 2022).

According to taxonomy of educational objectives, lower-order cognitive skills (LOCS), such as knowledge and understanding, and higher-order cognitive skills (HOCS), such as application, analysis, synthesis, and evaluation, are both important for clinical medicine students (Xu et al., 2023). In addition to examination scores, Paralikar et al. evaluated the acquisition of HOCS in medical students during physiology learning with either the FC or a traditional lecture, using multiple-choice questions based on clinical vignettes (Paralikar et al., 2022). The clinical vignettes involved different physiological systems, such as long-term regulation of blood pressure and cardiovascular reflexes, which were related to the multiple-choice questions and reflected the application and analysis abilities of the students. With the personalized learning experience in the FC model, the students gained a better understanding of the course materials and developed essential HOCS (Paralikar et al., 2022).

4.2 Dental students

As we know, dental education involves a high degree of practical skill acquisition, requiring hands-on training in specific fields and a combination of theoretical knowledge and practical experience. Since the COVID-19 pandemic, the compulsory shift of dental education to online learning has posed sudden challenges for both educators and learners, with diverse learning modalities (Elbadawi, 2023). It was found that satisfaction levels with online dental education were variable, and issues such as evening lectures and technical difficulties should be addressed with tailored interventions (Elbadawi, 2023).

To address the varying performances among dental students, Xiao et al. implemented the FC model once on the topic of the autonomic nervous system in physiology education for the 3-year Doctor of Dental Surgery program. They used a flipped classroom model (1-h online presentation plus 1-h assignment with 30-min discussion) or a 2-h lecture with a 30-min question-and-answer session to replace a

3-h lecture at the end of the first quarter in this program. Although this FC model was only implemented once, the mean quiz score of the students in the flipped approach group was significantly higher than that of the non-flipped group (80% vs. 69%, with $p < 0.001$) (Xiao et al., 2018). Importantly, with content-based questions, the students in the flipped approach group had a higher mean score compared to the non-flipped group, indicating that the flipped approach improved the average performance of the students and narrowed the gap between the low- and high-performing students (Xiao et al., 2018).

4.3 Nursing students

As a practical field, nursing also relies on hands-on training based on basic knowledge. The COVID-19 pandemic affected the implementation of on-campus practical training and hospital-based clinical training (Akiyama et al., 2023). Bingen et al. designed a physiology course incorporating FC principles, self-regulation, and off-campus activities to explore the use of self-regulated learning strategies in nursing students (Bingen et al., 2019). To evoke the students' interests, they set up an introductory program called "Warm-up Week" before the semester began, focusing on how to study within the FC model and be familiar with digital tools and their learning groups. After the iterative implementation of the education program, it was found that the majority of the students preferred viewing online lectures from their teachers over learning from textbooks, which promoted their self-regulated learning process (Bingen et al., 2019). In another study, the same research group focused on the on-campus activities of nursing students during physiology FC education, finding that the FC could enhance the nursing students' confidence in and mastery of physiology (Bingen et al., 2020).

A quasi-experimental study was conducted on the respiratory system in anatomy and physiology education with two classes of 112 first-year nursing students (Joseph et al., 2021). As expected, the mean score on the final examination for the students in the FC group was significantly higher than that of the control group, reflecting better performance in the FC group. Meanwhile, the investigators also administered a brief online questionnaire to assess student satisfaction with FC compared to didactic lectures. Although 68–78% of the students agreed or strongly agreed that the application of the FC improved their learning and interest in physiology education, a small percentage, ranging from 2 to 12%, disagreed or strongly disagreed with the utilization of the FC (Joseph et al., 2021). However, in a study focused on Clinical Physiology 1 and 2, the flipped teaching model did not improve the examination scores compared to the students in the online courses. In addition, the investigators highlighted the issue of student resistance to active learning citing discomfort with uncertainty about the correct answer and related concerns (Anderson and Jacobson, 2023).

In addition to theoretical courses, the physiology laboratory is also an important component of physiology principles. To explore the utilization potential of the FC in physiology laboratory courses and its impact on students' performance, Meng et al. implemented non-traditional classrooms (NTC), combining e-learning, peer teaching, and FC principles for nursing students (Meng et al., 2022). The pre-class e-learning had a more positive effect on the students than the textbook-based preview, with enhanced mean scores on the

pre-class tests and an increase in B graders. Importantly, the performance during the laboratory class also improved in the NTC group, with reduced time consumption and higher success rates, which were linked to the virtual experiments and self-paced procedural skill videos (Meng et al., 2022). The results suggest that the FC model is an effective pedagogy for physiology education, both in theoretical and laboratory courses for nursing students.

4.4 Pharmacy students

The pharmacy profession is quite different from the field of clinical medicine as it focuses on the principles and practices of drug therapy management, drug interaction, and pharmacology. Pharmacists are trained to provide medication information, counseling, and dosage recommendations to patients and cooperate with doctors for the best treatment strategies (Buhler et al., 2024). Before learning pharmacological principles, anatomy and physiology are crucial courses for pharmacy students, contributing to better retention and long-term retrieval of knowledge when facing complex cases (Dias et al., 2020).

To explore the effect of the FC on pharmacy students' physiology learning, Gopalan et al. carried out a series of studies focusing on the effect of the FC in pharmacy programs (Gopalan et al., 2020; Gopalan and Klann, 2017; Gopalan, 2019). They first reported the results for students in their professional *year 1*, after completing a preprofessional sophomore-level anatomy and physiology course. As this course covered different systems of physiology, the flipped classroom model was applied to the immune system for the first time, followed by neuro, endocrine, and cardiovascular physiology, while the final unit on renal, respiratory, and exercise physiology was covered using the unflipped format. The performance of the students on the flipped questions was found to be 17.5% higher than on the unflipped lecture questions ($p < 0.0001$). When the class was divided into the upper and lower 50th percentiles, both groups showed higher correct response rates in the flipped classroom (FC) format compared to the unflipped format, with increases of 13.91 and 12.02%, respectively. This suggests that flipped teaching benefits both higher and lower achievers (Gopalan and Klann, 2017).

Next, the researcher focused on the undergraduate sophomore-level physiology course, specifically an Introductory Physiology course, and implemented the FC with 653 students during the second year of their pre-pharmacy program. As expected, the exam scores of the students in the FC group were significantly higher compared to those in the control group, except for *semesters 3* and *4*. However, the students in the FC model group reported feeling rushed as they had to seek additional pre-class resources beyond the provided reading materials (Gopalan, 2019). Building on the previous advantages and disadvantages observed during FC implementation, Gopalan et al. aimed to refine the implementation of the FC for pharmacy students. They incorporated pre-class reading assignments and PowerPoint slides, along with ample opportunities for the students to ask questions, creating an interactive lecture format that is comparable to the FC model. To promote the participation of the students, peer evaluations were also carried out, allowing the students to assess their teammates with scores and specific explanations. During the implementation of the FC, the researchers also restructured the curriculum to reduce off-class workload based on the students'

feedback. Interestingly, the new format of the FC also showed a significant difference between the groups, with the students being able to prepare for class and gain more from the course (Gopalan et al., 2020). This series of investigations provided valuable research findings and reflections on the use of the FC for physiology education in pharmacy students, highlighting inconsistencies that should be addressed and refined during the implementation process.

4.5 Health Science undergraduate students

The Bachelor of Health Science degree is a specialized program in medical education, and graduates with this degree can be employed in assistant departments in hospitals, such as in clinical science laboratories, heart laboratories (ECG and cardiac catheter laboratories), and sleep clinics (EEG), working as clinical scientists or technicians (Yudkin et al., 2003). Meanwhile, cardiorespiratory and renal physiology is a core subject requirement in the Clinical Technologies major. Therefore, Rathner et al. enrolled ~60 students to complete advanced neuroscience before the commencement of cardiorespiratory and renal physiology in *semester 2*. Although the study was designed around a flipped classroom model, incorporating active learning questions, peer-to-peer discussions, and recruiting high-performing undergraduates as teaching assistants, it was unfortunate to find that the students rejected these flipped classroom team-based learning workshops. By midsemester, the number of students attending the workshops had decreased to only five. Therefore, the feedback from the students was largely negative, with comments such as "a lazy excuse," "too much content," "so many active learning questions," "did not like the online lecture aspect of this unit," "rushed through," "Nothing," and "a burden" (Rathner and Schier, 2020). Such results prompt deeper reflection on the application of the FC model in specific majors.

4.6 Graduate students

After completing their undergraduate education, graduates should work on improving various aspects of their post-graduation competencies, including both LOCS and HOCS (Sim et al., 2023). E-learning is a feasible method for healthcare professionals to improve their skills after graduation, with high levels of satisfaction reported (Iino et al., 2023). For the first time, Tune et al. investigated the effectiveness of the FC model for medical graduate students in physiology education (Tune et al., 2013). They employed three systems in physiology: cardiovascular, respiratory, and renal physiology. Although only 27 graduate students with similar backgrounds were enrolled in this program, the breakdown of the scores on the identical exams for the students in the traditional and modified flipped courses was significant. The students in the modified FC course achieved high scores in the cardiovascular, respiratory, and weighted cumulative sections, with an average of >12 percentage points. Importantly, the majority of the students in the modified FC course consistently watched the lecture videos before attending class. All students recommended the routine quizzes at the beginning of each session, which motivated their pre-class preparation and facilitated in-class discussions about key concepts (Tune et al., 2013). However, despite the application of the FC being reported effective in undergraduate

education, the utilization of the FC in graduate medical education is less common (French et al., 2020). Importantly, such investigations should be further conducted, considering the limited sample size.

As mentioned previously, the program directors of NPM placed physiology as the highest priority within the standardized national curriculum (French et al., 2018). To measure the effectiveness of and preference for the FC in NPM fellowships within the standardized national curriculum, a multicentered equivalence, cluster-randomized controlled trial (RCT) was conducted to compare physiology education through traditional didactic methods or FC education (Gray et al., 2022). Finally, 530 fellows from 61 NPM fellowships participated in this trial, with more fellows in both groups preferring group discussions. However, the FC fellows tended to rate classroom effectiveness more positively (Gray et al., 2022), which prompted further consideration of the use of the FC in physiology education, not only for undergraduates but also for graduate fellows. With the standardized national curriculum, the FC is considered a reasonable alternative to traditional didactic methods in physiology education (Gray et al., 2022). Recently, this research group gathered educator preferences through an online survey and compared demographic data along with pre- and post-intervention educator responses (Johnston et al., 2024). Interestingly, after the intervention, the educators in both groups expressed a preference for using the FC in physiology education, citing interactivity, learner enthusiasm, and learner-centeredness as key reasons. However, challenges such as limited time, content expertise, and enthusiasm among faculty should be addressed with dedicated efforts in the future (Johnston et al., 2024).

5 The feedback of the FC from participants

French et al. specified that physiology education is an area of study benefiting from spending class time on clinical applications rather than traditional lectures, suggesting that FC is highly effective in reinforcing physiological concepts for medical students (French et al., 2020). However, in addition to the examination score and/or performance of students, the experiences of both educators and learners throughout the entire process should be considered as the teaching process becomes more complicated and demanding when moving from traditional lectures to pre-, in-, and post-class sessions. Educators have to prepare videos, upload pre-class materials online, and design pre- and post-quizzes or questionnaires for discussion. Meanwhile, learners are required to begin their learning activities several days before the practical class and invest extra time and energy, even after the practical class. Therefore, in addition to the surveys used to evaluate exam scores and/or student performance mentioned above, the following research focused on feedback regarding the FC from various perspectives.

5.1 The feedback from educators

To evaluate the attitudes and opinions of educators implementing the FC, a research group carried out a series of studies on physiology education for NPM. Firstly, French et al. conducted two educational programs that paired online videos with the FC at five institutions with fellowship programs accredited by

the Accreditation Council for Graduate Medical Education (ACGME), which were peer-reviewed accordingly. Instead of traditional lectures, the educators guided the fellows and facilitated fellow-led discussions on NPM-related clinical cases, exercises, and discussion questions after the fellows viewed the online videos independently, along with pre- and post-video assessment questions (French et al., 2018). Using open-ended questions, the educators reported that the provided materials (video modules and FC guides) reduced the time required for FC preparation. Instead of designing FC strategies and recording videos, the educators spent more time evaluating the provided materials and focusing on key physiological principles within a clinical context. Not surprisingly, the educators proposed the FC as an effective, productive, and efficient education method to collaborate with learners on their comprehension, cognition, and learning skills (French et al., 2018). Shortly thereafter, they carried out a cross-sectional study of NPM fellows and faculty educators who had e-learning experience with the respiratory physiology FC.

Among 172 respondents out of 373 eligible participants (47% response rate), positive attitudes toward educational content and case discussions were very high, as was support for the national standardization of NPM physiology education (92%). Both faculty and fellows endorsed encouraging strengths rather than challenges during the FC experience (Gray et al., 2021). With these encouraging results, they designed and carried out a randomized controlled trial (RCT) to evaluate the effectiveness and learner preferences for FC versus traditional didactics physiology teaching in ACGME-accredited NPM fellowship programs. The preference for using the FC in physiology teaching increased by 17% among FC educators, while professional satisfaction was affected by challenges such as limited available time to create and/or deliver educational content, limited content expertise, lack of enthusiasm, and lack of perceived value in education. Therefore, to promote the utilization of the FC in physiology education, these issues should be noticed and addressed, including adequate trainee preparation, educational time, and the development of facilitation skills in educators (Johnston et al., 2024). With the development of FC utilization in physiology education, they launched a mixed-methods, cross-sectional study involving faculty educators who participated in an RCT on FC physiology education in NPM. With a 25-question survey about effective strategies for FC facilitation, it was found that more than half of the educators had not received prior training in FC facilitation. In addition, unprepared learners disrupted the learning environment, highlighting the importance of clear expectations and adequate time for learner preparation. Interestingly, they reported that creating a safe learning environment and engaging learners in critical thinking would facilitate effective FC sessions (Falck et al., 2024).

In addition to facilitators and observers, Rehman et al. also consulted with the leadership of the Department and the University while conducting flipped-style teaching in the respiration and circulation module, aiming to merge case-based discussion with small-group discussions in the form of FC activity (Rehman et al., 2020). Importantly, not only the facilitators and observers but also the leadership discussed and highlighted the usefulness of the FC in connecting basic science concepts of cardiovascular physiology and pathology, through student engagement and increased participation, to build understanding of the key concepts (Rehman et al., 2020).

5.2 The feedback from learners

However, how to set up a safe learning environment? What aspects should be considered for the FC design during physiology education? The voice of learners should be paid special attention to. As pre-class activities are very important for the in-class experience in the FC, Persky et al. explored the impact of prepared materials on pre-class learning time before the FC experience. Based on the self-reported results, an average of 3.2 h was spent preparing by reading the materials in TBL format, which was positively correlated with word count, the number of tables/figures, and overall page length. Interestingly, the time spent was much greater than predicted, indicating the deep involvement of students in pre-class activities (Persky and Hogg, 2017). However, in this study, the investigators did not evaluate the association between pre-class study time and in-class performance or the exam scores of the students. Meanwhile, as the authors mentioned, the primary limitation of this study was the self-reported nature of study time, which could be addressed using online materials with monitoring or timing methods. Xu et al. provided different types of pre-class materials and conducted three formal surveys, revealing a significant divergence in student preferences for different durations of the provided pre-class videos. It was found that the selection of videos with different durations, pre-, in-, or post-class, was significantly associated with the characteristics of the videos themselves, indicating the individualization of students in the online FC. Therefore, the design and construction of online FC teaching should pay more attention to the requirements of different student groups (Xu et al., 2022). Regarding the performance of students under different teaching models, Lu et al. found a significant correlation between usual performance and final exam scores in the flipped classroom but not in the traditional teaching groups. These findings were consistent with the results of an anonymous questionnaire survey, which showed that 77.85% of students agreed that their knowledge acquisition improved with the FC teaching model (Lu et al., 2023).

The majority of survey studies have mainly focused on learners' attitudes. A survey covering online courses in physiology, pathology, and pharmacology revealed that the majority (86.9%) of students agreed to participate in polls during online classes and that 88.9% recommended using the polls again. These results provided a strong foundation for interactive teaching using the FC (Bawazeer et al., 2023). As mentioned above, 75% of Omani nursing students were satisfied with the FC approach compared to traditional lectures (Joseph et al., 2021). Along with a nine-item electronic survey, a 15-min interactive peer-led FC session on physiology education for intensive cancer medicine residents received positive feedback from the participants. The residents reported that the session sparked their interest in learning and promoted their knowledge and understanding (Zante et al., 2020). In another 5-year investigation using a deep learning approach, focusing on the FC and PBL in physiology education for students registered nurse anesthetists (SRNAs), the majority of students favored these deep learning approaches to enhance their critical thinking skills (Walker et al., 2021). During the COVID-19 pandemic, the transition from offline to online education became compulsory. Although the majority of the participants had never taken a course using a similar FC method, the 49 students who

completed a 3-week online "Basic Concepts in Neurophysiology" course reported positive feedback for the FC model, including increased study frequency during the social distancing period (Carrazoni et al., 2021). Even in a short seminar, resident participants with high learning motivation reported having increased motivation during the post-seminar period. They recognized their insufficient knowledge of operating a mechanical ventilator and the importance of learning respiratory physiology before engaging in experiential learning (Takeda et al., 2023). In contrast, after a 3-h theory session on the FC approach, 20 student participants completed a two-part questionnaire with 22 Likert-style questions and five open-ended questions. All students disagreed that the FC was more engaging than traditional lectures. Among all the participants, 80% would not recommend the FC model to a friend. The flexibility of learning and time constraints were identified as factors related to the disappointed responses (Christopher, 2018).

6 Reflection and re-thinking of the FC in physiology education

The COVID-19 pandemic significantly accelerated the development of online teaching and learning approaches. Although the shift from offline to online was feasible, the advantages and challenges should not be overlooked. Interestingly, live interaction in a mixed model is more dynamic than recorded lectures, relying on internet connectivity (Camargo et al., 2020). Hew et al. suggested that, as a promising teaching method, the FC is considered to be more effective than traditional lectures in medical education, as an overall analysis revealed favorable attitudes toward the application of the FC among medical students (Hew and Lo, 2018). The current study reviewed the investigation of the application of the FC in physiology, which is a key bridge course between basic and clinical principles. However, among the preferred uses of the FC in physiology education, the disagreeing response should also be acknowledged and addressed promptly.

One explanation for the improved positive student perception is the flexibility of pre-class activities as students have the freedom to choose the time, location, and pace that works best for them. However, the internal driving force for learning is not the same for everyone, resulting in varying levels of preparation for in-class discussions, ranging from good to poor, or even complete non-preparation, which can disrupt the learning environment (Falck et al., 2024). Another advantage is the increased active learning time in class through discussions based on clinical cases, exercises, or questions. This section of the FC places high demands on educators in terms of their knowledge of key concepts, familiarity with previewed materials, on-site control capabilities, and communication skills, all of which are essential to ensure that the class proceeds smoothly. The efficient training of educators will facilitate the comparison and evaluation of the FC process by different educators (Gray et al., 2021). In other words, individualization applies to both learners and educators, influencing the application and effectiveness of the FC in physiology education.

Other challenges include the FC itself, which requires extensive material preparation, such as designing and recording videos, developing clinical cases, formulating related questions for

discussions, and creating questionnaires and assessment quizzes for videos or the FC process. Online databases offer a wealth of teaching resources that can facilitate the implementation of the FC in medical education. However, the quality of materials and their suitability for diverse groups should be evaluated. For example, MacDonald et al. introduced a video podcast that conveyed information through animated content, which was available to learners on demand and just-in-time for practice (MacDonald et al., 2020). They investigated the efficacy of this module as an educational tool for second-year medical students and found a 48% improvement in their average scores, along with positive feedback, such as "This module effectively taught concepts related to pulmonary physiology and pneumothorax" and "The animated format of this module was useful for illustrating concepts related to pulmonary physiology and pneumothorax." (MacDonald et al., 2020).

Importantly, approval from the ethics committee should be obtained before conducting the FC investigation to protect students' rights to be informed and to privacy. All of these require additional time and effort from educators, which necessitates support from the college or departments. Sufficient support will facilitate the application and refinement of the FC, making it more appealing to learners. French et al. provided a quite feasible system to promote the application of the FC in physiology education through relatively standardized mini-videos and FC guides (French et al., 2018). The materials provided to educators make the implementation of FC easier and more time-efficient. In addition, alternative learning models should be considered for learners as not all students are convinced of the potential of the FC. This presents high demands on educators, who must address the individual needs of learners.

7 Conclusion

Current evidence suggests that the use of the FC model in physiology education leads to greater effectiveness in learners compared to traditional lectures across different disciplines. The improvement effects include enhanced performance and exam scores in the short term, as well as better knowledge retention and increased active learning ability in the long term. In the future, the FC is a promising teaching method to stimulate students' intrinsic motivation for learning and strengthen academic exchange during the physiology education process. However, those implementing the FC model must be mindful of the variations in active learning attitudes among individual learners.

Author contributions

JL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. ZW: Data curation, Formal analysis, Investigation, Writing – original draft. Y-ZL: Data curation, Formal analysis, Investigation, Writing – original draft. W-JC: Data curation, Formal analysis, Writing – review & editing. B-XW: Writing – review & editing. W-TC: Writing – review & editing. H-TW: Conceptualization, Data curation, Formal analysis,

Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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