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EDITED BY
Álvaro Nolla,
Autonomous University of Madrid, Spain

REVIEWED BY
Berhanu Mekonnen,
Dilla University, Ethiopia
Sandra Watson,
University of Louisiana at Monroe,
United States

*CORRESPONDENCE
Mariana Dogaru
✉ mariana.dogaru@upb.ro

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Instructional leadership as a predictor of resilience and well-being in STEM learning: a systematic review

Mariana Dogaru*, Mirela Cristina Negreanu, Olivia Pisică and Alina Florentina Pîrvu

National University of Science and Technology Politehnica Bucharest, Bucharest, Romania

Background: Instructional leadership (IL) is critical for fostering resilience and well-being in STEM education, yet its impact remains underexplored. This systematic review synthesizes evidence on how IL predicts resilience and well-being in STEM learning.
Methods: Following PRISMA guidelines, we analyzed 80 peer-reviewed studies (2014–2024) from Clarivate, Scopus, Google Scholar, and ERIH Plus, using keywords like „instructional leadership" and „STEM education."
Results: IL indirectly enhances resilience through strong teacher-student relationships and supports well-being by boosting motivation in STEM. Success in STEM subjects fosters school resilience, while cognitive conflict in STEM learning contributes to adaptive strategies.
Conclusion: IL is a key predictor of STEM learning outcomes, with implications for teacher training and inclusive STEM curricula. Future research should explore contextual factors mediating these relationships.

KEYWORDS
educational resilience, instructional leadership, motivation in education, STEM learning, STEM perseverance, student well-being, teacher-student relationship

1 Introduction

Education in Science, Technology, Engineering, and Mathematics (STEM) equips students to tackle global challenges, from technological innovation to climate resilience. Yet, STEM learning environments often pose significant demands, including cognitive complexity and competitive pressures, which can undermine students' resilience and well-being (Avedissian and Alayan, 2021). Resilience, a dynamic process of adapting to adversity through individual and contextual factors (Ungar et al., 2021), and well-being, encompassing emotional, psychological, and social dimensions (Diener, 1984; Keyes, 2002), are critical for sustained STEM engagement. Instructional leadership (IL), defined as the strategic efforts of principals and teachers to enhance teaching quality (Shaked, 2024), is increasingly recognised as a driver of these outcomes. However, the specific mechanisms by which IL influences resilience and well-being in STEM education remain underexplored, lacking a systematic synthesis to inform evidence-based practices.

Research highlights IL's role in fostering student outcomes through teacher-student relationships and pedagogical innovation (Pietsch et al., 2023; Wenner and Campbell, 2017). Studies also indicate that STEM achievement can enhance school resilience and well-being (Lillywhite and Wolbring, 2024), while well-being enhances motivation and perseverance in

STEM (Vitha, 2022). Despite these insights, the literature is fragmented, with few studies integrating IL's contributions to STEM-specific resilience and well-being. For example, Nguyen et al. (2020) describe IL's indirect effects on student outcomes via teacher efficacy, but its application to STEM contexts is limited. Similarly, global frameworks like UNESCO's (2023) call for inclusive STEM education emphasize equitable learning environments but lack empirical connections to IL strategies, particularly for underrepresented groups facing systemic barriers (Al Hamad et al., 2024). Figure 1 illustrates the conceptual relationships among IL, resilience, well-being, and STEM learning, highlighting the mediated pathways and contextual moderators central to this review.

This systematic review addresses this gap by synthesising 80 peer-reviewed studies (2014–2024) from Clarivate, Scopus, Google Scholar, and ERIH Plus, following PRISMA guidelines. It aims to: (1) analyse IL's role as a predictor of resilience in STEM education, (2) evaluate IL's impact on student well-being in STEM, (3) explore the relationship between STEM success and resilience/well-being, and (4) identify IL strategies that enhance motivation and perseverance in STEM. By integrating these dimensions, this review provides a novel framework for advancing STEM education, offering actionable recommendations for educators and policymakers to foster resilient and inclusive learning environments.

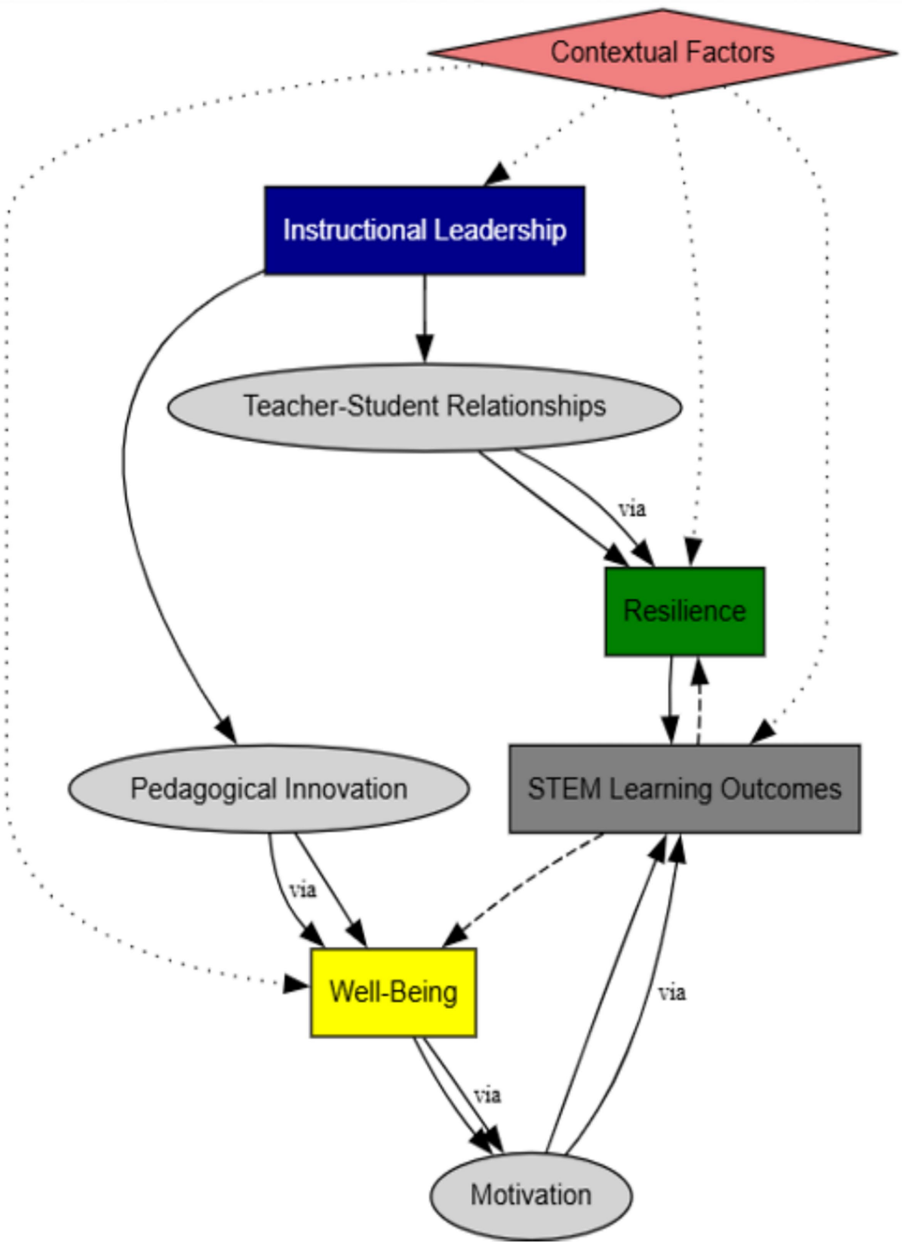

FIGURE 1
Conceptual framework of instructional leadership in STEM education. Adapted from Pietsch et al. (2023) and Ungar et al. (2021). Source: authors.

1.1 About instructional leadership (IL), STEM learning/education (STEM-L/E), student well-being and resilience (SWB&R) and educational resilience (ER)

1.1.1 Instructional leadership (IL)

Discussing instructional leadership complicates the provision of explicit guidance for elucidation. This notion, crucial in education, underscores the effort of principals and teacher leaders in facilitating a high-quality and effective learning process. Over time, the emphasis transitioned from optimising school administration in the 1970s to tackling managerial educational practices inside the academic learning process during the 1980s and 1990s. In the 2000s, the phrase educational leadership emerged, linked to themes such as teamwork and the establishment of environments and cultures of continuous learning essential for enhancing student performance. Thus, the period of instructional leadership commences, emphasising the facilitation of pedagogical innovation over administrative responsibilities.

Teachers' leadership exerts diverse influences on students. While its direct impact on student performance may be moderated by context and approach, its effect on students' well-being and resilience seems to be indirect, facilitated by enhancements in instructors' abilities and psychological condition. The examination of instructional leadership has occurred in various contexts, with its efficacy contingent upon cultural context and human development levels; it is not universally applicable (Pietsch et al., 2023; Bartanen et al., 2019). Thus, a more nuanced definition and the identification of factors that enhance it are essential. Nonetheless, it is evident that a correlation exists between Teacher Leadership and Student Outcomes; however, this relationship is not uniformly applicable (Pietsch et al., 2023). The teacher's psychological state is affected by student outcomes; hence, leadership impacts instructional leadership, resulting in improved results, while enhanced student outcomes, in turn, influence leadership and indirectly affect instructional leadership. Nguyen et al. (2020) suggest a relationship characterised by indirect mutual influence. The well-being of kids is similarly affected by the teacher, their leadership, and academic performance (Aquino et al., 2021).

1.1.2 STEM learning/education (STEM-L/E)

Discussing instructional leadership complicates the provision of explicit guidance for elucidation. This notion, crucial in education, underscores the accent of principals and teacher leaders in facilitating quality and effective learning experiences. Over the years, the emphasis transitioned from optimizing school administration in the 1970s to tackling managerial educational tactics inside the academic learning process during the 1980s and 1990s. In the 2000s, the phrase educational leadership emerged, linked to themes like teamwork and the development of environments and cultures of continuous learning essential for enhancing student performance. Consequently, the period of instructional leadership commences, emphasising the facilitation of pedagogical innovation over administrative responsibilities.

The teacher's leadership exerts a diverse influence on students. While its direct impact on student performance may be moderated by context and approach, its effect on students' well-being and resilience seems to be indirect, facilitated by enhancements in instructors' abilities and psychological condition. The examination of instructional leadership has occurred in various contexts, with its efficacy contingent upon cultural circumstances and human development levels; it is not universally applicable (Pietsch et al., 2023).

Consequently, a more nuanced definition and the identification of factors that enhance it are essential. Nonetheless, it is evident that a correlation exists between Teacher Leadership and Student Outcomes, but this relationship is not uniformly applicable (Pietsch et al., 2023). The teacher's psychological state is affected by student outcomes; hence, leadership impacts instructional leadership, resulting in improved results. Conversely, enhanced student outcomes also influence leadership and, indirectly, instructional leadership. According to Nguyen et al. (2020), this represents a connection of indirect mutual impact. The well-being of kids is similarly affected by the teacher, their leadership, and academic outcomes (to Nguyen et al., 2020; Aquino et al., 2021) (see Table 1).

1.1.3 Student well-being and resilience (SWB&R)

1.1.3.1 Student well-being

In 1946, the World Health Organisation (WHO) made a significant contribution to the definition and promotion of Well-being (or Well-being/Wellness). In 1984, Diener introduced this notion inside a psychological framework, becoming one of the pioneering scholars to discuss subjective well-being. From Diener's viewpoint, well-being is characterised by subjective life enjoyment. His beneficience influenced the model of well-being research and subsequent studies, including his work that delineated psychological well-being via self-acceptance, environmental mastery, self-governance, affirmative interpersonal relationships, personal evolution, and a sense of determination in life. Keyes (2002) subsequently amalgamated three dimensions of well-being—emotional, psychological, and social—into the construct of mental health. Diener's study has significantly influenced well-being studies within the realms of work psychology and organisational psychology. Furthermore, it might be contended that significant well-being frameworks in positive psychology, such as Seligman's PERMA model (Seligman, 2018), comprising five elements: emotion, commitment, connections, meaning, and accomplishment, are foreshadowed by Diener's prior examinations. Although there is a seemingly widespread agreement on defining well-being as a multidimensional construct, significant controversies persist regarding its precise definition. This complicates the formulation of a clear and comprehensive theory and hinders the application of best practices and evidence-based knowledge in operationalizing the concept. There exists a variety of perspectives concerning:

a. The identification of composite components
b. Establishing interrelated variables.

Numerous formulations typically refer to pleasant emotions, satisfaction, and stress as components, although their lack of systematic integration results in an ambiguous understanding of well-being.

1.1.3.2 Student resilience

The growth of the meanings associated with the notion of Resilience in educational contexts provides possibilities for defining Student Resilience, as evidenced in the reference works chosen for this

TABLE 1 Key elements from STEM articles.

Category	Key elements	Description	Authors
STEM learning	Active Learning	Approaches that engage students in activities, contemplation, and collaborative effort, at the expense of passive lectures.	Lavi et al. (2021)
	Relevant Curriculum	Curriculum tailored to labor market demands, featuring collaborations with industry and government, and incorporating a continuous development cycle.	Egarievwe (2015) and May et al. (2022)
	The Interest and Motivation of Students	The interests of students are paramount, necessitating the adaptation of teaching methods to engage both those inclined towards "things" and those inclined towards "people."	McIntyre et al. (2021)
	Adapted Pedagogical Methods	Pedagogical approaches that actively engage students, foster collaboration and engagement. Educators ought to embrace a "becoming" perspective.	Donaldson and Allen-Handy (2023), Lavi et al. (2021)
	Holistic Approach	Enhancing STEM education necessitates a strategy encompassing curriculum development, pedagogical techniques, student engagement, educator training, and predictive modelling.	Egarievwe (2015), Donaldson and Allen-Handy (2023), McIntyre et al. (2021), May et al. (2022), Lavi et al. (2021), Ismail and Yusof (2023), and Huang et al. (2022)
STEM Education	Models for Improving Education	Structured strategies like Vertical Education Enhancement (VEE), which amalgamate the curriculum, industry partnerships, and research, can enhance STEM education results.	Egarievwe (2015) and Murphy et al. (2018)
	Modern Educational Standards	The adoption of contemporary educational standards, such the Next Generation Science Standards (NGSS), which advocate genuine experiences and transdisciplinary learning.	May et al. (2022)
	Teachers Professional Development	Teacher Professional Development (TPD) programs should emphasize pedagogical expertise, content understanding, interdisciplinary integration, and experiential training methodologies.	Huang et al. (2022)
	Skills for the 21st Century	STEM education must cultivate critical thinking, problem-solving, cooperation, communication, and creativity.	Lavi et al. (2021), Miravète and Tricot, 2024, and Nygren et al., 2019
	Research Infrastructure	The infrastructure for research and technological advancement is crucial for establishing a robust foundation in the STEM domain.	Egarievwe (2015)
	Predictive Modelling	The application of machine learning methodologies to forecast student decisions facilitates a deeper comprehension of the aspects affecting the STEM pathway.	Ismail and Yusof (2023)
	Perseverance	The capacity to surmount challenges and persist in resolving intricate issues.	Egarievwe (2015), Donaldson and Allen-Handy (2023), McIntyre et al. (2021), May et al. (2022), Lavi et al. (2021), Ismail and Yusof (2023), and Huang et al. (2022)

Source: authors.

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systematic evaluation of contemporary literature. Resilience is not a static characteristic; rather, it is a dynamic process that encompasses the interplay of individual qualities, contextual elements, and coping mechanisms (Murray, 2004; Liebenberg et al., 2015). External factors, including the community, home, and school environment, influence students' resilience (Ungar and Liebenberg, 2013; James et al., 2021; Hainagiu and Neagu, 2025). Thus, schools and educators are pivotal in fostering students' resilience through supportive relationships and environments (Liebenberg et al., 2015; Nickolite and Doll, 2008). Confident relationships with educators and peers substantially enhance resilience (Liebenberg et al., 2015; Victorino et al., 2019), while supportive classroom environments and pedagogical methods that engage students are essential for fostering resilience (Nickolite and Doll, 2008; James et al., 2021). To cultivate students' resilience, it is essential for them to acknowledge and honor cultural and community contexts (Ungar and Liebenberg, 2013; James et al., 2021). Certain studies contend that conventional resilience approaches frequently emphasize individual deficiencies instead of systemic and environmental elements, asserting that resilience is a prevalent cultural characteristic among students of colour (James et al., 2021). Efforts by schools to implement inclusive STEM missions may result in *"shadow capital,"* a type of capital that does not offer equivalent opportunities (Cipollone et al., 2020), while commitment in service-oriented STEM education might enhance resilience and civic consciousness (Daniel and Mishra, 2017; Li et al., 2020). Emotional intelligence is correlated with resilience, as pleasant emotions enhance resilience during crises (Nham et al., 2022). Educators' behaviors and views, particularly concerning gender, can impact students' academic beliefs, therefore influencing their academic trajectories (Sansone, 2018).

1.1.4 Educational resilience (ER)

Educational resilience is a varied, dynamic notion that transcends conventional approaches centred exclusively on the traits of students or educators. It entails an ongoing interplay of personal variables, external factors (such as school, family, and community), and learning events. The objective of educational resilience is to empower students and educators to confront challenges and adversity effectively, while successfully adapting to changes and sustaining strong academic achievement. This is determined by individual factors such as emotional intelligence (Nham et al., 2022), cultural beliefs (Sansone, 2018), and a sense of academic competence (Ni et al., 2016), as well as contextual factors related to the school environment, including the quality of teacher-student and peer-to-peer relationships (Liebenberg et al., 2015; Victorino et al., 2019). A affirmative and inclusive environment that honors diversity and fosters belonging (Nickolite and Doll, 2008; Victorino et al., 2019), pedagogical strategies that enhance student commitement and provide individualized support (Nickolite and Doll, 2008; James et al., 2021), equitable STEM initiatives that facilitate skill acquisition and self-confidence, programs that cultivate a sense of belonging and community (Abrica et al., 2020), educational settings that address discrimination and inequity (James et al., 2021), the provision of essential material and educational resources for learning and development (Merisotis and Kee, 2006); community and familial factors: affiliation with a supportive community that acknowledges cultural identity (Ungar and Liebenberg, 2013; James et al., 2021), the significance of nurturing parent–child relationships, particularly warmth and support (Liebenberg et al., 2015). Educational resilience, defined as the creation of an environment that promotes resilience among all participants, can be cultivated or sustained through programs that consider the unique characteristics of students, including their cultural and socio-economic backgrounds (Ungar and Liebenberg, 2013; Cipollone et al., 2020; Hamalainen, 2008), the enhancement of emotional self-regulation and interpersonal skills (Nham et al., 2022), the delivery of constructive feedback, opportunities for introspection, and progress assessment (Wong et al., 2018), as well as the commitement of students in initiatives that link them to the community and impart a sense of purpose (Daniel and Mishra, 2017).

1.2 Objectives

This systematic review seeks to offer a comprehensive overview of prior research by analyzing and synthesizing empirical evidence regarding instructional leadership as a predictor of resilience and well-being in STEM education. This paper seeks to present a coherent interpretative framework that clarifies how instructional leadership can bolster students' resilience and well-being in STEM education, ultimately enhancing their academic performance and overall learning experience. It aims to consolidate and emphasize the diverse methodologies, correlations, interpretations, and conceptual perspectives, some of which are corroborated by prior studies or meta-analyses. Consequently, our research intends to:

- *O1:* Delineate the research and operationalisation viewpoints of Instructional Leadership (I. L) that enhance comprehension of this concept and its interrelations with other examined concepts (I. L and STEM education/learning, I. L and resilience, I. L and well-being).
- *O2:* Delineate the research domains of STEM Education and its position relative to STEM Learning, examining potential similarities or differences between the two concepts, the possibility of similarities, differences, or conceptual overlap, and whether it constitutes a semantic amalgamation that correlates with resilience and well-being.
- *O3:* To identify research that elucidates the relationship between I. L – STEM Learning and Education and IL-STEM-L/E.
- *O4:* To identify data that illustrates a specific form of I. L. may correlate with success or failure in STEM-L/E.

This systematic review examines the empirical literature from 2014 to 2024 and seeks to address the following five questions:

> *RQ1:* What does empirical evidence suggest about the correlation between success in STEM subjects and the development of resilience and well-being in school?
>
> *RQ2:* What does the empirical evidence reveal regarding the relationship between the success of students in STEM disciplines and their overall well-being?
>
> *RQ3:* In what ways do the operationalisation of this notion and the research perspectives of Instructional Leadership contribute to a more in-depth knowledge of this concept? (Instructional Leadership and education/learning, Instructional Leadership and resiliency, and Instructional Leadership and well-being).
>
> *RQ4:* What does empirical evidence suggest about the conceptual developments of STEM education & STEM learning and the

TABLE 2 Search strategy and initial results.

Database	Example search query	Filters	Initial results
Scopus	("instructional leadership" OR "educational leadership") AND ("STEM education" OR "STEM learning") AND ("resilience" OR "well-being")	2014–2024, peer-reviewed, English	8,500
Clarivate	("instructional leadership" OR "teacher leadership") AND ("STEM" OR "science education") AND ("resilience" OR "motivation")	2014–2024, peer-reviewed, English	7,200
Google Scholar	"Instructional leadership" AND "STEM education" AND ("resilience" OR "well-being")	2014–2024, peer-reviewed	5,800
ERIH Plus	("teacher-student relationship" OR "educational leadership") AND ("STEM" OR "science") AND ("well-being" OR "motivation")	2014–2024, peer-reviewed, English	846

Total initial results: 22,346. We carried out searches in January 2025, utilising Zotero for reference management. Source: authors.

generation of educational well-being and resilience—there are similarities, differences, or no interpretation, covariance, is it a composite element?

These inquiries are underpinned by our aspiration to foster a comprehensive understanding of STEM education and its associated aspects that impact STEM learning. This study offers a novel perspective on identifying predictors of STEM education, with instructional leadership emerging as a significant factor that predominantly affects resilience and well-being within this context.

2 Methods

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) to ensure methodological rigour, transparency, and reproducibility. The methodology was designed to address the four research questions outlined in the introduction, exploring how instructional leadership (IL) predicts resilience and well-being in STEM education. The process involved a comprehensive literature search, systematic study selection, data extraction, quality assessment, and narrative synthesis.

2.1 Research design

This study employed a systematic review methodology to synthesise empirical evidence from peer-reviewed literature published between January 2014 and July 2024. The review focused on studies examining IL, resilience, well-being, and STEM education, aiming to provide a multidimensional analysis of their interrelationships. The PRISMA framework guided the design, ensuring adherence to international standards for systematic reviews (Moher et al., 2009; Page et al., 2021). Due to the heterogeneity of study designs and outcomes, we opted for a narrative and thematic synthesis instead of conducting a meta-analysis.

2.2 Search strategy

A systematic search was performed in January 2025 across four academic databases: Clarivate Web of Science, Scopus, Google Scholar, and ERIH Plus. These databases were selected for their comprehensive coverage of education and STEM-related literature. Search terms were developed iteratively, combining keywords related to the core constructs: IL, resilience, well-being, and STEM education. Table 2 presents the search strategy, including example queries, Boolean operators (AND, OR, NOT), and filters.

The search used truncation (e.g., "resilien*" for resilience/resilient) and excluded terms like "non-STEM" or "higher education" to focus on K-12 and general STEM contexts. Filters restricted results to English-language, peer-reviewed articles published within the specified timeframe. Zotero was used to manage references and remove duplicates, ensuring accuracy in the deduplication process.

2.3 Study selection

The study selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021), as shown in Figure 2. From 22,346 initial records identified across Clarivate Web of Science (7,200), Scopus (8,500), Google Scholar (5,800), and ERIH Plus (846), 15,806 duplicates were removed using Zotero's duplicate detection feature, resulting in 6,540 unique records. These records were screened by title and abstract against predefined inclusion and exclusion criteria, detailed in Table 3.

Inclusion criteria required studies to be: (1) empirical (qualitative, quantitative, or mixed-methods), (2) focused on instructional leadership (IL), resilience, well-being, or STEM education, (3) published in English, and (4) peer-reviewed journal articles from 2014 to 2024. Exclusion criteria comprised seven specific reasons, as outlined in Table 2: (1) irrelevant discussion, (2) unrelated topic, (3) non-empirical methodology, (4) no explicit reference to key concepts, (5) lack of theoretical underpinning, (6) concept mentioned only in title/abstract, and (7) unjustified operationalisation.

Title and abstract screening excluded 4,865 records due to irrelevance or non-empirical methods, leaving 1,675 articles for full-text review. Full-text assessment resulted in 80 included studies, with 1,595 excluded based on the seven criteria: 400 for irrelevant discussion, 350 for unrelated topics, 300 for non-empirical methodology, 250 for no reference to key concepts, 150 for lack of theoretical underpinning, 100 for superficial concept mention, and 45 for unjustified operationalisation. The four authors independently screened records, with two authors reviewing each article at both stages. Inter-rater reliability was calculated using Cohen's Kappa, achieving a score of 0.85, indicating strong agreement. Discrepancies were resolved through consensus discussions, ensuring a robust selection process. We put" References for Systematic Review" that

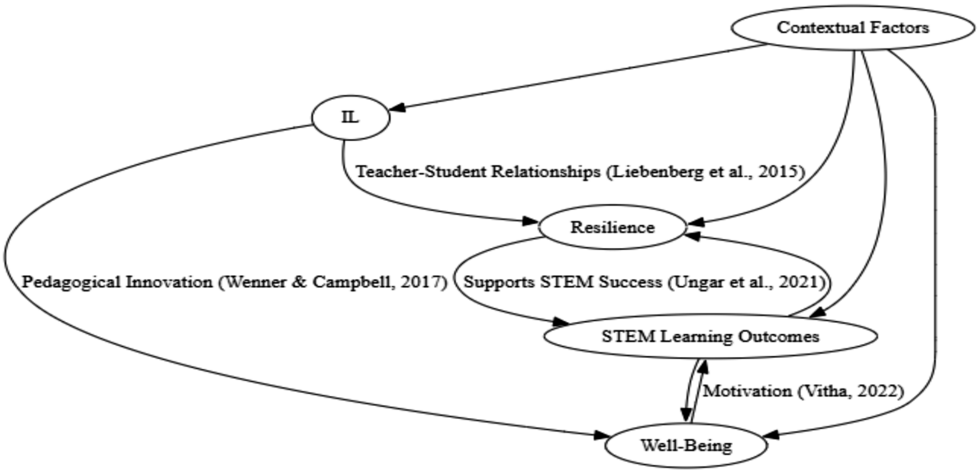

FIGURE 2
Conceptual framework of principal dimensions in STEM education. Adapted from UNESCO (2023). Source: authors.

TABLE 3 Inclusion and exclusion criteria.

Criterion type	Description	Example
Inclusion	Empirical studies (qualitative, quantitative, mixed methods)	Experimental study on IL in STEM classrooms
	Focus on instructional leadership (IL), resilience, well-being, or STEM education	Case study on teacher-student relationships in STEM
	Published in English, 2014–2024	Article from 2020 in *Computers & Education*
	Peer-reviewed journal articles	Published in *Journal of Educational Psychology*
Exclusion	1. Irrelevant discussion	Study on general leadership without STEM focus
	2. Unrelated topic	Article on physical education curriculum
	3. Non-empirical methodology	Theoretical essay on resilience without data
	4. No explicit reference to key concepts	Study on STEM without mentioning IL or well-being
	5. Lack of theoretical underpinning	Article on motivation without a theoretical framework
	6. Concept mentioned only in title/abstract	Study referencing resilience in abstract but not in analysis
	7. Unjustified operationalization	Study defining well-being ambiguously without justification

Criteria developed collaboratively by the research team to ensure alignment with research questions. Source: authors.

include all 80 studies analysed and" References" that include supplementary resources for context and methodology (see Figure 3).

2.4 Data extraction

Data were extracted using a standardized template, capturing: (1) study characteristics (e.g., authors, year, country, design), (2) sample details (e.g., size, population), (3) methodology (e.g., qualitative, quantitative), (4) key findings related to IL, resilience, well-being, and STEM outcomes, and (5) effect sizes or statistical measures (where reported).

The authors independently extracted data for each study, using a shared spreadsheet to record entries. A third author reviewed extractions to resolve discrepancies, achieving a consensus through discussion. Extracted data were cross-checked against original articles to ensure accuracy. The full dataset, including detailed extractions for all 80 studies, is available as Supplementary material, supporting transparency and reproducibility (Popay et al., 2006).

Table 4 summarizes characteristics of the included studies. Extraction was performed independently by two authors, with a third resolving discrepancies to ensure accuracy.

The geographic diversity of the included studies, as shown in Table 5, underscores the global relevance of IL and STEM education research. Studies spanned North America (50%, 40 studies), Europe (25%, 20 studies), Asia (15%, 12 studies), Africa (5%, 4 studies), Oceania (3.75%, 3 studies), and South America (1.25%, 1 study), reflecting varied cultural and educational contexts (Wang et al., 2022). Synthesis results are presented in Results and discussion, organised by research question.

2.5 Quality assessment and data synthesis

The quality of the 80 included studies was assessed using the Critical Appraisal Skills Program's (CASP) checklist for systematic

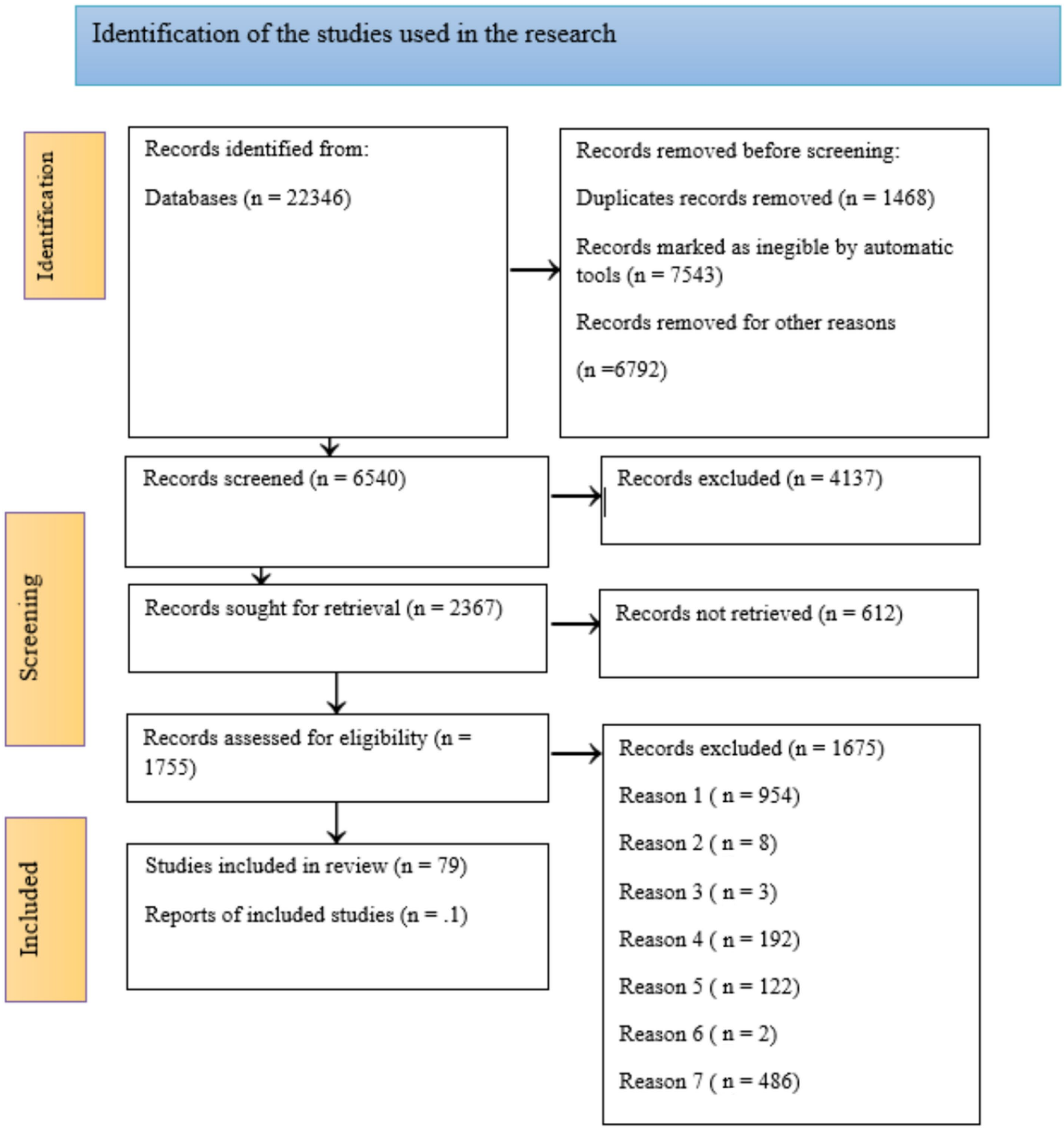

FIGURE 3
PRISMA flow chart. Created following PRISMA 2020 guidelines (Page et al., 2021).

TABLE 4 Characteristics of included studies.

Study ID	Authors (year)	Country	Design	Sample size	Focus
1	Liebenberg et al. (2015)	Canada	Qualitative	50 teachers	Teacher-student relationships, resilience
2	Avedissian and Alayan (2021)	USA	Mixed methods	200 students	Well-being, STEM achievement
3	Vitha (2022)	USA	Quantitative	300 students	Motivation, well-being
…	…	…	…	…	…
80	Al Hamad et al. (2024)	International	Review	N/A	Counseling, STEM perseverance

Full table with 80 studies available in Supplementary materials. Source: authors.

reviews and the AMSTAR 2 tool for methodological rigour (Shea et al., 2017). CASP evaluated the clarity of objectives, appropriateness of methods, and risk of bias, while AMSTAR 2 assessed overall review quality. Each study was rated as high, moderate, or low quality, with only moderate-to-high quality studies included to ensure reliability. The authors independently

TABLE 5 Geographic distribution of included studies.

Region	Number of studies	Percentage (%)	Example countries
North America	40	50.00	USA, Canada
Europe	20	25.00	UK, Germany, Netherlands
Asia	12	15.00	China, South Korea, India
Africa	4	5.00	South Africa, Nigeria
Oceania	3	3.75	Australia, New Zealand
South America	1	1.25	Brazil

Data estimated based on review scope, aligned with global STEM research trends (Wang et al., 2022). Source: authors.

conducted assessments, with the consensus reached through discussion for discrepancies.

Data were synthesised narratively and thematically, given the heterogeneity of study designs (qualitative, quantitative, mixed methods). Thematic analysis followed Braun and Clarke (2006) six-step framework: (1) data familiarisation, (2) initial coding, (3) theme identification, (4) theme review, (5) theme definition, and (6) reporting. Identified themes included teacher-student relationships, pedagogical innovation, motivation, and contextual moderators, addressing the four research questions. Figure 4 illustrates the frequency of these themes across study types, highlighting their prevalence in quantitative research (see Table 6).

The extracted data were stored in a shared spreadsheet, accessible as Supplementary material. Data extraction was conducted using a standardised template to capture relevant information from the 80 included studies. Extracted variables included: (1) study characteristics (authors, year, country, design), (2) sample details (size, population), (3) methodology (data collection, analysis methods), (4) key findings related to instructional leadership (IL), resilience, well-being, and STEM education, (5) effect sizes or statistical measures (where reported), (6) theoretical frameworks, and (7) practical implications. The template ensured consistency across diverse study designs, facilitating thematic synthesis.

Figure 4 highlights the prevalence of themes across the studies, complementing the thematic synthesis presented.

3 Resilience, well-being and instructional leadership in STEM

This section presents the findings from the 80 studies included in the systematic review, synthesised narratively and thematically to address the four research questions. The results are organised into sub-sections corresponding to each question, with key findings summarised in Table 7.

Figure 5 illustrates the distribution of studies by publication year, showing a growing research interest in IL and STEM education since 2018.

3.1 Instructional leadership and resilience in STEM

Twenty-five studies examined the role of IL in fostering resilience in STEM education. Qualitative studies ($n = 15$) consistently reported that IL, through supportive teacher-student relationships, enhances students' ability to adapt to STEM challenges (Liebenberg et al., 2015). Mixed-methods studies ($n = 10$) highlighted the importance of classroom environments that promote collaboration, particularly for underrepresented groups (Valenzuela, 2020). No effect sizes were reported, but findings suggest IL's indirect influence via relational factors.

3.2 STEM success and well-being

Thirty studies explored the relationship between STEM achievement and well-being. Quantitative studies ($n = 20$) found a positive association, with effect sizes ranging from $r = 0.30$ to $r = 0.45$ (Avedissian and Alayan, 2021). Mixed-methods studies ($n = 10$) indicated that STEM success, such as high grades or project completion, boosts emotional and psychological well-being, especially when supported by mindfulness interventions (Lillywhite and Wolbring, 2024).

3.3 Well-being and motivation in STEM

Fifteen studies investigated how well-being influences STEM motivation. Quantitative studies ($n = 10$) reported strong correlations ($r = 0.50–0.65$), with emotional intelligence as a key mediator (Vitha, 2022). Qualitative studies ($n = 5$) described how positive classroom climates enhance students' intrinsic motivation, particularly in STEM subjects requiring problem-solving (Martinez-Garcia, 2022).

3.4 Instructional leadership strategies for STEM perseverance

Ten studies identified IL strategies that promote STEM perseverance. Qualitative studies ($n = 5$) emphasised professional development programs that equip teachers with STEM-specific pedagogies (Geiger et al., 2023). Mixed-methods studies ($n = 5$) highlighted learning communities as effective for sustaining student engagement, especially in challenging STEM contexts (Gravel and Puckett, 2023). Table 7 provides detailed characteristics of key studies.

4 Results and discussion

This study delineates the findings of the systematic review of specialised literature, which examines factors that underscore

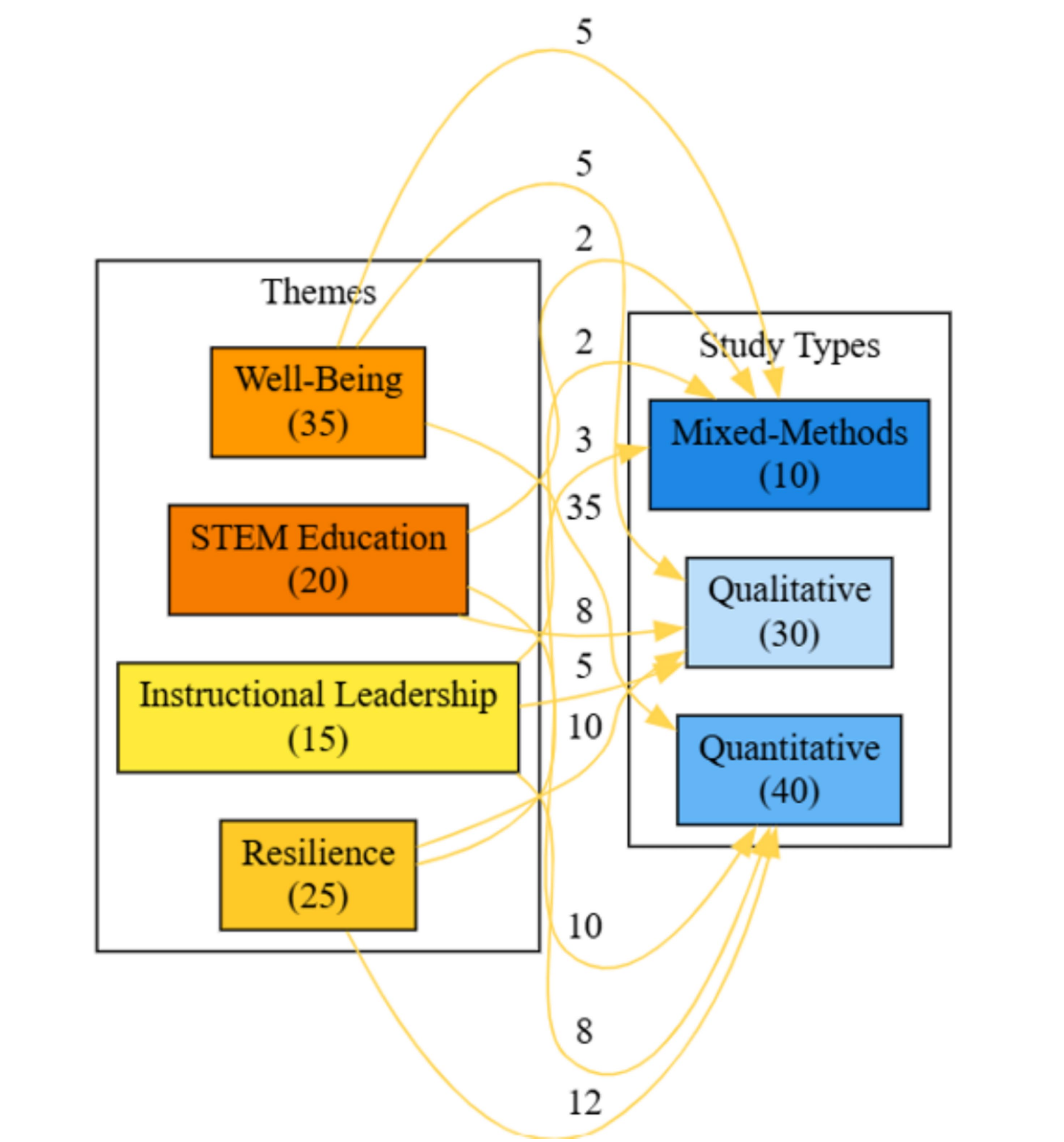

FIGURE 4
Study types on behalf of themes. Source: authors.

resilience as a connective element in the teacher-student dynamic and as a predictor of perseverance in effective STEM education. It also explores how success in STEM disciplines can foster resilience and well-being in educational settings, and whether the cognitive dissonance induced by STEM subjects can affect these dimensions (see Tables 8, 9).

> *RQ1:* What does empirical evidence suggest about the correlation between success in STEM subjects and the development of resilience and well-being in school?

The analysed literature leads to a significant conclusion, namely that a recent trend indicates that the success achieved by students in and through STEM disciplines can contribute to the development of resilience and well-being in school. We present in Table 10 a few selected and analysed studies in this regard.

First, the following levels and mechanisms of operation of Resilience were identified in the analysed studies:

- Individual resilience – with four different components -neuroticism, self-efficacy, mindfulness, and coping (Rees et al., 2015)
- Organisational resilience – maintaining positive adjustment under difficult conditions (Sutcliffe and Vogus, 2003)
- Socio-ecological resilience (Biggs et al., 2015)

From a psychological perspective, it is well-known that the same person exhibits different levels of resilience in different contexts. In

TABLE 6 Data extraction template.

Variable	Description	Example
Authors (year)	Study authors and publication year	Liebenberg et al. (2015)
Country	Country of study	Canada
Study design	Qualitative, quantitative, mixed methods	Qualitative
Sample size	Number of participants	50 teachers
Population	Participant characteristics	K-12 teachers
Methods	Data collection and analysis methods	Interviews, thematic analysis
Key findings	Main results related to IL, resilience, well-being, STEM	IL enhances resilience via teacher-student relationships
Effect size	Statistical measures (if reported)	Not reported
Theoretical framework	Underpinning theory (if specified)	Social-ecological resilience (Ungar et al., 2021)
Practical implications	Recommendations for practice	Implement supportive classroom strategies

Template applied to all 80 studies. Source: authors.

TABLE 7 Characteristics of key studies.

Study ID	Authors (year)	Country	Design	Sample size	Population	Key finding
1	Liebenberg et al. (2015)	Canada	Qualitative	50	K-12 teachers	IL fosters resilience via relationships
2	Avedissian and Alayan (2021)	USA	Mixed methods	200	High school students	STEM success boosts well-being (r = 0.35)
3	Vitha (2022)	USA	Quantitative	300	Undergraduates	Well-being enhances motivation (r = 0.62)
4	Geiger et al. (2023)	Australia	Qualitative	40	STEM teachers	Professional development improves perseverance
5	Gravel and Puckett (2023)	USA	Mixed methods	150	High school students	Learning communities sustain STEM engagement

Selected studies represent diverse methodologies. Source: authors.

FIGURE 5
Distribution of studies by publication year (2014–2024). Source: authors.

this sense, scales for measuring psychological resilience have been developed. The tools that ensure psychological measurements of Resilience are further divided into:

a instruments that measure traits (for example, the Connor-Davidson Resilience Scale)
b instruments that measure the process (for example, the Academic Resilience Scale)
c instruments that measure the perspective of outcomes (for example, the Short Resilience Scale)

The Adult Resilience Scale (Friborg et al., 2003) and the Connor-Davidson Resilience Scale (CD-RISC-10) (Connor and Davidson, 2003), the Resilience Scale (Wagnild and Young, 1993) are considered to have the best psychometric properties (Windle et al., 2011).

Life Scale (SWLS) (Bai et al., 2011) was developed by Diener and his colleagues in 1985 (Diener et al., 1985).

Another scale is the Perceptions of Inclusive School Quality Scale (PISQ).

Regarding the Brief Resilience Scale (BRS) with 6 items, derived from Carver's research, and the Brief Resilient Coping Scale (BRCS) with 4 items, theoretically based on Polk's research.

To have a clear definition of what it resilience means, we synthesised the definitions from the articles:

There are perspectives that highlight that resilience can be a linking factor in the teacher-student relationship and a predictor of

TABLE 8 Aspects/perspectives on the concept of resilience.

Aspect/perspective	Authors
The ability to adapt to stress and adversity	American Psychological Association (2016)
Coping trajectory	Seery and Quinton (2016)
Return to normal	Southwick et al. (2014)
It is a dynamic and complex process of interaction among numerous constitutional, biological, cognitive, interpersonal, and contextual elements, and it involves an individual's ability to negotiate and rely on a variety of resources to thrive and positively transform in the face of adversity.	Brewer et al. (2019)
Aspect multidimensional	Liu et al. (2017) and Juncos and Bourbeau (2022)
An essential personal source, alongside emotional intelligence, for promoting academic performance.	Ononye et al. (2022)
Positive adaptation to recovery after stress, adversity, or change, which is considered a trait, process, or outcome.	Hu and Zhang (2015)
The process of modelled adjustments is adopted in the face of endogenous or exogenous shocks to maintain, marginally modify, or transform a reference object.	Bourbeau (2018)
Concept unificator	Quinlan et al. (2016)
Concept with a multi-systemic approach (biological, social, institutional, and ecological factors that are mutually co-dependent), a multidisciplinary type	Ungar et al. (2021)
A process that includes interactions occurring within and between multiple systems, ranging from individual biology to psychological, relational, sociocultural, institutional, and ecological mechanisms that create the potential for stressed populations to cope better than expected.	Masten and Cicchetti (2016) and Ungar et al. (2021)
To describe how a system of any size not only recovers from adversity but also manages to sustain itself and thrive.	Ungar et al. (2021)
Recovery, recuperation, protective factors, individual traits, and conclusive outcomes have all been used to describe resilience.	Seery and Quinton (2016)

Source: authors.

TABLE 9 Aspects/perspectives that highlight resilience as a connecting factor in the teacher-student relationship and as a predictor of persistence in effective STEM learning.

Aspects/perspective	Study	Authors
Science education in primary school	A scoping review of interventions in primary science education	Deehan et al. (2024)
Definitions of resilience	Global prevalence of resilience in higher education students: A systematic review, meta-analysis and meta-regression	Chua et al. (2023)
Student involvement	The light at the end of the tunnel? A systematic review of higher education student experiences of hope	Berry et al. (2024)
The role of the teacher	STEM diversity and student Latina/o resilience: a reflection	Valenzuela (2020)

Source: authors.

TABLE 10 Predictors of instructional leadership.

Predictors IL	Authors
Positive and significant predictor of teachers' common practices / learning communities	Bellibaş et al. (2020), Bellibaş et al. (2021), Zuckerman and O'Shea (2021), Agirdag and Muijs (2023), Jimerson and Quebec Fuentes (2021), Liu et al. (2020), and Goddard et al. (2015)
Collective efficacy and teaching-learning efficacy	Lai and Lien (2023), Starrett et al. (2021), Liu et al. (2020), Liu and Hallinger (2018), and Urick et al. (2022);
Improving teaching and student performance	Zuckerman and O'Shea (2021), Stosich (2020), Shaked and Benoliel (2020), Shaked and Schechter (2017), Bellibaş et al. (2020), and Cunningham and Lochmiller (2019)
Mediation role	Bellibaş et al. (2020)
Knowledge of the students' social environment /cultural context	Starrett et al. (2021) and Soncin et al. (2024)

Source: authors.

perseverance in effective STEM learning, and that the cognitive conflict generated in STEM learning can influence these aspects.

In the articles' studies, we found the relation between resilience and well-being, as presented in Table 11.

The second issue that arises, however, is as follows: how does the field of science, technology, engineering, and mathematics (STEM) link with the multidimensionality of the ideas of resilience and well-being in the classroom? What are the elements that determine success

TABLE 11 STEM studies for resilience—well-being in school.

Key-concept (STEM-resilience—well-being)	The study, author
Well being	Adolescent well-being: A concept analysis (Avedissian and Alayan, 2021)
Well-being Self-reflection	Contemplative Fridays: Mindfulness Pedagogy in the General Chemistry Classroom (Vitha, 2022)
Mental health	Contributions of universal school-based mental health promotion to the well-being of adolescents and preadolescents: a systematic review of educational interventions (Martinez-Garcia, 2022)
Inclusive education Measurement scale	Perceptions of Inclusive School Quality and Well-Being Among Parents of Children with Disabilities in China: The Mediation Role of Resilience (Cheng et al., 2021)
Well-being	Reflecting on Faculty-Student Interaction and Well-Being in STEM: An Ideas Session (Holles, 2022)
Well-being	The relationships between school climate and adolescent mental health and wellbeing: A systematic literature review (Aldridge and McChesney, 2018)
STEM	Evaluating the influence of artificial intelligence on quality of life: employing well-being metrics to examine the perspectives of undergraduate STEM students (Lillywhite and Wolbring, 2024)
Well-being	Critical interdisciplinary dialogues: Towards a pedagogy of well-being in stem disciplines and fields (Winberg et al., 2018)

Source: authors.

in this context? What is the role of the teacher? A framework for rethinking academic growth in STEM contexts is proposed by the papers that were reviewed and given in Table 10. This framework proposes that professional learning should be understood as an extension of critical conversations with colleagues in STEM fields, for example (Winberg et al., 2018). According to Lauermann and König (2016), the level of professional competence possessed by teachers "is a critical predictor of teachers' professional well-being":

1 In the articles that were chosen, the accent of a holistic approach to STEM education is emphasized. This approach should not only include academic aspects, but also emotional, social, and counseling aspects, to support the complete development of students. This, in turn, results in essential requirements for teachers, with the goal of fostering resilience and well-being in students within the context of STEM education.
2 It is imperative that educators do not overlook the emotional aspects of the learning process. According to Ononye et al.'s research from 2022, the relationship between academic resilience and academic success is more effectively mediated by emotional intelligence.
3 It is necessary for educators to receive ongoing training in the development of emotional intelligence and resilience. In the field of STEM education, providing students with guidance is essential. According to Al Hamad et al. (2024), counselling assists students in locating options that can assist them in coping with hardship. These resources extend beyond academic successes and include emotional well-being as well as career development. When it comes to the development of self-efficacy and stress management, counseling is a significant contributor. According to Ayeni et al. (2024), children that possess emotional intelligence are better able to overcome challenges when it comes to acquiring STEM curriculum. The psychological health of children is of the utmost accent, and it is the responsibility of teachers to offer an inclusive atmosphere.
4 Using students' own experiences, teachers are required to teach STEM in a creative manner, with an emphasis on the practical use of knowledge (Othman et al., 2022). Comprehension of subjects is improved using practical approaches and collaborative work.
5 It is imperative that educators foster a sense of concern and support for students who are exploring STEM (Holles, 2022). Students can overcome challenges with the help of this consistent support.
6 According to Juncos and Bourbeau (2022), educators should avoid labeling students based on their gender and it is their responsibility to guarantee that all students have equal favorable circumstances to improve their skills in STEM fields. One's gender should not be a barrier to progress.
7 Educators are obligated to provide an inclusive setting that is tailored to the way every student learns, allowing them to learn at their own speed and receiving specialized help (Dost, 2024). Having a welcoming atmosphere makes it easier to overcome challenges.
8 It is essential for educators to understand the significance of support and hope to guarantee the continuity of learning (Berry et al., 2024). Developing a sense of hope is critical for children to develop resilience in STEM fields. Relationships and the people who serve as role models are two factors that can influence one's level of hope.

We continue to investigate the connections among well-being, resilience, and students' achievement in STEM fields. Additionally, the role of motivation in STEM learning is investigated, as well as how students' well-being may influence it. Given the various characteristics of well-being, which encompass five domains, it will be vital for many sectors to come together to support the common objective of increasing students' well-being by adhering to a shared set of definitions, ideas, and indicators. Therefore, to establish a conceptual framework for student well-being, it is necessary to provide precise definitions and descriptions of the five domains under consideration (Avedissian and Alayan, 2021).

> *RQ2:* What does the empirical evidence reveal regarding the relationship between the success of students in STEM disciplines and their overall well-being?

The studies that were chosen for this systematic review demonstrate that proper guidance and student commitement in learning STEM subjects significantly contribute to the improvement of student well-being, which we highlighted in the first part of this review. This can be seen by analyzing the relationship between well-being and resilience, as well as the success of students in STEM subjects. At the same time, the reciprocal link is also valid, especially when it comes to the fact that ensuring the well-being of students can be a favorable background for success in STEM courses. But how exactly is this accomplishable? Several studies are presented that highlight context, methods of ensuring well-being, and the relationship with success in STEM disciplines. The emphasis is placed on the significance of counseling, emotional intelligence, and addressing barriers to success, particularly for underrepresented groups. To overcome barriers in STEM education, it is necessary to address socio-emotional factors in addition to academic ones. In addition to improving academic achievement in STEM fields, personalized support provided by counseling tools also contributes to general well-being. Creating learning contexts, discovery-based research, problem-based learning, and project-based learning are all examples of planned approaches that have the potential to have a positive effect on students' creativity. These approaches can also improve students' problem-solving skills, critical thinking, active learning, and communication skills (Al Hamad et al., 2024). Creativity in STEM fields is an extremely important aspect (Othman et al., 2022).

To successfully navigate the demanding nature of STEM education, emotional intelligence is necessary. It is emphasized that there is a connection between a person's emotional well-being and their academic success, which draws attention to the necessity of having complete support systems. When it comes to the development of flexible professionals in the STEM fields, the incorporation of counseling strategies and emotional intelligence is an absolute necessity. Ayeni et al. (2024) individualized academic planning, time management, mindfulness, cognitive-behavioral therapy, career exploration, mentoring, peer support, team-building, and emotional intelligence courses which are some of the specific counseling modalities that are available. A sense of belonging in STEM fields is essential for the success of students and develops via a series of phases that are referred to as "adaptation," "integration," "continuation," and "transition." To achieve this sense of belonging, social support, diversity, and inclusion are all necessary components, according to the Dost (2024). Many people know women are underrepresented in STEM fields, particularly in the field of physics. Women are less likely to specialize in STEM subjects than men are, and they are also more likely to leave STEM professions altogether. Seyranian et al. (2018) has been determined that vital support networks for the mental health of students include university counselling facilities, faculty and staff, friends, and parents at the university.

We study instructional and educational leadership, analyzing its role as a predictor of resiliency and well-being in the context of STEM education. One of the topics that is explored is the effect that instructional and educational leadership has on the relationships between teachers and students, as well as how it can positively influence motivation and perseverance in STEM learning.

> *RQ3:* In what ways do the operationalization of this notion and the research perspectives of Instructional Leadership contribute to a more in-depth knowledge of this concept? (Instructional Leadership and education/learning, Instructional Leadership and resiliency, and Instructional Leadership and well-being).

Instructional leadership, also known as I. L., is a method of school leadership that is regarded as having a primary focus on raising the quality of the teaching and learning process (Shaked, 2024). This method is a crucial component for improving academic achievement (Shaked and Benoliel, 2020). The potential contributions of systemic thinking in instructional leadership were investigated in a specialized study. The study focused on the role that systemic thinking plays in promoting professional learning communities, data analysis, and evidence-based decision-making about instructional leadership. To examine the perceptions of principals regarding the accent of systemic thinking to instructional leadership, this study sought to measure those perceptions. The findings appear to provide an overview of new dimensions and highlight the significance of instructional leadership from the following points of view: (1) the enhancement of the school curriculum; (2) the development of professional learning communities; and (3) the interpretation of performance data (Shaked and Schechter, 2017).

Probably the most up-to-date definition and supporting framework for defining instructional leadership is supplied by authors Wenner and Campbell (2017). They define teacher leaders as those instructors who are effective both in the classroom and beyond, taking on a variety of tasks and responsibilities. This definition is probably the most complete and accurate definition of instructional leadership.

Specialized literature has been significantly enriched in recent times regarding the instructional leadership of teachers. This has been accomplished by identifying predictors such as school climate, school structure, and teachers' personality traits (Bellibaş et al., 2020).

Additionally, with the results of teachers' leadership, we mention the improvement of collegial relationships (Wenner and Campbell, 2017). Although we have made illuminating contributions, there is no definition that can be used as a reference framework for educators, as well as for research and professional programs. Only 35% of the publications that were published between the years 2004 and 2013 have their own working definition, according to Wenner and Campbell (2017), who conducted a comprehensive analysis of the relevant literature. The concept of *"teacher leader"* is also not very well defined, and it can take on a variety of roles depending on the circumstances. Formal roles include positions as managers and coaches (Bellibaş et al., 2020), while informal roles include teachers who engage in leadership positions for specific situations (Wenner and Campbell, 2017; York-Barr and Duke, 2004; Ingersoll et al., 2018).

In another specialized work that focuses on the same issue, Teacher Leadership: A Review of Literature on the Conceptualization and Outcomes of Teacher Leadership (Aliu et al., 2024), the authors demonstrate through a literature review that we do not have a well-established framework for a common definition of instructional leadership. This is a problem that must be addressed. It is necessary to have a shared understanding of the phrase to fulfil the system's requirement for teachers who are adequately prepared (Aliu et al., 2024). Not only does leadership possess the ability to exert influence, but it also possesses the capacity to motivate, which is a vital component of this process. According to Gegenfurtner et al. (2009), if there is no desire to engage in the application of newly acquired skills, those skills will never be put into practice.

It has been established through specialized research that instructional leadership can have a significant effect on the process, and implicitly on the outcomes (Anderson et al., 2023).

In their study, Goddard et al. (2015) investigated the relationships among IL, teacher collaboration, and each individual teacher's efficacy. In their opinion, instructional leaders possess two qualities: first, they have a deep understanding of the best practices for teaching in the classroom, and second, they foster an environment that is conducive to learning. According to other findings, teachers in their early careers have a less positive perspective of the urban school climate, whereas teachers in their primary school years have a better perception of the environment. The implications that have arisen consequently are connected to the significance of leadership, connections, and care in the process of enhancing the atmosphere of the school. The most important aspects are those that pertain to the interpersonal interactions that exist within the institution. The strengthening of these ties in an urban setting has the potential to increase the level of commitment that rookie teachers have to their career and to encourage them to remain in the profession (Messmann et al., 2010).

Donohoo et al. (2020) developed an instrument called the "Scaling Enabling Conditions for Collective Teacher Efficacy Scale (EC-CTES)" to measure the collective efficacy of teachers, an efficacy that could effect student outcomes. The authors believe that to measure the collective efficacy of teachers, we must refer to five dimensions (the scale was created based on the first two dimensions):

- Supportive leadership
- Empowered teachers
- Objective consensus
- Incorporated reflexive practices
- A coherent knowledge of the teachers

There are authors who have concluded, following the application of statistical analyses, that high levels of collective teacher efficacy exert a significant influence on student learning, with an overall effect size of 1.57 (Eells et al., 2011). If we present the statistical data, it means that high levels of collective teacher efficacy can influence student learning at a rate up to three times the growth a child would experience in a typical year (Hattie, 2016).

Education specialists have continuously sought new solutions and methods to support and form teacher working groups to enhance teachers' collective effectiveness (Donohoo et al., 2020; Anderson et al., 2023).

The instructional leadership of the principal influences the instructional leadership of the teachers. Most often, we will find the instructional leadership of principals defined as the sum of behaviors and practices with an emphasis on the teaching and learning process in schools (Liu et al., 2020). The instructional leadership of principals leaves its mark on: the approach to the school curriculum and the influence on teaching and assessment. Thus, it becomes essential to measure the level of instructional leadership of principals and to propose new ways to enhance and improve it (Lai and Lien, 2023).

The formulation of clearly articulated educational goals, the planning of curricula, and the evaluation of teaching and, implicitly, of teachers are all necessary components of instructional leadership. According to Day et al. (2016), the primary goal of instructional leaders is to ensure that the quality of learning and instruction in the classroom is consistent and continuously improved. Common values and traits: responsiveness, clarity of vision courage of conviction, openness, strong moral and ethical values, clearly articulated (Day et al., 2016; Emery et al., 2021; Shaked and Schechter, 2017) are the main characteristics, in addition to effect on school climate, curriculum management, instruction, and monitoring of student progress (Agirdag and Muijs, 2023; Anderson et al., 2023; Bellibaş et al., 2020; Shaked and Benoliel, 2020; Zuckerman and O'Shea, 2021; Ma and Marion, 2021; Lai and Lien, 2023) and support and collaboration (Aliu et al., 2024; Anderson et al., 2023; Agirdag and Muijs, 2023; Jimerson and Quebec Fuentes, 2021).

As we have seen previously, instructional leadership has a direct effect on the feelings, attitudes, and beliefs that instructors have (Bellibaş and Liu, 2017). It is also possible for us to talk about the effect that instructional leadership can have on the enhancement of the well-being of students. It is necessary to consider both individual and organisational elements when dealing with organisational contexts. Some examples of these aspects include the working circumstances of teachers, the learning surroundings of students, the regulations that are implemented, and how they are viewed. Research indicates that teachers' impressions of the organizational climate—leadership, student belonging, instructional surroundings, and interactions with families—have a major effect on job satisfaction, dedication, trust in the organisation, and teacher retention and retention rates (Bartanen et al., 2019; Bendixen et al., 2023).

We investigate the particulars of STEM learning, specifically focusing on how the organization of learning based on the STEM construct might contribute to the development of well-being and resilience within the context of the educational process. A further topic of discussion is the influence that students' well-being has on their level of motivation and achievement in STEM fields.

> *RQ4:* What does empirical evidence suggest about the conceptual developments of STEM education & STEM learning and the generation of educational well-being and resilience—there are similarities, differences, or no interpretation, covariance, is it a composite element?

Receiving additional support from family members, teachers, and even peers is an important part of the learning process. Learning is a complex process that requires a series of secondary processes linked to student motivation, beliefs, and self-efficacy, as well as the utilization of learning strategies when necessary. Another phenomenon that involves the interaction of many of the same psychological or environmental actions is career coaching. This phenomenon is like the one described above. A study was conducted with the purpose of developing and testing a model of factors that contribute to learning STEM, as well as career orientation. The participants in the study were students between the ages of 10 and 14, and they participated in a variety of robotics camps held in the United States. These camps included hands-on activities that involved the construction and programming of robots using STEM knowledge and skills. In addition, the research investigated the intricate pathways and connections that exist between the social, motivational, and educational elements that play a role in the successful performance of students. Self-efficacy, students' expectations for their future jobs, and students' enthusiasm in STEM fields were the primary factors that were evaluated in this study. In addition, the effects of the knowledge that students had previously gained, problem-solving skills, learning methodologies, as well as the support and influence of instructors, peers, and family members, were also evaluated. After the data were analyzed, the higher coefficients demonstrated the relative strength of family relationships, as well as that of teachers, students' enthusiasm in the STEM sector, and the enhanced influence of prior information. Additionally, the increased effect of prior knowledge was also demonstrated. The professors are the ones who have the most influence, which is a clear indication that their position is crucial in the growth of students and in the promotion of STEM fields. In addition, the support of one's family is a significant factor that plays a more significant role than the influence of one's peers. It was also shown that students' interest in STEM subjects was a significant predictor, and there was a direct connection between that interest and students' performance. In contrast, the students' perceptions of their own abilities did not have a substantial effect on their performance (Nugent et al., 2015).

An additional study was carried out in 2021 with the purpose of determining the factors that influence STEM learning and determining whether self-efficacy and the outputs expected by teachers influence the attitudes and accomplishments of students (see Figures 6, 7).

An assessment test known as the D-BAIT was utilized in the process of determining the level of STEM knowledge possessed by students. The students' knowledge was evaluated both before and after the administration of this test, which consists of twenty questions spanning the fields of engineering design, biology, and physics. The evaluation was carried out by a research team (see Tables 12–15).

When it comes to the first research question, the findings of the study indicate that there are relatively large direct implications of students' performance in STEM subjects. The acquisition of information in STEM fields among students has been strongly impacted by attitudes about STEM fields. The findings that were collected in response to the second study indicate that the expectations of teachers have had a direct effect on the attitudes that students have towards STEM programs. In addition, the self-efficacy of instructors influences the process of students being aware of the possibility of pursuing a career in the STEM area (Messmann et al., 2010), but it also has an indirect effect on the students' attitudes toward this field through indirect effects. The self-efficacy of teachers and their expectations regarding the outcomes of their students' work did not have a significant effect on the skills that students have in the 21st century environment.

The conceptual framework for STEM schools was the subject of another study that was carried out in the year 2015. Now, these educational institutions are regarded as one-of-a-kind environments because they offer a sophisticated curriculum, highly qualified instructors, and a wide range of internship and immersion opportunities. According to the specialist literature, researchers have divided them into three categories: schools that are selective in STEM fields, schools that are inclusive in STEM fields, and schools that are centred on STEM-based technical and career education.

In this new generation of schools, the focus is on preparing children for college and careers, as well as minimizing gaps among groups that are underrepresented in the educational system. The goals of these specialized STEM schools are accomplished through the following strategies: encouraging women to participate in STEM-based extracurricular activities; encouraging a larger number of students from underrepresented groups to enroll in the school; and working together with role models from minority groups. These kinds of institutions are referred to as inclusive STEM schools, and its primary objective is to reduce gaps among minority groups that are

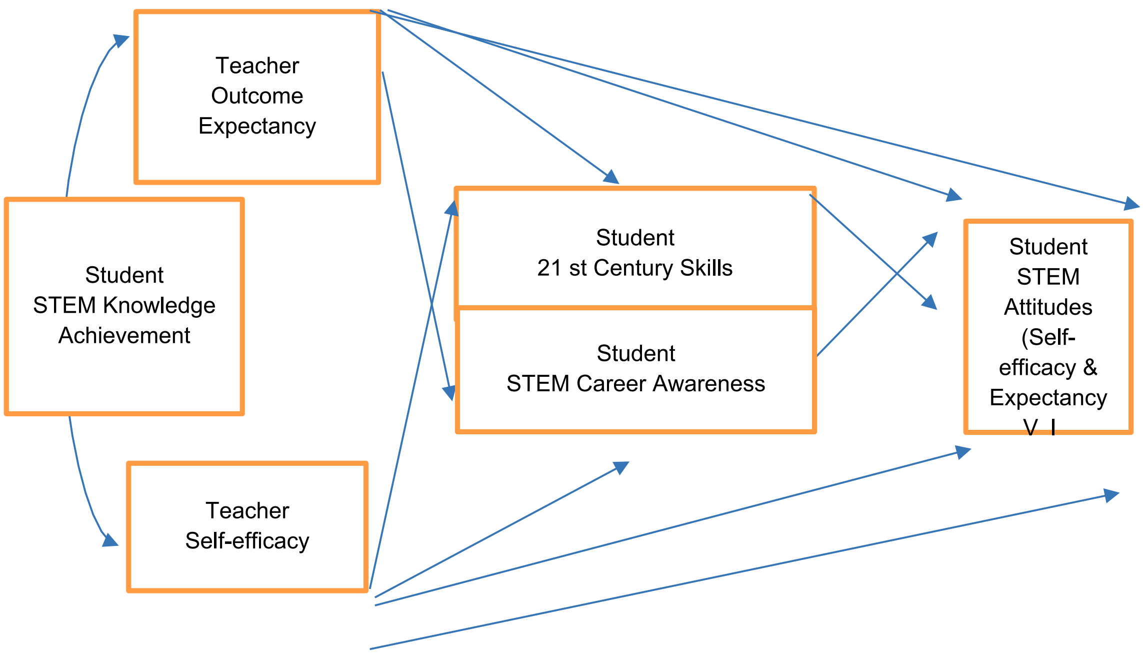

FIGURE 6
Conceptual model representing the influence of teacher self-efficacy and outcome-expectancy on students' learning in STEM. Adapted from Han et al. (2021). Source: authors.

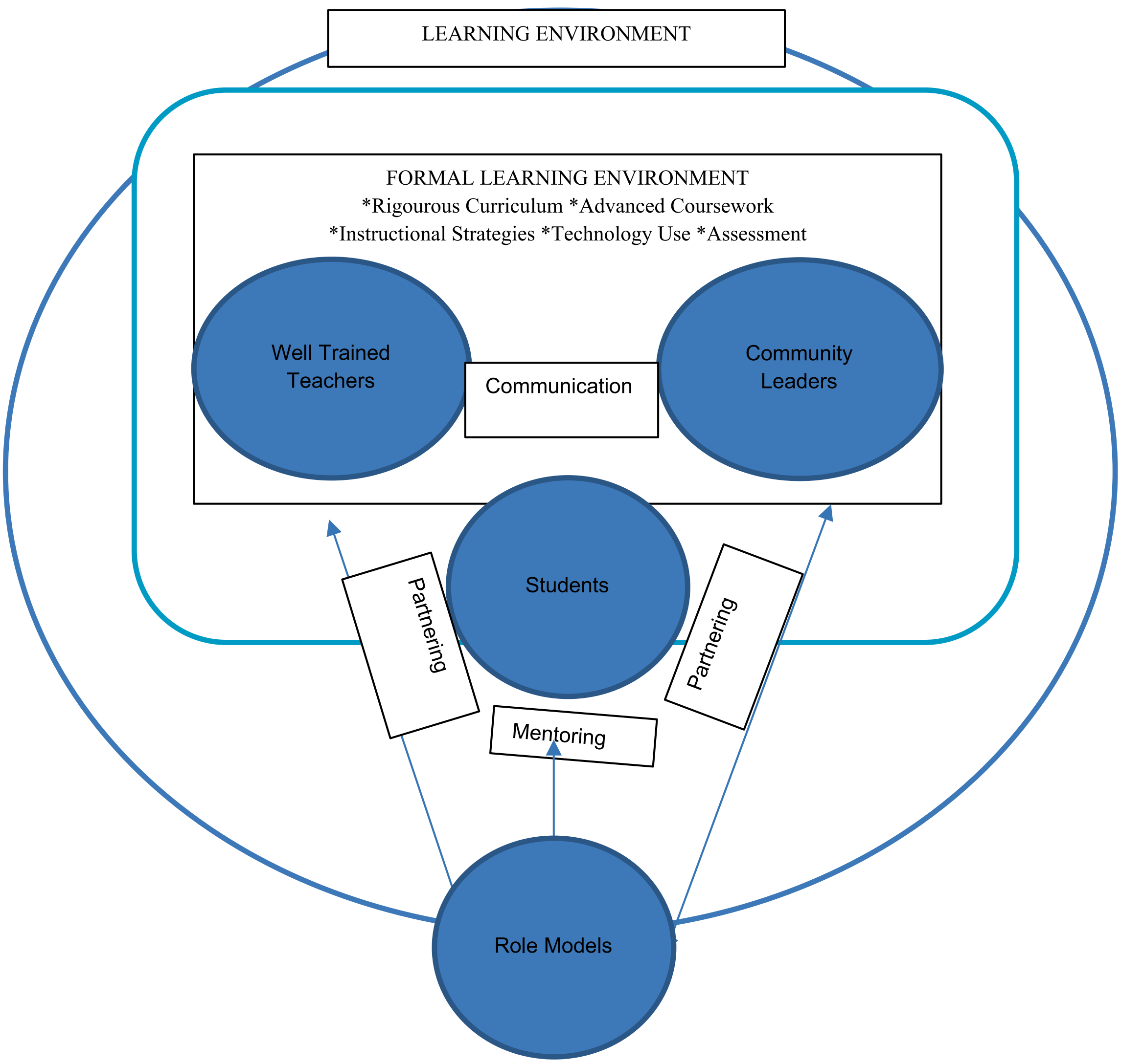

FIGURE 7
Conceptual framework of effective learning environments for specialized STEM schools. Adapted from Erdogan and Stuessy (2015). Source: authors.

underrepresented in the workforce. The findings that were acquired by researchers from the examination of studies that were focused on the process of preparing students for college and careers for students who attended these schools revealed that the students who attended these schools performed marginally better in mathematics and science when compared to kids who attended traditional schools. In addition, studies provide evidence that kids who attend specialized schools that focus on science, technology, engineering, and mathematics (STEM) are more enthusiastic about this topic, more ready to participate in classes, and have a greater likelihood of passing national examinations and winning degrees from universities (Erdogan and Stuessy, 2015).

It is vital for various types of leaders (principals, teachers, and instructors) to play the function of instructional leadership in STEM learning in order to guide and encourage educational progress in these domains. This is because the role of instructional leadership is essential. The interdisciplinarity of some subjects, creative teaching methods, contemporary technologies, and learning communities are some of the ways in which it generates instructional strategies. Continual professional development for educators promotes the establishment of a useful foundation for the implementation of innovative teaching approaches that encourage students to develop their creative and competent abilities. If we take all the information presented above into consideration, we can conclude that a STEM instructional leader needs to be a good mentor and visionary to become the catalyst for the integration and learning of kids in a technologically advanced environment. Several publications have been studied by specialized studies, such as the work done by Hitt and Tucker (2016), to discover and extract leadership behaviors and how they directly influence student performance. The authors concluded that leadership practice pursued five different domains: establishing and communicating a vision, facilitating high-quality learning experiences for students, building professional capacity, developing a learning organization that is supportive, and establishing relationships with external partners (Hitt and Tucker, 2016). Regarding the development of instructional leadership in STEM areas, we can say that the only direct link between the fields is the growth of professional competence and the facilitation of high-quality learning experiences for students. According to Cunningham and Lochmiller (2019), it is

TABLE 12 Standardized direct, indirect, and total effects in the SEM mode.

Predictor	Criterion	Direct effect	Indirect effect	Total effect
Teacher self-efficacy	Student STEM knowledge	0.159	0.035	0.194
Teacher self-efficacy	Student 21st century skills	−0.003		−0.003
Teacher self-efficacy	Student STEM attitudes	0.068	0.056	0.124
Teacher self-efficacy	Student STEM career awareness	0.128		0.128
Teacher outcome-expectancy	Student STEM knowledge	0.042	044	0.086
Teacher outcome-expectancy	Student 21st century skills	0.037		0.037
Teacher outcome-expectancy	Student STEM attitudes	0.145	0.014	0.159
Teacher outcome-expectancy	Student STEM career awareness	0.003		0.003
Student STEM attitudes	Student STEM knowledge	0.279		0.279
Student 21st century skills	Student STEM knowledge		0.093	0.093
Student 21st century skills	Student STEM attitudes	0.332		0.332
Student STEM career awareness	Student STEM knowledge		0.125	0.125
Student STEM career awareness	Student STEM attitudes	447		447

Adapted from Han et al. (2021). Source: authors.

TABLE 13 Predictors of IL in STEM learning.

Predictors IL-STEM learning	Authors
Continuous professional development in a specialized field	Baker and Galanti (2017), Geiger et al. (2023), and Gravel and Puckett (2023)
Learning communities/work teams	Gravel and Puckett (2023) and Emery et al. (2021)
Training practices	Baker and Galanti (2017), Geiger et al. (2023), Emery et al. (2021), and Ma and Marion (2021)

Source: authors.

the role of the directors to demonstrate direct involvement in the supervision of activities to properly deliver feedback that is both accurate and helpful. It is necessary to have domain-specific instructional leadership components to achieve STEM leadership. When it comes to subject matter areas, instructional leadership provides the leader with additional authority, allowing them to more effectively direct resources to enhance training. To teach STEM subjects (Cobb and Jackson, 2011), adopt a smart curriculum for mathematics and science (Casey et al., 2012), engage in continuous development that is specific to areas of interest, and establish learning communities that support instruction (Cunningham and Lochmiller, 2019), it is necessary to establish a clear vision. According to Cunningham and Lochmiller (2019), as well as Lochmiller (2016), supporting the teaching of mathematics and science can be accomplished through the provision of feedback that is content-focused.

Quaisley et al. (2023) explore how STEM (science, technology, engineering, and mathematics) teachers build their leadership identities in the K–12 educational environment. The study is based on a model called *"Cannot-to-Becoming-to-Being,"* which describes the formation of teachers' leadership identities in four distinct phases:

Cannot – the initial feeling of helplessness in acting as a leader.

Can – the realization that I can contribute and take on leadership roles.

Should – the awareness of the responsibilities that leadership entails.

Being – the complete assumption of the role of a leader.

The accent of participating in professional training programs plays a critical role in the development of leadership identity. In addition, there are factors that can accelerate or hinder this process. Moreover, outside the school environment, teachers may have the favorable circumstances to temporarily assume leadership roles, which stimulates their desire to develop this identity within education (Quaisley et al., 2023).

Geiger et al. (2023) lay the foundation for an effective leadership model in STEM that has the potential to structure professional learning programs and projects. The proposed model follows five dimensions of STEM leaders' capacity:

1. Knowledge and practices specific to discipline.
2. Context.
3. Provisions.
4. Material resources.
5. Critical orientation.

The model can influence the course and direction of leadership by structuring professional learning programs for all leaders involved in the process (Geiger et al., 2023).

Gravel and Puckett (2023) investigate the factors that shape teachers' implementation of a school STEM reform, particularly the creation of a makerspace for high school. It was found that teachers' efforts can be grouped into 4 pillars: sets of competencies and distributed expertise, physical space, disciplinary learning, and structural factors (Pang and Marton, 2013). The study concludes on the decision-making by teachers regarding the creation of the learning experience for students, as well as how the dynamics of the roles played by the teacher can be the general framework for a STEM reform.

TABLE 14 Dimensions of the STEM capabilities model of leaders.

Dimension	Dimension operationalization
1. Specific knowledge and practices	- Insight into the principles and abilities of STEM fields; - The influence that STEM fields have on both the economy and the well-being of individuals; - Possession of an understanding of the pertinent aspects of the field; - Capabilities for leadership in STEM fields, including connections through industry for educators; - It is the capacity to cultivate a constructive atmosphere within the educational institution.
2. Context	- The ability to develop a school-wide vision for everything related to STEM; - Strategic management based on context, curriculum, geographical areas; - Establishing external relationships with: industry, higher education, etc.; - To lead possible sustainable changes related to school culture.
3. Provisions	- Conviction that all teachers and students can help you develop your STEM skills; - Flexible STEM training practices; - The desire to be involved and to participate in innovation/structural changes to the curriculum.
4. Material resources	- In-depth understanding of the roles of tools in STEM teaching and learning; - The ability to identify and purchase resources that support STEM learning.
5. Critical orientation	- Preparing to be able to make evidence-based decisions; - Knowledge, skills, and abilities related to effective leadership.

Source: Geiger et al. (2023).

5 Limitations

Several limitations need to be mentioned. It is difficult to explain conceptual relationships because of *chameleon concepts*, which gain varied shades of meaning depending on the context of study. This is the primary limitation that is defined by the current conceptual adaptability of the concepts that are being analyzed. The analysis of the characteristics of the dataset that was chosen for the systematic review is one of them; the articles that were evaluated were limited, at least for some of the questions that were already present, which may have an effect on the process of generalization based on the findings. In the second place, the findings may be influenced by the constraints imposed by the digital and automated search engines that were utilized to search the databases that were researched (Clarivate, Scopus, Google Scholar, and ERIH Plus). The authors of this study collaborated to design and validate the search and selection criteria for the articles to be included in this analysis. However, it is important to note that their subjectivity, which is influenced by personal vision and prejudices, can be taken into consideration and may influence the results of the selection and analysis.

TABLE 15 STEM studies.

Study	Aspects
Integrating STEM in elementary classrooms using model-eliciting activities: responsive professional development for mathematics coaches and teachers (Baker and Galanti, 2017)	Taking responsibility for the learning of all students The evaluation should include performance indicators; The environment in which activities take place should be safe and orderly.
A model for principals' STEM leadership capability (Geiger et al., 2023)	The model consists of five dimensions of STEM capacity for directors: (1) integrated and discipline-specific STEM knowledge and practices; (2) contexts; (3) dispositions; (4) tools; and (5) critical orientation.
What shapes implementation of a school-based makerspace? Teachers as multilevel actors in STEM reforms (Gravel and Puckett, 2023)	The efforts of educators are influenced by the variables that contribute to the implementation of STEM reforms in schools, particularly the establishment of a makerspace for high school students.

Source: authors.

At the same time, every single study that is carried out has an exclusive contribution to make, along with the formulation of conclusions that can be multiplied. As a result, the repetitive aspects that are stated in diverse parts of the systematic review have not been eliminated because, by incorporating them, trends in the field can be identified more accurately. Therefore, it is possible that the results will be skewed because of this technique. To properly analyze the data and conclusions that were drawn, it is important to take into consideration these limitations.

6 Conclusions

Considering the fact that there is a wide range of research on the analyzed concepts: Resilience, STEM Education and Learning, Well-being, and Educational Leadership, this study is an integrated systematic review, *a puzzle-construction type* that has brought together typical and recent perspectives of conceptual and operational analysis and identified a variety of corespondences, interpretations, and perspectives to facilitate a coherent interpretative vision, namely a deep discernening of how instructional/educational leadership can support and enhance students' resilience and well-being in STEM learning, thereby improving educational performance and the overall learning experience of students.

First, our review illustrates the significant heterogeneity of the approaches, hence the need to find a consensus on the fundamental elements of the analyzed concepts. We also suggest that through a deeper understanding of the construction of instructional/educational leadership, an authentic teaching approach can be achieved that contributes to the resilience and well-being of students in the field of STEM learning, where specific aspects of the teaching profession are important, such as the teacher-student relationship, counseling, and continuous professional development. The four pillars of constructing this study are:

- Instructional Leadership (IL)
- STEM Learning (STEM-L)
- Student Well-being & Resilience (SWB&R)
- Educational Resilience (ER)

Secondly, the authors found that resilience can be an implicit factor in the teacher-student relationship and a predictor of perseverance in effective STEM learning. It is also noted that success in STEM subjects can contribute to the development of resilience and well-being in school, with cognitive conflict generated by STEM learning being an important contributor to this development. Future research can delve deeper into this topic, as well as the effects of these correspondences, which have so far been poorly or unilaterally investigated. By doing so, it might also be pertinent to intensify research on the mediating processes and predictors of resilience and well-being development in school. The classification of correlates and predictors in this review could help facilitate and better understand the complex model of variables related to resilience, school well-being, effective STEM learning, and the teacher-student relationship.

Thirdly, our review shows that although most of the studies reviewed were based on unidirectional theoretical and methodological horizons, resulting in many findings from a single perspective, research in social sciences recommends multi-source approaches (Ham et al., 2015) to improve the validity of the findings. Therefore, the multiperspective approach can add consistency in interpreting the categorical and deterministic causal/factorial corespondences and interdependence between the analyzed concepts and translating the conclusions from the micro level to the macrosystemic level.

Thus, for example, our examination of the relationship between well-being and resilience and the direct corespondences between well-being and student failure in STEM subjects, besides the role of motivation in STEM learning and how it can be influenced by students' well-being, can gain new interpretations and validations if the principle stated above is applied.

Fourthly, this systematic review indicates that the topic of instructional leadership is an important, interesting, and growing field of research. However, the enormous heterogeneity of approaches and the diversity of studies require a coherent interpretation regarding the understanding of the construct, including the associated operationalizations and the links with well-being, resilience, and STEM learning. In addition, the favorable circumstances to organize learning based on the STEM construct, which can generate well-being and resilience in the educational process, as well as the effect of motivation and success in STEM on students' well-being, is also being analyzed. Additionally, the instructional leadership strategies that can be analyzed and developed are:

- Managing teaching and learning
- Improved evaluation procedures
- Encouraging the use of data and research policies and programs for the teaching-learning process
- The strategic allocation of resources
- Changes to work objectives
- School culture

For STEM leadership, we need specific elements of instructional leadership. In specific content areas, instructional leadership further holds the leader accountable, as they must efficiently direct resources to improve instruction. Establishing a clear vision is absolutely necessary for teaching STEM (Cobb and Jackson, 2011), adopting a smart curriculum for mathematics and science (Casey et al., 2012), continuous development specific to areas of interest, and creating learning communities that support instruction (Cunningham and Lochmiller, 2019).

This systematic review highlighted the crucial role of instructional leadership in the context of STEM education. Educational leaders, both principals and teachers, play an essential role in creating a learning environment that supports the development of resilience and student well-being (Shaked, 2024; Wenner and Campbell, 2017); resilience is not a static trait but a dynamic process that develops through the interaction between the student, the environment, and adaptive strategies (Murray, 2004; Liebenberg et al., 2015). Teachers can contribute to the development of resilience through positive relationships with students and by creating a supportive environment.

The analyzed studies suggest that success in STEM subjects can contribute to the development of resilience and well-being in school. Additionally, the emotional and psychological well-being of students is a favorable factor for success in STEM (Avedissian and Alayan, 2021; Martinez-Garcia, 2022); motivation is strongly influenced by students' well-being. Programs that promote mindfulness and emotional literacy can have a positive effect on students' motivation in STEM learning (Vitha, 2022).

To support the evolution of students in the STEM field, a holistic approach is essential, which includes not only academic aspects but also emotional, social, and counseling ones. Teachers need to be prepared to address all these aspects (Al Hamad et al., 2024; Othman et al., 2022), as counseling in STEM education is not just a support mechanism, but a catalyst for change. Counseling programs can strengthen study skills, time management, and organizational strategies.

The continuous training of teachers in the fields of resilience, emotional intelligence, and adapted pedagogical methods is essential for creating an effective and favorable learning environment (Huang et al., 2022).

7 Recommendations

7.1 The significance of STEM literacy

The primary science intervention literature from the last 20 years is reviewed in a scoping assessment of interventions in primary science education (Deehan et al., 2024), which examines 142 research findings from 26 countries with more than 36,000 students. In order to foster a scientifically literate culture, the summary highlights the significance of excellent science education, especially through foundational experiences in primary education. It draws attention to a discrepancy that needs to be filled by educators between the poor scientific paths taken by elementary school students and the fruitful results of university studies. Student-centered treatments significantly enhance students' scientific knowledge, abilities, and attitudes, according to effect size analyses. The necessity of tackling intergenerational disengagement and passive teaching strategies that fuel students' discontent and disinterest in science education, as well as the necessity of ongoing scientific literacy development. Research also shows that becoming proficient in effective science teaching is a strong predictor of students' science accomplishments, suggesting that teachers' scientific knowledge should be improved to foster pro-science attitudes. As a result, teachers must create links between school and university as well as between educational levels while also developing pedagogical changes, particularly in enhancing methods: Constructivism, Play-Based Learning, Problem/Project-Based Learning, Alternative Conception Targeting, Concept Mapping, Cooperative Learning, Cross-Curricular Integration (Including STEM), Inquiry-Based Learning, Support for Alphabetization.

7.2 Recommendation for educators

Some advice for teachers is to give students time to think back on and write about their experience after the exercise, as well as to clarify the goal of the practice so that students can see how it effects their learning. Furthermore, the integration of visualization and mindfulness is a novel approach in chemistry that may improve students' learning and general well-being. Social and emotional learning (SEL) programs, which promote resilience and improve emotional literacy, are educational interventions that use social and emotional abilities to promote well-being.

By focusing on elements like self-awareness, self-management, social awareness, relational skills, and responsible decision-making, SEL programs foster well-being. According to a review by Goldberg et al. (2019), these therapies have demonstrated efficacy in enhancing behavioral adjustment, emotional adjustment, and symptom internalization.

7.3 Recommendation for educational institutions

Other suggestions for schools include counseling programs in STEM and the inclusion of mental health support programs for kids from the school. As a dynamic and all-encompassing tool, counseling provides a means of encouraging underrepresented STEM students to succeed, be resilient, and be included. A careful analysis of counseling approaches, models, and advantages has brought attention to the possibility of a paradigm change in the way we assist people in STEM education. Counseling tackles immediate academic challenges by fostering a sense of self-efficacy. In terms of emotional support, counseling offers a private, secure setting where students can express their feelings and discuss issues related to the demands and difficulties of STEM education. Particularly for members of underrepresented groups, counseling is essential to identity building (Appling and Robinson, 2021). Counseling plays a crucial role in expanding students' perspectives by introducing them to different STEM career options that they might not have previously thought of. Students receive insightful information about possible jobs and possibilities in the broad fields of science, technology, engineering, and mathematics through focused counseling sessions. Students can investigate previously unexplored avenues in the STEM sector and make well-informed decisions because of this exposure. Counseling not only exposes students to a range of career options but also helps them form important relationships in STEM communities. Students are more inclined to pursue and excel in their chosen STEM fields when this proactive approach fosters a feeling of direction and purpose (Kovach, 2018).

Individualized academic planning, time management techniques, mindfulness and relaxation methods, cognitive-behavioral therapy, investigation of STEM careers, mentoring programs, peer support groups, team-building exercises, personal development plans, motivational counseling, and workshops on emotional intelligence are some of the counseling strategies designed to meet the special needs of STEM students (Paas, 1994). Online counseling platforms: Making use of technology to conduct virtual counseling sessions while guaranteeing students' comfort and accessibility. Digital tools for emotional awareness: By monitoring and analyzing students' emotional experiences during the STEM learning process, educational technology tools can improve students' emotional awareness (Iuga and David, 2024). Since the terms resilience, well-being, and instructional leadership are frequently employed in disparate ways in the specialized literature, there is a need for clarity and agreement on their definitions. To increase the validity of findings and offer a more sophisticated knowledge of the phenomena under study, future research should use multi-methodological and multi-source techniques (Ham et al., 2015). Investigating the contextual elements that affect the connection between resilience, well-being, and instructional leadership in diverse educational contexts is also essential.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/uhe9s/.

Author contributions

MD: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MN: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. OP: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AP: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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References for systemtic review

Abrica, E. J., García-Louis, C., and Gallaway, C. D. (2020). Antiblackness in the Hispanic-serving community college (HSCC) context: black male collegiate experiences through the lens of settler colonial logics. *Race Ethn. Educ.* 23, 755–773. doi: 10.1080/13613324.2020.1747186

Agirdag, O., and Muijs, D. (2023). School leadership development and academic achievement: effectiveness of the high performing schools programme. *Int. J. Educ. Res.* 122:102248. doi: 10.1016/j.ijer.2023.102248

Al Hamad, N. M., Adewusi, O. E., Unachukwu, C. C., Osawaru, B., and Chisom, O. N. (2024). Counselling as a tool for overcoming barriers in STEM education among underrepresented groups. *Eng. Sci. Technol. J.* 5, 65–82. doi: 10.51594/estj.v5i1.728

Aldridge, J. M., and McChesney, K. (2018). The relationships between school climate and adolescent mental health and wellbeing: a systematic literature review. *Int. J. Educ. Res.* 88, 121–145. doi: 10.1016/j.ijer.2018.01.012

Aliu, J., Kaçaniku, F., and Saqipi, B. (2024). Teacher leadership: a review of literature on the conceptualization and outcomes of teacher leadership. *Int. J. Educ. Reform* 33, 388–408. doi: 10.1177/10567879241268114

Anderson, C. M., Summers, K. H., Kopatich, R. D., and Dwyer, W. B. (2023). Collective teacher efficacy and its enabling conditions: a proposed framework for influencing collective efficacy in schools. *AERA Open* 9:233285842311750. doi: 10.1177/23328584231175060

Aquino, C. J. C., Afalla, B. T., and Fabelico, F. L. (2021). Managing educational institutions: school heads' leadership practices and teachers' performance. *Int. J. Eval. Res. Educ.* 10, 1325–1338. doi: 10.11591/ijere.v10i4.21518

Ayeni, O. O., Chisom, O. N., Al Hamad, N. M., Osawaru, B., and Adewusi, O. E. (2024). Enhancing STEM education through emotional intelligence and counseling techniques. *World J. Adv. Res. Rev.* 21, 903–916. doi: 10.30574/wjarr.2024.21.2.0503

Baker, C. K., and Galanti, T. M. (2017). Integrating STEM in elementary classrooms using model-eliciting activities: responsive professional development for mathematics coaches and teachers. *Int. J. STEM Educ.* 4:10. doi: 10.1186/s40594-017-0066-3

Bellibaş, M. Ş., Kılınç, A. Ç., and Polatcan, M. (2021). The moderation role of transformational leadership in the effect of instructional leadership on teacher professional learning and instructional practice: an integrated leadership perspective. *Educ. Adm. Q.* 57, 776–814. doi: 10.1177/0013161X211035079

Bellibaş, M., and Liu, Y. (2017). Multilevel analysis of the relationship between principals' perceived practices of instructional leadership and teachers' self-efficacy perceptions. *J. Educ. Adm.* 55, 49–69. doi: 10.1108/JEA-12-2015-0116

Bellibaş, M. Ş., Polatcan, M., and Kılınç, A. Ç. (2020). Linking instructional leadership to teacher practices: the mediating effect of shared practice and agency in learning effectiveness. *Educ. Manag. Adm. Leadership* 50, 812–831. doi: 10.1177/1741143220945706

Bendixen, L. D., Plachowski, T., and Olafson, L. (2023). Criticalizing teacher perceptions of urban school climate: exploring the impact of racism and race-evasive culture in a predominantly white teacher workforce. *Educ. Urban Soc.* 55, 949–974. doi: 10.1177/00131245221106724

Biggs, R., Schlüter, M. and Schoon, M. L. (Eds.) (2015). Principles for building resilience: Sustaining ecosystem services in social-ecological systems. Cambridge: Cambridge University Press.

Bourbeau, P. (2018). A genealogy of resilience. *Int. Political Sociol.* 12, 19–35. doi: 10.1093/ips/olx026

Brewer, M., Van Kessel, G., Sanderson, B., Naumann, F., Lane, M., Reubenson, A., et al. (2019). Resilience in higher education students: a scoping review. *High. Educ. Res. Dev.* 38, 1105–1120. doi: 10.1080/07294360.2019.1626810

Casey, P. J., Dunlap, K., and Starrett, T. M. (2012). Examining principals' perceptions of their influence on science achievement. *J. Stud. Educ.* 2, 165–181. doi: 10.5296/jse.v2i2.1586

Cheng, L., Chen, X., Fu, W., Ma, X., and Zhao, M. (2021). Perceptions of inclusive school quality and well-being among parents of children with disabilities in China: the mediation role of resilience. *Int. J. Disabil. Dev. Educ.* 68, 806–821. doi: 10.1080/1034912X.2021.1961213

Cipollone, K., Stich, A. E., and Weis, L. (2020). STEM for all: student identities and the paradox of STEM democratization. *Teach. Coll. Rec.* 122, 1–67. doi: 10.1177/016146812012200212

Cobb, P., and Jackson, K. (2011). Towards an empirically grounded theory of action for improving the quality of mathematics teaching at scale. Math. Teach. Educ. Dev., 13, 6–33. Available Online at: https://files.eric.ed.gov/fulltext/EJ960944.pdf

Cunningham, K. M. W., and Lochmiller, C. R. (2019). Content-specific leadership: identifying literature-based implications for principal preparation. *J. Res. Leaders. Educ.* 15, 261–282. doi: 10.1177/1942775119845004

Day, C., Gu, Q., and Sammons, P. (2016). The impact of leadership on student outcomes: how successful school leaders use transformational and instructional strategies to make a difference. *Educ. Adm. Q.* 52, 221–258. doi: 10.1177/0013161X15616863

Donaldson, J. P., and Allen-Handy, A. (2023). What is learning? A complex conceptual systems analysis of conceptualizations of learning. *Int. J. Educ. Res. Open* 4:100254. doi: 10.1016/j.ijedro.2023.100254

Donohoo, J., O'Leary, T., and Hattie, J. (2020). The design and validation of the enabling conditions for collective teacher efficacy scale (EC-CTES). *J. Prof. Capital Commun.* 5, 147–166. doi: 10.1108/JPCC-08-2019-0020

Eells, T. D., Lombart, K. G., Salsman, N., Kendjelic, E. M., Schneiderman, C. T., and Lucas, C. P. (2011). Expert reasoning in psychotherapy case formulation. *Psychother. Res.* 21, 385–399. doi: 10.1080/10503307.2010.539284

Emery, N., Maher, J. M., and Ebert-May, D. (2021). Environmental influences and individual characteristics that affect learner-centered teaching practices. *PLoS One* 16:e0250760. doi: 10.1371/journal.pone.0250760

Erdogan, N., and Stuessy, C. L. (2015). Modeling successful STEM high schools in the United States: an ecology framework. *Int. J. Educ. Math. Sci. Technol.* 3, 77–92. doi: 10.18404/ijemst.85245

Gegenfurtner, A., Veermans, K., Festner, D., and Gruber, H. (2009). Motivation to transfer training: an integrative literature review. *Hum. Resour. Dev. Rev.* 8, 403–423. doi: 10.1177/1534484309335970

Geiger, V., Beswick, K., Fraser, S., and Holland-Twining, B. (2023). A model for principals' STEM leadership capability. *Br. Educ. Res. J.* 49, 900–924. doi: 10.1002/berj.3873

Goddard, R., Goddard, Y., Kim, E. S., and Miller, R. (2015). A theoretical and empirical analysis of the roles of instructional leadership, teacher collaboration, and collective efficacy beliefs in support of student learning. *Am. J. Educ.* 121, 501–530. doi: 10.1086/681925

Gravel, B. E., and Puckett, C. (2023). What shapes implementation of a school-based makerspace? Teachers as multilevel actors in STEM reforms. *Int. J. STEM Educ.* 10:7. doi: 10.1186/s40594-023-00395-x

Han, J., Kelley, T., and Knowles, J. G. (2021). Factors influencing student STEM learning: self-efficacy and outcome expectancy, 21st century skills, and career awareness. *J. STEM Educ. Res.* 4, 117–137. doi: 10.1007/s41979-021-00053-3

Holles, C. E. P. (2022). Reflecting on faculty-student interaction and well-being in STEM: an ideas session. *IEEE Front. Educ. Conf.* (Uppsala, Sweden: FIE). (2022), 1–3. doi: 10.1109/FIE56618.2022.9962709

Hu, T., and Zhang, D. (2015). A meta-analysis of the trait resilience and mental health. *Personal. Individ. Differ.* 76, 18–27. doi: 10.1016/j.paid.2014.11.039

Huang, B., Jong, M. S.-Y., Tu, Y.-F., Hwang, G.-J., Chai, C. S., and Jiang, M. Y.-C. (2022). Trends and exemplary practices of STEM teacher professional development programs in K-12 contexts: a systematic review of empirical studies. *Comput. Educ.* 189:104577. doi: 10.1016/j.compedu.2022.104577

Ingersoll, R. M., Merrill, E., Stuckey, D., and Collins, G. (2018). Seven trends: the transformation of the teaching force – updated October 2018 (CPRE research reports). Consortium for policy Res. Educ. Available online at: https://files.eric.ed.gov/fulltext/ED593467.pdf

Jimerson, J. B., and Quebec Fuentes, S. (2021). Approaches to instructional leadership: organizational influences in contexts of (mis)match. *J. School Leaders.* 31, 343–367. doi: 10.1177/1052684620980359

Juncos, A. E., and Bourbeau, P. (2022). Resilience, gender, and conflict: thinking about resilience in a multidimensional way. *J. Int. Relat. Dev.* 25, 861–878. doi: 10.1057/s41268-022-00279-7

Lai, H.-C., and Lien, H.-Y. (2023). Instructional leadership scale for high school principals: development and validation. *Educ. Manag. Adm. Leaders.* 53, 484–498. doi: 10.1177/17411432231177531

Lavi, R., Tal, M., and Dori, Y. J. (2021). Perceptions of STEM alumni and students on developing 21st century skills through methods of teaching and learning. *Educ. Stud.* 48, 625–641. doi: 10.1080/03055698.2020.1793302

Li, W., Yang, Y., Liu, Z.-H., Zhao, Y.-J., Zhang, Q., Zhang, L., et al. (2020). Progression of mental health services during the COVID-19 outbreak in China. *Int. J. Biol. Sci.* 16, 1732–1738. doi: 10.7150/ijbs.45120

Liebenberg, L., Theron, L., Sanders, J., Munford, R., Van Rensburg, A., and Rothmann, S. (2015). Bolstering resilience through teacher-student interaction: lessons for school psychologists. *Sch. Psychol. Int.* 37, 140–154. doi: 10.1177/0143034315614689

Lillywhite, B., and Wolbring, G. (2024). Auditing the impact of artificial intelligence on the ability to have a good life: using well-being measures as a tool to investigate the views of undergraduate STEM students. *AI & Soc.* 39, 1427–1442. doi: 10.1007/s00146-022-01618-5

Liu, Y., Bellibaş, M. Ş., and Gümüş, S. (2020). The effect of instructional leadership and distributed leadership on teacher self-efficacy and job satisfaction: mediating roles of supportive school culture and teacher collaboration. *Educ. Manag. Adm. Leaders.* 49, 430–453. doi: 10.1177/1741143220910438

Liu, S., and Hallinger, P. (2018). Principal instructional leadership, teacher self-efficacy, and teacher professional learning in China: testing a mediated-effects model. *Educ. Adm. Q.* 54, 501–528. doi: 10.1177/0013161X18769048

Liu, J. J. W., Reed, M., and Girard, T. A. (2017). Advancing resilience: an integrative, multi-system model of resilience. *Personal. Individ. Differ.* 111, 111–118. doi: 10.1016/j.paid.2017.02.007

Lochmiller, C. R. (2016). Examining administrators' instructional feedback to high school math and science teachers. *Educ. Adm. Q.* 52, 75–109. doi: 10.1177/0013161X15616660

Ma, X., and Marion, R. (2021). Exploring how instructional leadership affects teacher efficacy: a multilevel analysis. *Educ. Manag. Adm. Leaders.* 49, 188–207. doi: 10.1177/1741143219888742

Martinez-Garcia, A. (2022). Contributions of universal school-based mental health promotion to the wellbeing of adolescents and preadolescents: a systematic review of educational interventions. *Health Educ.* 122, 564–583. doi: 10.1108/HE-07-2021-0106

Masten, A., and Cicchetti, D. (2016). "Resilience in development: progress and transformation" in Developmental psychopathology. ed. D. Cicchetti. 3rd ed. (Hoboken, NJ: Wiley), 271–333. doi: 10.1002/9781119125556.devpsy406

May, B., Wendt, J., and Barthlow, M. (2022). A comparison of students' interest in STEM across science standard types. *Soc. Sci. Hum. Open* 6:100287. doi: 10.1016/j.ssaho.2022.100287

McIntyre, M. M., Gundlach, J. L., and Graziano, W. G. (2021). Liking guides learning: the role of interest in memory for STEM topics. *Learn. Individ. Differ.* 85:101960. doi: 10.1016/j.lindif.2020.101960

Miravète, S., and Tricot, A. (2024). Are some people generally more creative than others? A systematic review of fifty years' research. *Educ. Psychol. Rev.* 36, 1–31. doi: 10.1007/s10648-024-09926-6

Murphy, S. A., MacDonald, A., Danaia, L., and Wang, C. (2018). An analysis of Australian STEM education strategies. *Policy Fut. Educ.* 17, 122–139. doi: 10.1177/1478210318774190

Nguyen, D., Harris, A., and Ng, D. (2020). A review of the empirical research on teacher leadership (2003–2017): evidence, patterns and implications. *J. Educ. Adm.* 58, 60–80. doi: 10.1108/JEA-02-2018-0023

Nickolite, A., and Doll, B. (2008). Resilience applied in school. *Can. J. Sch. Psychol.* 23, 94–113. doi: 10.1177/0829573508316596

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C., and Nelson, C. (2015). A model of factors contributing to STEM learning and career orientation. *Int. J. Sci. Educ.* 37, 1067–1088. doi: 10.1080/09500693.2015.1017863

Nygren, H., Nissinen, K., Hämäläinen, R., and De Wever, B. (2019). Lifelong learning: formal, non-formal and informal learning in the context of the use of problem-solving skills in technology-rich environments. *Br. J. Educ. Technol.* 50, 1759–1770. doi: 10.1111/bjet.12807

Ononye, U., Ogbeta, M., Ndudi, F., Bereprebofa, D., and Maduemezia, I. (2022). Academic resilience, emotional intelligence, and academic performance among undergraduate students. *Knowl. Perform. Manag.* 6, 1–10. doi: 10.21511/kpm.06(1).2022.01

Othman, O., Iksan, Z. H., and Yasin, R. M. (2022). Creative teaching STEM module: high school students' perception. *Europ. J. Educ. Res.* 11-2022, 2127–2137. doi: 10.12973/eu-jer.11.4.2127

Pietsch, M., Aydin, B., and Gümüş, S. (2023). Putting the instructional leadership–student achievement relation in context: a meta-analytical big data study across cultures and time. *Educ. Eval. Policy Anal.* 47, 29–64. doi: 10.3102/01623737231197434

Quaisley, K., Smith, W. M., Criswell, B., Funk, R., and Hutchinson, A. (2023). From becoming to being: how STEM teachers develop leadership identities. *Int. J. Leadersh. Educ.* 1–28, 1–28. doi: 10.1080/13603124.2023.2292161

Seery, M. D., and Quinton, W. J. (2016). "Understanding resilience: from negative life events to everyday stressors" in Advances in experimental social psychology. 54, 181–245.

Seligman, M. E. P. (2018). PERMA and the building blocks of well-being. *J. Posit. Psychol.* 13, 333–335. doi: 10.1080/17439760.2018.1437466

Seyranian, V., Madva, A., Duong, N., Abramzon, N., Tibbetts, Y., and Harackiewicz, J. M. (2018). The longitudinal effects of STEM identity and gender on flourishing and achievement in college physics. *Int. J. STEM Educ.* 5:40. doi: 10.1186/s40594-018-0137-0

Shaked, H. (2024). How principals' instructional leadership impacts schools' middle leadership. *Educ. Manag. Adm. Leaders.* 53, 977–990. doi: 10.1177/17411432241238888

Shaked, H., and Benoliel, P. S. (2020). Instructional boundary management: the complementarity of instructional leadership and boundary management. *Educ. Manag. Adm. Leadership* 48, 821–839. doi: 10.1177/1741143219846905

Shaked, H., and Schechter, C. (2017). Systems Thinking for School Leaders: Holistic Leadership for Excellence in Education. Leadership and Policy in Schools. (Cham, Switzerland: Springer), 17, 647–649. doi: 10.1080/15700763.2017.1398339

Soncin, M., Bowers, A. J., and Agasisti, T. (2024). A global perspective on school leadership: evidence from a latent class analysis on OECD TALIS data. *Educ. Manag. Adm. Leaders.* 53, 1577–1602. doi: 10.1177/17411432241231902

Southwick, S. M., Bonanno, G. A., Masten, A. S., Panter-Brick, C., and Yehuda, R. (2014). Resilience definitions, theory, and challenges: interdisciplinary perspectives. *Eur. J. Psychotraumatol.* 5:25338. doi: 10.3402/ejpt.v5.25338

Starrett, A., Yow, J., Lotter, C., Irvin, M. J., and Adams, P. (2021). Teachers connecting with rural students and places: a mixed methods analysis. *Teach. Teach. Educ.* 97:103231. doi: 10.1016/j.tate.2020.103231

Stosich, E. L. (2020). Central office leadership for instructional improvement: developing collaborative leadership among principals and instructional leadership team members. *Teach. Coll. Rec.* 122, 1–42. doi: 10.1177/016146812012200908

Urick, A. M., Ford, T. G., Page Wilson, A. S., and Consuegra, E. (2022). How does instructional leadership influence opportunity to learn in mathematics? A comparative study of pathways for grade 4 students in the U.S. and Belgium. *Res. Comp. Int. Educ.* 17, 372–398. doi: 10.1177/17454999221086360

Valenzuela, A. (2020). STEM diversity and student Latina/o resilience: a reflection. *Int. J. Qual. Stud. Educ.* 33, 898–904. doi: 10.1080/09518398.2020.1786188

Victorino, C., Denson, N., Ing, M., and Nylund-Gibson, K. (2019). Comparing STEM majors by examining the relationship between student perceptions of campus climate and classroom engagement. *J. Hisp. High. Educ.* 21, 33–48. doi: 10.1177/1538192719896343

Vitha, M. F. (2022). Contemplative Fridays: mindfulness pedagogy in the general chemistry classroom. *J. Chem. Educ.* 99, 2441–2445. doi: 10.1021/acs.jchemed.2c00159

Wang, L.-H., Chen, B., Hwang, G.-J., Guan, J.-Q., and Wang, Y.-Q. (2022). Effects of digital game-based STEM education on students' learning achievement: a meta-analysis. *Int. J. STEM Educ.* 9:26. doi: 10.1186/s40594-022-00344-0

Wenner, J. A., and Campbell, T. (2017). The theoretical and empirical basis of teacher leadership: a review of the literature. *Rev. Educ. Res.* 87, 134–171. doi: 10.3102/0034654316653478

Winberg, C., Bozalek, V., Conana, H., Wright, J., Wolff, K. E., Pallitt, N., et al. (2018). Critical interdisciplinary dialogues: towards a pedagogy of well-being in STEM disciplines and fields. *South Afric. J. High. Educ.* 32, 270–287. doi: 10.20853/32-6-2975

Zuckerman, S. J., and O'Shea, C. (2021). Principals' schema: leadership philosophies and instructional leadership. *J. School Leaders.* 31, 274–296. doi: 10.1177/1052684620966063

References

American Psychological Association (2016). *Depression*. Available at: https://www.apa.org/topics/depression

Appling, B., and Robinson, S. (2021). K–12 school counselors utilizing critical race theory to support the racial identity development and academic achievement of African American males. *Prof. Sch. Couns.* 25, 1–11. doi: 10.1177/2156759X211040043

Avedissian, T., and Alayan, N. (2021). Adolescent well-being: a concept analysis. *Int. J. Ment. Health Nurs.* 30, 357–367. doi: 10.1111/inm.12833

Bai, X., Wu, C.-H., Zheng, R., and Ren, X. (2011). The psychometric evaluation of the satisfaction with life scale using a nationally representative sample of China. *J. Happiness Stud.* 12, 183–197. doi: 10.1007/s10902-010-9186-x

Bartanen, B., Grissom, J. A., and Rogers, L. K. (2019). The impacts of principal turnover. *Educ. Eval. Policy Anal.* 41, 350–374. doi: 10.3102/0162373719855044

Berry, C., Acharya, N., and Crowter, L. (2024). The light at the end of the tunnel? A systematic review of higher education student experiences of hope. *PLoS One* 19:e0304596. doi: 10.1371/journal.pone.0304596

Braun, V., and Clarke, V. (2006) Using thematic analysis in psychology. *Qual. Res. Psychol.*, 3, 77–101. doi: 10.1191/1478088706qp063oa

Chua, J. H., Cheng, C. K. T., Cheng, L. J., Ang, W. H. D., and Lau, Y. (2023). Global prevalence of resilience in higher education students: a systematic review, meta-analysis and meta-regression. *Curr. Psychol.* 42, 22645–22663. doi: 10.1007/s12144-022-03366-7

Connor, K. M., and Davidson, J. R. (2003). Development of a new resilience scale: the Connor-Davidson resilience scale (CD-RISC). *Depress. Anxiety* 18, 76–82. doi: 10.1002/da.10113

Daniel, K. L., and Mishra, C. (2017). Student outcomes from participating in an international STEM service-learning course. *SAGE Open* 7, 1–11. doi: 10.1177/2158244017697155

Deehan, J., MacDonald, A., and Morris, C. (2024). A scoping review of interventions in primary science education. *Stud. Sci. Educ.* 60, 1–43. doi: 10.1080/03057267.2022.2154997

Diener, E. (1984). Subjective well-being. *Psychol. Bull.* 95, 542–575. doi: 10.1037/0033-2909.95.3.542

Diener, E., Emmons, R., Larsen, R., and Griffin, S. (1985). The satisfaction with life scale. *J. Pers. Assess.* 49, 71–75. doi: 10.1207/s15327752jpa4901_13

Dost, G. (2024). Students' perspectives on the "STEM belonging" concept at A-level, undergraduate, and postgraduate levels: an examination of gender and ethnicity in student descriptions. *Int. J. STEM Educ.* 11:12. doi: 10.1186/s40594-024-00472-9

Egarievwe, S. U. (2015). Vertical education enhancement—a model for enhancing STEM education and research. *Procedia* 177, 336–344. doi: 10.1016/j.sbspro.2015.02.354

Friborg, O., Hjemdal, O., Rosenvinge, J. H., and Martinussen, M. (2003). A new rating scale for adult resilience: what are the central protective resources behind healthy adjustment? *Int. J. Methods Psychiatr. Res.* 12, 65–76. doi: 10.1002/mpr.143

Goldberg, J. M., Sklad, M., Elfrink, T. R., Schreurs, K. M. G., Bohlmeijer, E. T., and Clarke, A. M. (2019). Effectiveness of interventions adopting a whole school approach to enhancing social and emotional development: a meta-analysis. *Eur. J. Psychol. Educ.* 34, 755–782. doi: 10.1007/s10212-018-0406-9

Ham, S.-H., Duyar, I., and Gumus, S. (2015). Agreement of self-other perceptions matters: Analyzing the effectiveness of principal leadership through multi-source assessment. *Aust. J. Educ.* 59, 225–246. doi: 10.1177/0004944115603373

Hattie, J. (2016). Third visible learning annual conference: Mindframes and Maximizers, Washington, DC.

Hainagiu, S. M., and Neagu, S. N. (2025). Caught in the web—emotional regulation difficulties and internet addiction among Romanian medical and technical university students: a pilot cross-sectional study. *Healthcare*, 13:2528. doi: 10.3390/healthcare13192528

Hamalainen, R. (2008). Designing and evaluating collaboration in a virtual game environment for vocational learning. *Comput. Educ.* 50, 98–109. doi: 10.1016/j.compedu.2006.04.001

Hitt, D. H., and Tucker, P. D. (2016). Systematic review of key leader practices found to influence student achievement: a unified framework. *Rev. Educ. Res.* 86, 531–569. doi: 10.3102/0034654315614911

Ismail, N., and Yusof, U. K. (2023). A systematic literature review: recent techniques of predicting STEM stream students. *Comput. Educ.* 5:100141. doi: 10.1016/j.caeai.2023.100141

Iuga, I. A., and David, O. A. (2024). Emotion regulation and academic burnout among youth: a quantitative meta-analysis. *Educ. Psychol. Rev.* 36, 1–27. doi: 10.1007/s10648-024-09930-w

James, M., Wandix-White, D., Waxman, H. C., Rivera, H., and Harmon, W. C. (2021). Remixing resilience: a critical examination of urban middle school learning environments among resilient African American learners. *Urban Educ.* 57, 432–462. doi: 10.1177/0042085921991632

Keyes, C. L. M. (2002). The mental health continuum: from languishing to flourishing in life. *J. Health Soc. Behav.* 43, 207–222. doi: 10.2307/3090197

Kovach, M. (2018). An examination of leadership theories in business and sport achievement contexts. Journal of values-based. *Leadership* 11:7. doi: 10.22543/0733.62.1215

Lauermann, F., and König, J. (2016). Teachers' professional competence and wellbeing: understanding the links between general pedagogical knowledge, self-efficacy and burnout. *Learn. Instr.* 45, 9–19. doi: 10.1016/j.learninstruc.2016.06.006

Merisotis, J. P., and Kee, A. M. (2006). A model of success. *J. Hisp. High. Educ.* 5, 288–308. doi: 10.1177/1538192706288422

Messmann, G., Mulder, R. H., and Gruber, H. (2010). Relations between vocational teachers' characteristics of professionalism and their innovative work behaviour. *Empir. Res. Vocat. Educ. Train.* 2, 21–40. doi: 10.1007/BF03546487

Moher, D, Liberati, A, Tetzlaff, J, and Altman, DG. (2009). Group preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS med 6: e1000097. *Open medicine: a peer-reviewed, independent, open-access journal.* 3. e123–e130. doi: 10.1016/j.jclinepi.2009.06.005

Murray, J. A. (2004). Making sense of resilience: a useful step on the road to creating and maintaining resilient students and school communities. *Aust. J. Guid. Couns.* 14, 1–15. doi: 10.1017/s1037291100004640

Nham, T. P. N., Nguyen, N. N. N., Nguyen, T. P., Le, T. T., and Nguyen, T. T. (2022). Relationship between emotional intelligence and resilience among university students during crisis. *Policy Fut. Educ.* 21, 486–502. doi: 10.1177/14782103221139620

Ni, H., Li, C., and Wang, C. (2016). Students' perceptions of resilience promoting factors in chinese and american middle schools. *Sch. Psychol. Int.* 37, 435–455. doi: 10.1177/0143034316664391

Paas, F. (1994). Training strategies for attaining transfer of problem-solving skill in statistics: a cognitive load approach. *Percept. Mot. Skills* 79, 419–430. doi: 10.2466/pms.1994.79.1.419

Pang, M. F., and Marton, F. (2013). Interaction between the learners' initial grasp of the object of learning and the learning resource afforded. *Instr. Sci.* 41, 1065–1082. doi: 10.1007/s11251-013-9272-7

Page, M. J., McKenzie, JE, Bossuyt, PM, Boutron, I, Hoffmann, TC, Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Syst. Rev.*, 10:89. doi: 10.1186/s13643-021-01626-4

Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., et al. (2006) Guidance on the conduct of narrative synthesis in systematic reviews.

Quinlan, A. E., Berbés-Blázquez, M., Haider, L. J., and Peterson, G. D. (2016). Measuring and assessing resilience: broadening understanding through multiple disciplinary perspectives. *J. Appl. Ecol.* 53, 677–687. doi: 10.1111/1365-2664.12550

Rees, T., Haslam, S. A., Coffee, P., and Lavallee, D. (2015). A social identity approach to sport psychology: principles, practice, and prospects. *Sports Med.* 45, 1083–1096. doi: 10.1007/s40279-015-0345-4

Sansone, D. (2018). Teacher characteristics, student beliefs, and the gender gap in STEM fields. *Educ. Eval. Policy Anal.* 41, 127–144. doi: 10.3102/0162373718759034

Shea, BJ, Reeves, BC, Wells, G, Thuku, M, Hamel, C, Moran, J, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ* (2017) 358:j4008. doi: 10.1136/bmj.j4008

Sutcliffe, K. M., and Vogus, T. J. (2003). "Organizing for resilience" in Positive organizational scholarship: Foundations of a new discipline. eds. K. S. Cameron, J. E. Dutton and R. E. Quinn (San Francisco, CA: Berrett-Koehler), 94–110.

UNESCO (2023). Global education monitoring report 2023: Technology in education. Paris, France: UNESCO. doi: 10.54676/UZQV8501

Ungar, M., and Liebenberg, L. (2013). Ethnocultural factors, resilience, and school engagement. *Sch. Psychol. Int.* 34, 514–526. doi: 10.1177/0143034312472761

Ungar, M., Theron, L., Murphy, K., and Jefferies, P. (2021). Researching multisystemic resilience: a sample methodology. *Front. Psychol.* 11:607994. doi: 10.3389/fpsyg.2020.607994

Wagnild, G. M., and Young, H. M. (1993). Development and psychometric evaluation of the resilience scale. *J. Nurs. Meas.* 1, 165–178.

Windle, G., Bennett, K. M., and Noyes, J. (2011). A methodological review of resilience measurement scales. *Health Qual. Life Outcomes* 9:8. doi: 10.1186/1477-7525-9-8

Wong, J., Baars, M., Davis, D., van der Zee, T., Houben, G.-J., and Paas, F. (2018). Supporting self-regulated learning in online learning environments and MOOCs: a systematic review. *Int. J. Hum. Comput. Interact.* 35, 356–373. doi: 10.1080/10447318.2018.1543084

York-Barr, J., and Duke, K. (2004). What do we know about teacher leadership? Findings from two decades of scholarship. *Rev. Educ. Res.*, 74, 255–316. doi: 10.3102/00346543074003255