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EDITED BY
Serafeim A. Triantafyllou,
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REVIEWED BY
Ikhsan Hidayat,
State University of Gorontalo, Indonesia
Himendra Balalle,
National Institute of Business Management,
Sri Lanka

*CORRESPONDENCE
Aliya Myrzanova
✉ myrzanova_ak@enu.kz

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Understanding how gamified programming environments shape pre-service teachers' engagement and instructional readiness in Kazakhstan

Ainash Davletova[1], Aliya Myrzanova[1]* and Manshuk Sabyrgalieva[3]

[1]L.N. Gumilyov Eurasian National University, Astana, Kazakhstan, [2]Nigde Ömer Halisdemir University, Nigde, Türkiye, [3]Zhangir Khan West Kazakhstan Agrarian and Technical University, Oral, Kazakhstan

Introduction: Gamification is increasingly used in education to promote engagement, especially in STEM and digital literacy domains. However, limited research has explored how gamified programming platforms like Code.org support teacher education, particularly in Kazakhstan.

Methods: This study applied a mixed-methods approach, guided by the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT), to examine pre-service teachers' perceptions of Code.org during a four-week intervention at Bolashak University. Forty participants engaged in structured training and completed surveys and focus groups.

Results: Findings show high overall acceptance of Code.org among pre-service teachers, with strong ratings for usability and instructional relevance. While gamified features increased engagement initially, some participants noted declining motivation over time. Key challenges included infrastructure limitations and student readiness.

Discussion: The study highlights the importance of pedagogical alignment and sustained support for integrating gamified tools in teacher training. Motivational gains can be maintained by incorporating meaningful learning tasks and adaptive scaffolding.

Conclusion: Code.org demonstrates strong potential for teacher preparation in computational thinking and digital literacy, but its successful integration depends on contextual adaptation, professional development, and institutional support.

KEYWORDS

Code.org, computational thinking, digital literacy, educational technology, gamification, Kazakhstan, teacher training

1 Introduction

The adoption of digital technologies in education is influencing teaching and learning internationally. As part of this transition, computer science education has emerged as a priority to ensure that 21-century learners have opportunities to develop digital literacy, computational thinking, and programming skills. To prepare future educators to promote these skills requires teacher-training programs to develop their skills and in developing the pedagogical practices to be able to effectively implement computer science in practice. Because engagement is consistently linked to learning persistence and outcomes in technology-based education—and is shaped by context factors such as delivery mode, tool design, and infrastructure—understanding engagement has become especially urgent as institutions scale digital and gamified instruction; recent evidence syntheses show that gamification commonly supports motivation and engagement, while also highlighting the need to examine implementation conditions that enable sustained participation (Balalle, 2024).

Kazakhstan's education reform initiatives focus on implementing STEM programs and enhancing educators' digital literacy, which are seen as critical in modernizing school curriculums and enhancing the quality of teacher education (Karatayeva et al., 2024; Tokzhigitova et al., 2023; Zhao et al., 2023). Despite an increase in access to technology and digital learning opportunities, there is still a significant gap regarding pre-service teachers' confidence and competence in effectively using digital tools within their classrooms. Consequently, it is important to determine not only the appeal of gamification elements; but also how these elements support pre-service teachers' engagement with and readiness to implement gamification within local educational contexts.

Gamification's approach incorporates game-like features, such as monitoring progress, earning rewards and performing interactive activities throughout the process of learning. In addition, many gamified programming environments also function as playful learning spaces, emphasizing exploration, trial-and-error, and iterative problem solving rather than reward pursuit alone. International research has shown that gamification can support motivation, engagement, and retention; however, these effects are highly dependent on context, learner characteristics, and instructional design (Mukhtarkyzy et al., 2025; Prieto-Andreu et al., 2022). The growth of K-12 classrooms using gamified platforms continues to accelerate, and the potential of gamified platforms as a tool for enhancing teacher professional development has received little attention to date. Kazakhstan has set national policy goals around digital literacy and STEM education; and, therefore, the development and use of gamified platforms will likely serve as a bridge between national goals and teachers' actual practices day-to-day.

There continues to be emerging research related to gamification in teacher education programs within Kazakhstan, although significant global research has addressed gamification's use within teacher education programs (Abildinova et al., 2024; Yilmaz, 2022). In this instance, Code.org is one of the most popular gamified programming platforms in the world that offers interactive lessons, tracking of student progress and rewards for diminishing fees, all of which help to promote progressive development of problem-solving skills related to computational design; however, little is yet known about how pre-service teachers within Kazakhstan use and perceive the features of the platform, including usability and engagement, or how the features of the platform affect the preparation of pre-service teachers to implement the platform within their classrooms upon entering the field of education. Beyond these gamified elements, tools such as App Lab and Game Lab support "learning through making," where users create, test, and debug programs in a low-stakes, playful way. A screenshot illustrating a sample depiction of the Code.org platform's features and resources available to students, teachers, and the community is provided (Figure 1).

This study aims to explore pre-service teachers' perceptions of Code.org as a gamified tool for teacher training and to assess its usability, engagement, applicability, and challenges in implementation. Specifically, it seeks to evaluate usability and engagement, examine perceived applicability for teaching programming and computational thinking in alignment with Kazakhstan's educational standards, and identify implementation barriers. Accordingly, the study addresses the following research questions: (1) How do pre-service teachers perceive Code.org's usability and ease of integration in teacher training? (2) What motivational factors influence pre-service teachers' engagement with Code.org? (3) What challenges and infrastructure limitations impact the adoption of Code.org in Kazakhstani teacher training programs? The findings provide context-specific evidence to inform teacher-education design and the integration of gamified programming environments in Kazakhstan.

This study makes four specific contributions to the literature on gamification and teacher education. First, it provides

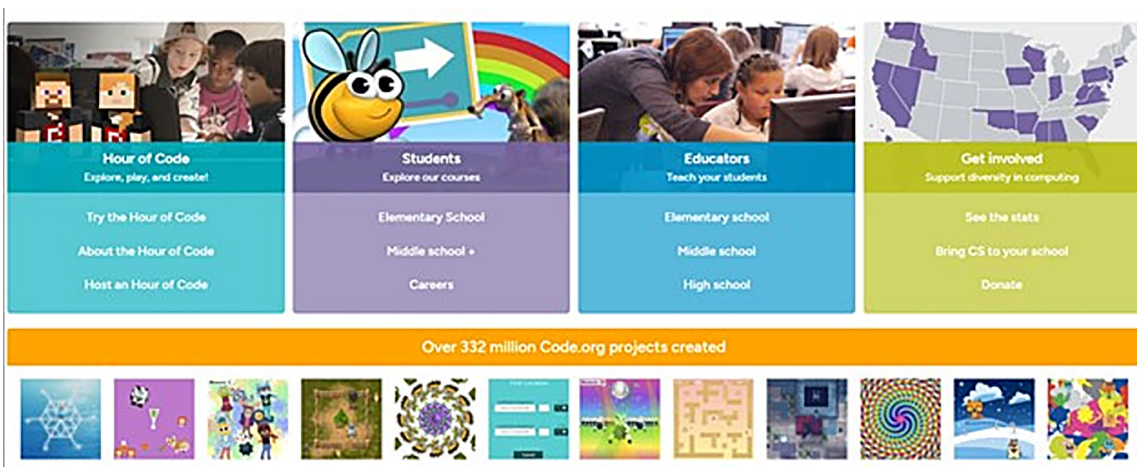

FIGURE 1
Screenshot of the Code.org homepage.

context-specific empirical evidence from Kazakhstan, a national setting that remains underrepresented in research on gamified programming platforms and teacher preparation. Second, unlike much of the existing Code.org literature that focuses on K–12 student outcomes, this study examines pre-service teachers' engagement and perceived instructional readiness, addressing an important gap in teacher education research. Third, the study integrates the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT) to jointly explain both technology adoption judgments and the sustainability of motivation within a playful programming environment. Finally, by identifying conditions under which initial engagement declines, the study offers practical implications for the pedagogical design of gamified teacher-training programs aimed at sustaining motivation beyond early novelty effects.

2 Literature review

Gamification of education is supported by psychological and technological theories that seek to explain its effects on motivation, engagement, and learning outcomes (Jaramillo-Mediavilla et al., 2024; Lah et al., 2022). There are two theoretical perspectives that help frame how and why educators may adopt gamified tools effectively: TAM and SDT (Gupta and Goyal, 2022; Panagiotarou et al., 2020).

TAM states that people are more likely to utilize new technologies into their pedagogical practices when they think the technology is easy-to-use and useful (Venkatesh and Davis, 2000). There is reasonably strong evidence in the educational field regarding ease-of-use and use of technology, in that researchers have shown that new digital technologies with simplistic, seamless user experiences see greater rates of adoption. However, ease-of-use alone is not enough to ensure deep or meaningful learning is guaranteed. While this is enough of a draw to get users engaged, there remain questions of whether gamified technology actually promotes deep learning as opposed to simply being a short term engagement tool (Chatterjee et al., 2021; Zalat et al., 2021).

SDT presents a different perspective—what motivates people. It elaborates on intrinsic and extrinsic motivation, where intrinsic describes learning by curiosity or learning for enjoyment and extrinsic pertains to rewards that are added externally, such as points, badges, or rankings (Deci and Ryan, 2000). Many gamified options will extensively add extrinsic motivators which will attract attention in the beginning. But if many extrinsic rewards are used too often, they can lead to a more shallow level of engagement. Furthermore, for gamification to foster real learning to occur, there needs to be a balance of pairing the extrinsic rewards with experiences of autonomy, challenge, and a sense of mastery. Studies show that when learners feel autonomy and challenge meaningfully then learners are more likely to stay engaged and persist in regard for retention of learning (Mitchell et al., 2020; Ryan and Deci, 2020; Sansone and Tang, 2021; Yang et al., 2021).

TAM and SDT have a good association for studying platforms like Code.org. TAM would tell us if teachers believe the tool is easy to use and a good use of their time. SDT would indicate two things related to whether the tool is going to facilitate long-lasting motivation. Both theories emerge from rewards, but experiences of interest and independence in learning go beyond motivation experience. Figure 2 summarises how TAM and SDT jointly inform the study design, instrument constructs, and interpretation of engagement and instructional readiness outcomes. While TAM and SDT are frequently applied in studies examining student motivation and technology acceptance, they are less often integrated to examine how pre-service teachers experience gamified platforms as professional-learning environments rather than as learners alone. This study adopts a combined TAM–SDT perspective to address this gap.

Beyond just theory, some experiential evidence points that gamification can help with engagement, motivation, and learning outcomes (Opriș et al., 2021; Uaidullakyzy et al., 2022). The value of that motivation is even more evident in STEM education because

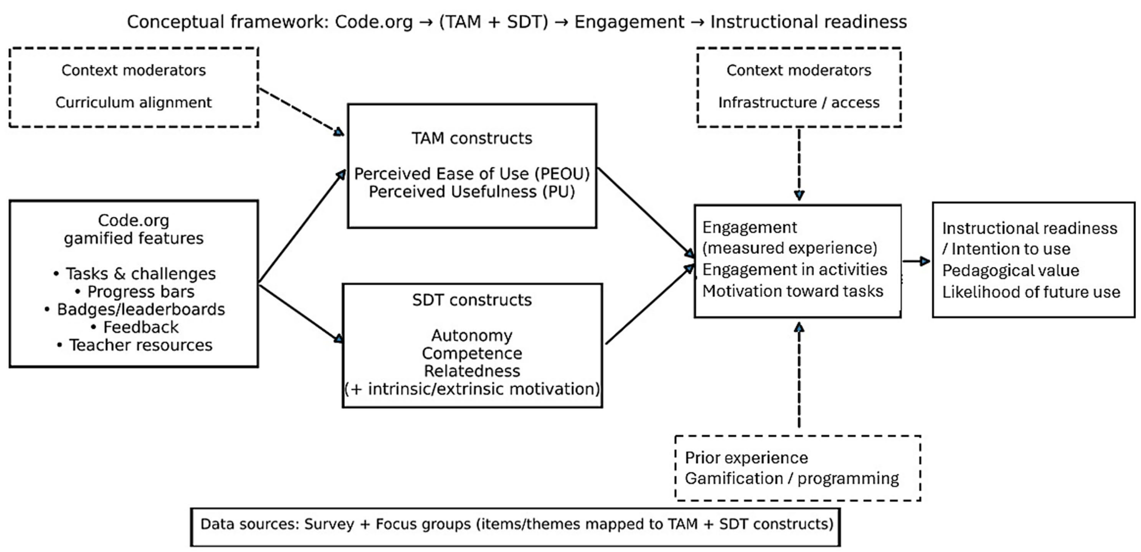

FIGURE 2
Conceptual framework integrating TAM and SDT for examining Code.org use in teacher training.

game-based learning is focused on collaboration, critical thinking, and real-world problem-solving (Moral-Sánchez et al., 2022; Sánchez-Martín et al., 2020). To help conceptualize content and topics, gamification situates an abstract concept into context by breaking it down to interactive, step, step tasks, which can all be accomplished at the learner's pace.

Several studies caution that gamification may only offer brief engagement if learners have been conditioned to rely on reward (Opriş et al., 2021; Uaidullakyzy et al., 2022; Urh et al., 2015). If learners prominent are points or badges as the most valuable component, their opportunity for deeper learning will be lost. Technical barriers, and accessibility barriers, will add momentum to this discussion - especially in low-resourced contexts with limited internet and digital infrastructure (Kalogiannakis et al., 2021; Khaldi et al., 2023). Another major concern involves the alignment of gamification to educational goals. Gamified platforms can be highly engaging, but such engagement relies on their inclusion in structured curriculum content. Implemented without alignment to clear pedagogical goals, gamification risks being superficial engagement rather than impactful educational innovation (Ohn and Ohn, 2020).

While a substantial body of gamification research focuses on student engagement and achievement in K–12 settings, considerably fewer studies examine how gamified environments function as professional-learning tools within pre-service teacher education. Research indicates that pre-service teachers benefit from a firsthand experience on gamified platforms, as they help foster technical abilities and pedagogical thinking for applications in the future use (Guerrero Puerta, 2024; Martínez Sánchez, 2023). Therefore, training profiles that effectively incorporate gamification can serve as a bridge between theory and practice, allowing pre-service teachers to understand how to use gamified tools and be able to utilize them in a meaningful way.

In the specific case of Code.org, teacher learning is supported through educator-facing resources (e.g., lesson plans, assessments, and progress monitoring) and formal professional-learning pathways (e.g., facilitator-led workshops and self-paced modules) intended to build teachers' confidence and implementation capacity (Code.org, 2025). However, clearer empirical evidence is still needed on how pre-service teachers experience Code.org during teacher preparation and how their engagement with its gamified features translates into instructional readiness under contextual constraints (e.g., infrastructure and curriculum alignment).

To date, a number of gamified platforms are used in teacher education. Gamified platforms that use quizzes, such as Kahoot!, Classcraft, and Quizizz are commonplace today, along with learning management systems such as Moodle and Edmodo, which have accompanying tools, such as status reports, tracking and badges/rewards included. Code.org is widely used in K–12 computer science education and offers teacher-facing supports and professional-learning pathways, yet the pre-service teacher-preparation evidence base—especially linking engagement to instructional readiness in Kazakhstan—remains under-developed. In addition to engagement, gamification for teacher training should ensure that teacher training goes beyond task completion. There is evidence to demonstrate that in the case of teacher training, gamification should be beyond task completion for K–12 teachers and can include adaptive learning, project-based learning, and critical learning (Khaldi et al., 2023; Najjar and Salhab, 2022). Even there are numerous examples found in the teacher education literature on gamified platforms, Code.org has received considerably less attention specifically for professional learning. There clearly is a shortage in teacher education research for professional development professional learning pathways for teacher education.

In Kazakhstan, recent developments represent a national strategy for integrating STEM education and digital literacy into the national curriculum (Karatayeva et al., 2024; Manan et al., 2024; Zulpykhar et al., 2023). The State Program for the Development of Education and Science Issue 3 also clearly includes updates of teacher education attains with the use of educational technology through new trends. While education has been subject to many advances, the application of gamification as a process for teacher development remains limited and inconsistent.

The existing literature regarding gamification and STEM education in Kazakhstan indicates some promising evidence, however, there remain significant gaps. The empirical literature focused on physics education research demonstrates that game-based instruction has the potential to enhance student motivation and student performance (Andrade et al., 2020; Hsiao et al., 2023). Evidence from the initial studies piloting gamified learning in vocational education contexts shows that gamified learning has potential to lower student cognitive load and encourage the development of computational thinking and to enhance engagement in learning (Qu et al., 2023). However, to date, empirical literature has been limited to the perceptions of pre-service teachers and their understanding of how to apply gamification in practice.

Many contextual and structural challenges exist that prevent gamification from becoming an integrated part of teacher education. Digital information inequities are especially problematic in remote and under-resourced communities and particularly impact the sustainability of using gamified tools. Many teachers do not have the training or pedagogical content knowledge to design or use game-enhanced learning strategies (Mahat et al., 2021). Issues with gamification are also exacerbated by the lack of a national policy framework for gamification in the curricular standards, resulting in a sporadic and episodic use of gamification in schools. It will take a more multi-faceted and integrated approach to mitigate these challenges, including but not limited to some targeted investments in infrastructure, a set of national guidelines for gamified pedagogies, and professional opportunities for teachers to acquire content knowledge for using gamified pedagogies.

A platform that demonstrates considerable potential in this area is Code.org. It is well-known in K–12 circles as a platform for teaching computer science, but it has potential for teacher education too. Beyond reward features, Code.org also functions as a playful "learning-by-making" environment through App Lab and Game Lab, where pre-service teachers can experiment, tinker, and iteratively design, test, and debug artifacts in low-stakes ways. Due to its interactive structure, built-in progress tracking, and challenge-based lessons, users slowly build core computational thinking skills (Kalelioğlu, 2015). Code.org has already created the Hour of Code, with large-scale initiatives that introduced millions of students across the globe to programming and has established itself as a platform for expanding digital literacy (Garcia et al., 2015).

Existing Code.org research has predominantly examined student learning outcomes, classroom engagement, or computational thinking development, with limited attention to how pre-service teachers experience the platform during professional preparation. Despite strong evidence of its effectiveness in student learning, Code.org's role in teacher education remains largely unexplored. Most research focuses on how students use the platform, with much less attention given to how pre-service teachers perceive and apply it in their professional preparation (Carlos Begosso et al., 2020; Lee and Su, 2023; Sebastian and Nugraha, 2023). Key gaps remain regarding its alignment with teacher training curricula, its perceived pedagogical value, and the specific challenges educators face when adopting it. Although Code.org is designed with usability in mind, little is known about whether its structure adequately prepares pre-service teachers to bring gamified approaches into their own classrooms.

Considering Kazakhstan's robust national movement towards STEM education reform, it is a particularly relevant time to investigate how future educators engage with a platform like Code.org. Understanding their experiences with usability, persuasion, and the realities of implementing Code.org could inform whether Code.org and similar platforms play a role in modernizing educator preparation.

Game-based platforms are well-known tools for developing computational thinking and critical reasoning capacities (Arlinwibowo et al., 2023; Vang, 2023). Yet, while Code.org has been a widespread success in K-12 classrooms, and evidence has shown that pre-service teacher candidates could greatly benefit from the experience of gamified learning, we still do not know enough about the implications of these experiences on their practice as educators.

Accordingly, this study is positioned not as an evaluation of gamification effectiveness per se, but as an exploration of how a gamified programming environment is perceived and adopted within pre-service teacher education under contextual constraints. It examines pre-service teachers' perceptions of Code.org in terms of usability, engagement, motivation, and perceived implementation barriers, with the aim of understanding conditions that shape sustained engagement and perceived instructional readiness. These insights contribute to ongoing discussions on digital pedagogy in teacher preparation and the responsible integration of gamified programming platforms.

Positioned within the Research Topic's focus on playful learning, Code.org can be understood not only as a gamified system of points and badges, but as a playful digital learning environment that supports exploration, trial-and-error, and iterative making/debugging as central learning processes. In this framing, pre-service teachers' engagement reflects how playful interaction (e.g., experimenting with solutions, receiving immediate feedback, refining code) can build confidence and instructional readiness for working with school-age learners. Accordingly, TAM is used to explain adoption-related judgments (perceived ease of use and usefulness) within this playful environment, while SDT is used to interpret how playful participation can support autonomy and competence—and why motivation may "wear off" when tasks no longer provide optimal challenge or meaningful choice.

3 Methodology

This exploratory mixed-methods study combined quantitative surveys with qualitative focus groups to investigate how pre-service teachers perceive Code.org. A convergent parallel mixed-methods design was applied, in which quantitative and qualitative data were collected during the same period, analyzed separately, and then interpreted together to generate an integrated account of participants' experiences. The four-week intervention was designed to give participants hands-on experience with the platform so they could reflect on its usability, level of engagement, and pedagogical value. Table 1 summarizes the study flow and intervention schedule, including recruitment and grouping, week-by-week training activities, data collection in Week 4, and the subsequent quantitative, qualitative, and integration procedures.

The study was conducted at Bolashak University in Kyzylorda, Kazakhstan, with 40 pre-service teachers participating in the intervention. The target population comprised pre-service teachers enrolled in teacher training programmes at the institution, and participants were recruited using convenience sampling based on accessibility and voluntary participation. Given the exploratory aim of identifying perception patterns and implementation challenges in a specific teacher-education setting, convenience sampling was considered appropriate. The study does not claim representativeness of all pre-service teachers in Kazakhstan; therefore, findings are interpreted as context-specific and indicative rather than generalizable. Transferability is supported through detailed description of the context, intervention, and participant characteristics.

Participants were divided into two groups based on their prior experience with gamification: those who were new to gamified learning and those with some exposure to gamification tools. Figure 3 illustrates participants' familiarity with gamification before the study, showing that 28% reported being slightly familiar, while 30% considered themselves very familiar. In contrast, 19% had no prior exposure to gamification, indicating that a significant portion of the participants was engaging with gamified learning for the first time. As shown in Figure 4, 45% of participants had never used gamification tools before, while 55% had prior experience integrating gamification into learning activities. These variations in familiarity provided a useful framework for analyzing differences in perceptions of Code.org. Given the exploratory and descriptive aims of the study, no formal sample size calculation was conducted; instead, the sample size was considered sufficient to identify perception trends and support thematic saturation in the qualitative component.

The program duration was 4 weeks, with three sessions per week lasting 2 h each. Week one began with a detailed description of gamification and the structure of Code.org—the program platform and curricular approach. Participants navigated through the platform, learning how features such as tracking progress, coding challenges, and interactive tasks, would support and increase learning. Participants also explored some of the key tools on the platform, App Lab and Game Lab, and engaged in preliminary exercises for familiarity with the interface. Week one focused on orientation and foundational practice, including guided navigation, introductory block-based activities, and an initial emphasis on basic sequencing and logic. All participants completed the same Code.org modules and learning activities to ensure consistent exposure across the cohort.

Weeks two and three built on active, experiential learning experiences. Participants engaged in structured coding and gamified elements of Code.org, such as progress indicators, digital badges and leaderboards as tools for either individual exploration or collaborative problem-solving in order to support applied learning. As participants advanced through progressively more challenging tasks, observational notes and participant comments suggested increased confidence and task persistence. This phase of the study is illustrated in Figure 5 which represents the overall engagement of students in the coding and programming aspects of their educational technology immersion

TABLE 1 Study design, intervention schedule, and analysis procedure.

Stage	Timing	Focus	What happened (procedure)	Data source(s)	Output used in...
Recruitment and consent	Pre-intervention	Sampling + ethics	Convenience recruitment; informed consent; ethics approval	Consent forms; ethics documentation	Methods (ethics), sample description
Baseline grouping	Pre-intervention	Participant profiling	Grouping by prior gamification familiarity (self-report)	Background items (Table 2); Figures 3, 4	Sample description; subgroup interpretation
Intervention—Week 1	Week 1 (3 × 2h)	Orientation + foundations	Intro to gamification + Code.org structure; guided navigation; introductory block-based activities; sequencing and logic; initial App Lab/Game Lab exploration	(Optional) instructor notes/attendance; participant reflections (if recorded)	Intervention description; context for engagement patterns
Intervention—Week 2	Week 2 (3 × 2h)	Guided practice (progression)	Structured coding challenges with increasing complexity; gamified elements (progress indicators, badges/ leaderboards); individual + collaborative problem-solving	(Optional) observation notes; participant comments	Context for motivation/ engagement findings
Intervention—Week 3	Week 3 (3 × 2h)	Applied problem-solving	Continued progression (loops/conditionals → more complex tasks); classroom-oriented scenarios using App Lab/Game Lab; collaborative work	(Optional) observation notes; participant comments	Context for "challenge vs. repetition" theme
Outcomes—Week 4 (Data collection)	Week 4 (3 × 2h)	Measurement	Survey administered (TAM/ SDT-aligned constructs + open-ended items); focus groups conducted	Survey (Table 2); focus groups; open-ended responses	Results + Discussion
Quantitative analysis	Post-collection	Statistics + reliability	Descriptive stats (means, frequencies); internal consistency (Cronbach's alpha)	Survey scales	Results (quantitative)
Qualitative analysis	Post-collection	Thematic analysis	Thematic analysis of focus groups + open-ended responses	Transcripts/notes; open-ended responses	Results (qualitative themes) + Table 3
Integration	Interpretation stage	Convergent parallel mixing	Compare/merge quantitative patterns with qualitative themes (convergence/ divergence)	Quant + qual results	Discussion (integrated interpretation)

experience. Weeks two and three emphasized guided practice and applied problem-solving, with tasks progressing from loops and conditionals to more complex activities and classroom-oriented scenarios using App Lab and Game Lab, supported by both individual and collaborative work.

During the last week of the program, we started to gather data to assess outcomes. Participants completed a structured survey instrument that captured their perceptions of the platform usability, motivational affordances, and pedagogical alignment. Survey items were organized into thematic focus areas, as illustrated in Table 2. The survey instrument combined adapted and study-specific items. Items targeting TAM constructs (perceived ease of use and perceived usefulness) were adapted from established technology acceptance measures used in educational settings, with wording adjusted to fit the Code.org context. Items related to motivational experiences were informed by SDT and focused on engagement-related experiences and perceived competence and autonomy during task completion. Additional items were newly developed to capture context-specific implementation challenges,

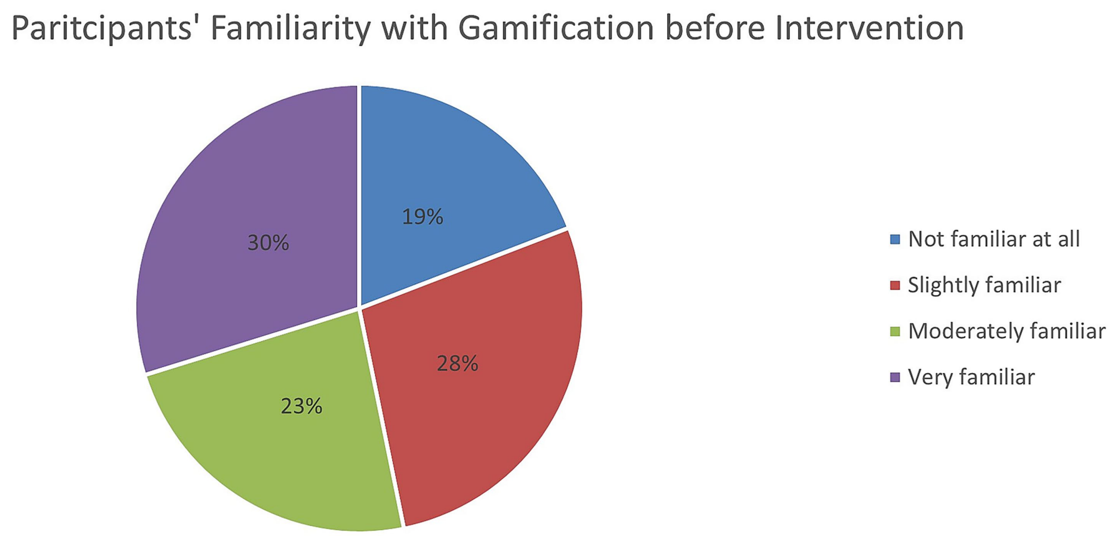

FIGURE 3
Participants' familiarity with gamification before intervention.

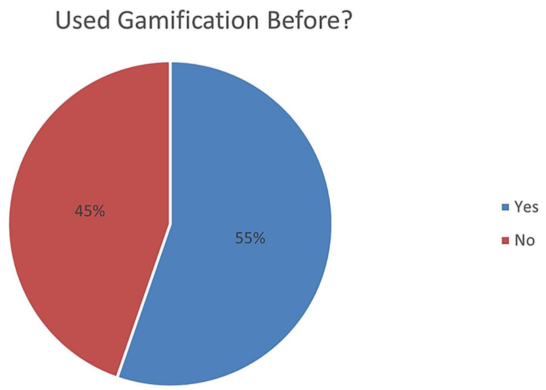

FIGURE 4
Participants' prior use of gamification tools.

FIGURE 5
Pre-service teachers participating in a robotics and programming session as part of the intervention.

including infrastructure limitations, time constraints, and anticipated student readiness. Content validity was addressed through construct mapping (aligning each item to a TAM or SDT construct or to an implementation barrier domain) and review by one faculty members with expertise in educational technology and research methods; revisions were made for clarity and construct alignment.

Semi-structured focus group discussions were conducted in parallel with the surveys to elicit richer qualitative insights into participants' experiences, including perceived strengths and limitations of the platform and recommendations for improving the use of gamification in teacher education. Quantitative survey data were analyzed descriptively (means, standard deviations, and frequency distributions) to characterize perception patterns across constructs. Inferential statistical tests were not conducted due to the exploratory purpose of the study and the limited sample size; the quantitative component was intended to describe trends rather than test causal hypotheses. Internal consistency of the survey scales was examined using Cronbach's alpha, with acceptable reliability ($\alpha \geq 0.70$).

To provide a more nuanced descriptive interpretation, survey responses were also summarized by prior gamification experience (participants with prior experience versus none), comparing mean ratings across key constructs related to usability, engagement, and perceived implementation barriers. Qualitative data from focus group discussions and open-ended survey responses were analyzed thematically using an iterative coding process to identify recurring themes related to usability, motivation, and implementation constraints. Themes were then compared with quantitative trends as part of the convergent mixed-methods integration. Integration of quantitative and qualitative findings provided a composite understanding of pre-service teachers' evaluations of Code.org across three domains: usability, motivational design affordances, and pedagogical alignment with 21st-century classroom contexts.

Throughout the research study, ethical standards were maintained. Before providing consent, participants were fully educated regarding the purpose, process, and their rights within the study. They were also

TABLE 2 Categorized survey questions used to assess participants' perceptions of Code.org.

Section	Question	Question type
Background	What is your teaching experience?	Multiple Choice
	How familiar are you with gamification in education?	Multiple Choice
	Have you ever used gamification tools in teaching or training before?	Yes/No
Usability	How would you rate the overall usability of Code.org?	Likert Scale (1–5)
	How intuitive did you find the interface of Code.org?	Likert Scale (1–5)
	Did you encounter any technical issues while using Code.org?	Yes/No
	What specific usability challenges or strengths did you notice while using Code.org?	Open-Ended
Engagement and Motivation	How engaging did you find the activities on Code.org?	Likert Scale (1–5)
	How motivated were you to complete tasks on Code.org?	Likert Scale (1–5)
	Which features of Code.org (e.g., coding activities, progress tracking, rewards) did you find most engaging?	Open-Ended
Applicability	How relevant do you think Code.org is for teacher training programs?	Likert Scale (1–5)
	How likely are you to use Code.org or similar platforms in your future teaching?	Likert Scale (1–5)
	In what classroom scenarios or topics do you think Code.org would be most useful?	Open-Ended
Challenges and Concerns	How concerned are you about the following challenges when using Code.org:	
	(a) Technical difficulties	Likert Scale (1–5)
	(b) Time constraints in lesson planning	Likert Scale (1–5)
	(c) Students' acceptance of gamified tools	Likert Scale (1–5)
	What challenges do you anticipate in implementing Code.org in real-world teaching scenarios?	Open-Ended
Overall Perception	What do you believe is the biggest strength of Code.org as a tool for teacher training?	Open-Ended
	Would you recommend Code.org to other future teachers?	Multiple Choice
	Do you have any additional comments or suggestions about Code.org or gamification in teacher training?	Open-Ended

free to decide whether or not to participate. Participants supplied their responses voluntarily, and all responses were anonymized in order to support confidentiality. After confirming that their research complied with standard guidelines for conducting research with humans, an ethics approval was provided by Ethical Committee of L. N. Gumilyov Eurasian National University.

4 Results

This section brings together findings from surveys, focus groups, and classroom observations. Participants shared their experiences with Code.org, reflecting on its usability, engagement, motivational impact, relevance for teacher training, likelihood of future use, and the challenges they encountered. Figure 6 summarizes these ratings, drawing attention to the platform's main strengths as well as the areas that may need improvement.

As shown in Figure 6, the highest score was given to Relevance to Teacher Training ($M = 4.47$), followed closely by Likelihood of Future Use ($M = 4.36$). By contrast, Students' Acceptance received the lowest rating ($M = 3.32$), reflecting uncertainty about how easily students might adapt to gamified coding environments. Technical issues ($M = 3.21$) and time constraints ($M = 3.77$) were rated as moderate challenges, pointing to infrastructure readiness and lesson planning demands as critical factors for successful adoption.

4.1 Usability and technical performance

Participants rated overall usability positively ($M = 4.06$), with the interface receiving a slightly higher score ($M = 4.17$) and their qualitative feedback reinforced these impressions. Participants frequently praised Code.org's clear navigation, structured learning sequences, and visually appealing progress tracking. Still, 34% reported technical difficulties, including slow loading, occasional freezes, and disruptions during group activities. To address these issues, participants recommended system improvements and the introduction of an offline mode—something they saw as especially important for schools with limited digital resources.

4.2 Engagement and motivation insights

The quantitative data suggest participants found Code.org to be engaging and motivating. The mean for engagement in activities was 4.06 and for motivation toward the task was 4.04. They credit their perception of enjoyment to the gamified design features of the context, including interactive exercises, badges for completion, leaderboards and visual progress features, reporting that these along with the task enhanced enjoyment and continued engagement. The qualitative thematic analysis revealed that the motivational impact waned over time, especially among those learners who were more experienced in programming, who stated the tasks were repetitive and not challenging enough. As such, it is critical to provide more differentiated and adaptive learning pathways, such as

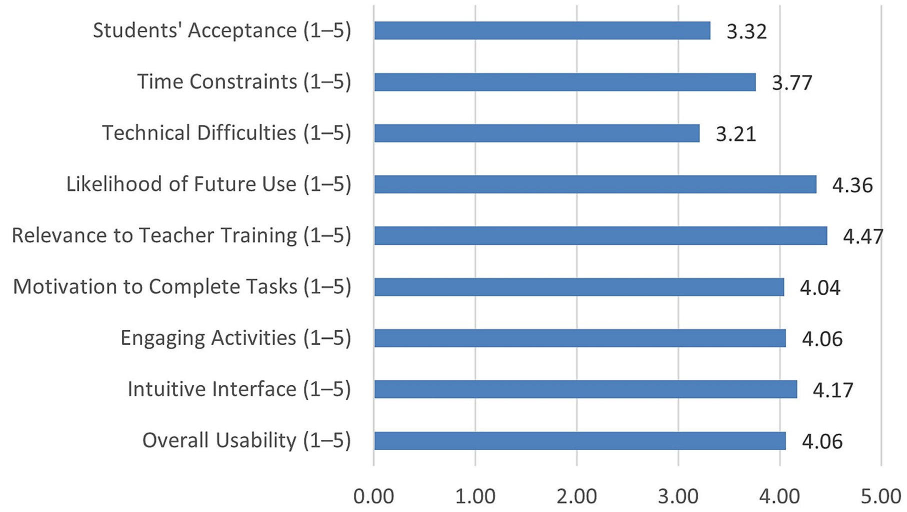

FIGURE 6
Average ratings for key aspects of Code.org by participants.

project-based activities or more advanced engagement tasks to aid in sustaining intrinsic motivation across varying learners.

4.3 Relevance to teacher training and curriculum integration

Code.org had the most favorable overall rating in pedagogical relevance, ($M = 4.47$), suggesting participants think that it would provide value for developing foundational competencies in computational thinking, problem-solving, and digital literacy. However, concerns were raised about the extent to which the instructional content on the platform adheres to structure and requirements of the national curriculum in Kazakhstan. Participants indicated the need for localized curricular materials, alongside supplementary teacher training modules to help teachers integrate instructional content into the classroom relevant to context.

4.4 Likelihood of future use and implementation barriers

Participants indicated a strong desire to implement Code.org in their future teaching practices as evident by the high mean ratings for Likelihood of Future Use ($M = 4.36$) in the survey. That said, multiple barriers to implementation were suggested by participants. The most pressing barriers related to structural issues in the context of rural education settings across the country, such as reliable access to the internet, and appropriate access to digital equipment. Participants recommended that educators consider developing an offline version of the platform and were optimistic about the opportunities for investment in digital infrastructure. They further elaborated on the need for professional development resources tailored to educators to help support teachers in using gamified pedagogical approaches within traditional pedagogical practice, particularly for time management and orchestration of lessons.

4.5 Student acceptance and classroom readiness

The students' acceptance of Code.org's gamified instructional teaching model received the lowest average acceptance rating ($M = 3.32$) indicating participants' concern related to students' initial adaptability—especially for students who were new to programming. Some participants noted the potential for initial confusion or student boredom early in the course. In response, participants suggested including scaffolding and teaching the sequences of tasks/challenges by explicitly outlining each step and providing opportunities for students to experience success in meaningful increments. These strategies were suggested in order to support student confidence and readiness.

4.6 Qualitative insights from open-ended responses

Table 3 summarizes the thematic analysis of participants' open-ended survey responses, presenting the main themes, key insights, and illustrative excerpts. The analysis of open-ended survey comments provided further insight into participant experiences with the platform. Usability stood out as a recurring strength; participants praised its user friendly interface, logical pathways for navigation, and tracking of progress. These were said to contribute to learner autonomy and facilitated self-exploration. Gamified elements such as badges and visual indications of achievement were cited as increasing engagement and feelings of accomplishment.

TABLE 3 Thematic analysis of open-ended responses.

Theme	Key insights	Example response
Usability strengths	Easy navigation, clear structure, motivating progress tracking, smooth performance.	*"Very user-friendly and easy to navigate." / "Progress tracking was very motivating."*
Usability challenges	Occasional slow loading, confusing navigation for beginners, need for more guidance.	*"Occasionally confusing when switching between sections." / "More guidance for beginners would be helpful."*
Gamification elements	Rewards, badges, leaderboards, and progress tracking were engaging.	*"The badges and leaderboards were a great incentive."*
Coding activities	Interactive, hands-on, challenging yet rewarding.	*"Completing coding projects was very rewarding."*
Visual and structural appeal	Well-designed interface, visual progress tracking, clear tutorials.	*"Seeing my progress visually was the best part."*
Challenges and suggestions	Repetitive tasks, lack of task variety, long exercises.	*"Some tasks were repetitive, but overall good."*
Classroom applications	Useful for teaching coding, problem-solving, and computational thinking.	*"Teaching logic through step-by-step challenges."*
Collaborative learning	Encourages teamwork, project-based learning, and engaging group work.	*"Team-based coding challenges enhance collaboration."*
Anticipated challenges	Student difficulties with coding, time constraints, technical barriers.	*"Some students may find coding too challenging without prior exposure."*
Teacher preparation	Need for extra training, balancing gamification with traditional teaching.	*"Finding time for extra training to master the tool could be difficult."*
Technical barriers	Device compatibility, internet issues, software glitches.	*"Occasional technical glitches may disrupt lessons."*
Teacher adoption	Requires teacher familiarity, convincing colleagues, managing large classes.	*"Convincing skeptical colleagues about its benefits might be a hurdle."*
Content and curriculum	Need for advanced topics, more lesson variety, high school-level content.	*"It could include more advanced topics for experienced users."*
Gamification and learning features	Suggestions for certificates, more interactivity, improved feedback.	*"Adding certifications for completed courses would be a nice touch."*
Collaboration and teaching support	Requests for group challenges, lesson planning tools, and structured materials.	*"It would be helpful to include lesson plans for teachers."*
Technical and accessibility enhancements	Requests for external tool integration, local language options, offline access.	*"Including an offline version could be beneficial for low-resource areas."*

However, areas for improvement were also highlighted. Participants with previous coding experience felt that there was insufficient content variety and challenge progression, which decreased engagement. Suggested improvements included project-based modules, differentiation options for advanced learners, and contextualised elements for the Kazakhstani setup.

Participants highlighted the importance of collaborative structures. Suggestions for improvement included peer-to-peer group project, professional teacher networks, and access to shared planning tools and resources to promote learning, sharing of ideas, and support.

Under the theme of implementation, challenges emerged such as the availability of technology and diversity of student coding experience, or time involved in preparing lessons, to mandate their use. Some participants reported limited institutional support or colleague buy-in when creating buy in when using gamified tools subscription, limiting their use within their context.

To support the long-term scalability and sustainability of gamified platforms like Code.org, participants emphasized the importance of systemic institutional support. Participants specifically recommended adapting offline versions of these gamified platforms for use in low-connectivity environments, ensuring that instructional materials aligned with existing national curricular frameworks, and offering guided professional development in order to build educators' capacity to engage with the gamification of learning through digital technologies. All of these recommendations demonstrate the need to create inclusive, flexible, and context-centric educational technologies, especially in resource-constrained areas.

5 Discussion

This study examined how pre-service teachers in Kazakhstan experienced Code.org as a gamified programming environment in initial teacher education, using a convergent parallel mixed-methods design in which survey and focus-group data were collected during the same period, analyzed separately, and then integrated for interpretation. Beyond reward features, Code.org also supports playful learning through experimentation, immediate feedback, and low-stakes debugging, where learners iteratively test ideas and refine solutions. In this framing, TAM helps explain uptake by clarifying how perceived ease of use and usefulness shape adoption intentions in a playful digital environment. SDT helps interpret how these playful affordances can support autonomy and competence—and why "wear-off" can occur when tasks no longer provide optimal challenge or meaningful choice. Accordingly, this Discussion explicitly "weaves" quantitative patterns (survey means and frequencies reported in Results) with qualitative themes (focus-group and open-ended responses summarized in Tables 2, 3) to explain where findings converge and where they diverge. Overall, the quantitative data showed high acceptance and perceived relevance—usability ($M = 4.06$), interface intuitiveness ($M = 4.17$), relevance to teacher training ($M = 4.47$), and likelihood of future use ($M = 4.36$)—while highlighting weaker points such as student acceptance ($M = 3.32$) and moderate concern about technical issues ($M = 3.21$) and time constraints ($M = 3.77$). Qualitative findings aligned with these patterns: participants repeatedly described Code.org as "user-friendly," motivating through visible progress, and valuable for building computational thinking, but also emphasized constraints (internet/device access), curriculum-fit concerns, and motivational "wear-off" when tasks felt repetitive for more experienced users. These integrated results reflect broader evidence that gamification often boosts engagement and motivation, but outcomes depend strongly on design quality and implementation conditions (Balalle, 2024; Prieto-Andreu et al., 2022; Khaldi et al., 2023; Urh et al., 2015).

5.1 Technology adoption and gamification: connecting findings to TAM

TAM proposes that technology adoption is shaped primarily by perceived ease of use and perceived usefulness (Venkatesh and Davis, 2000). The survey results strongly reflected both constructs: participants rated overall usability highly ($M = 4.06$) and the interface as intuitive ($M = 4.17$), and they judged Code.org to be highly relevant for teacher training ($M = 4.47$) with a strong intention to use it in the future ($M = 4.36$). The qualitative data converged with these ratings, as participants emphasized clear navigation, structured learning sequences, and progress monitoring as reasons Code.org "felt easy" and "worth using" for preparing to teach computational thinking—supporting a TAM-consistent pathway from usability/usefulness to adoption intention. This pattern aligns with wider educational technology research showing that user-friendly design and perceived instructional value are central predictors of acceptance (Venkatesh and Davis, 2000; Zalat et al., 2021).

At the same time, the data indicate that acceptance does not eliminate implementation friction. Participants reported moderate concern about technical issues ($M = 3.21$), and qualitative responses repeatedly referenced slow loading, occasional freezes, and connectivity/device constraints—especially salient for rural or under-resourced settings. This convergence suggests that perceived ease of use can be undermined by contextual barriers, echoing calls in the gamification and e-learning literature to examine infrastructure and access as critical conditions for successful uptake (Kalogiannakis et al., 2021; Khaldi et al., 2023). In practical terms, the findings imply that institutional support (devices, connectivity, troubleshooting routines) is necessary for TAM-based acceptance to translate into sustainable classroom implementation.

5.2 Intrinsic and extrinsic motivation in gamified learning: connecting findings to SDT

SDT differentiates between motivation supported by internal interest and competence development (intrinsic) and motivation stimulated by external incentives (extrinsic) (Deci and Ryan, 2000; Ryan and Deci, 2020). In this study, the quantitative results indicated strong perceived engagement ($M = 4.06$) and motivation to complete tasks ($M = 4.04$), and participants frequently attributed these experiences to gamified affordances such as badges, leaderboards, and visible progress indicators. Qualitative accounts converged with this pattern: many participants described "enjoyment," "achievement," and "feeling motivated" when progress was tracked and rewards were earned, suggesting that Code.org's extrinsic cues effectively initiated participation.

However, the integrated findings also point to a sustainability challenge. While mean engagement and motivation were high, qualitative themes indicated motivational decline ("wear-off") over time among participants with prior programming experience, who described tasks as repetitive or insufficiently challenging. This divergence—high overall ratings alongside narratives of diminishing motivation—matches SDT's expectation that rewards can trigger engagement but long-term persistence depends on supporting autonomy, competence (mastery), and meaningful challenge (Ryan and Deci, 2020; Mitchell et al., 2020; Sansone and Tang, 2021). It also aligns with broader gamification research cautioning that reward-dominant designs may produce short-term engagement unless paired with deeper learning structures (Urh et al., 2015; Prieto-Andreu et al., 2022).

For teacher preparation, these results imply that gamification should be paired with instructional designs that sustain intrinsic motivation: differentiated pathways for advanced learners, project-based tasks (e.g., App Lab/Game Lab classroom scenarios), and collaborative challenges that build authentic teaching competence. This recommendation is consistent with evidence that gamified environments are most effective when aligned with meaningful goals and appropriately scaffolded challenge rather than relying mainly on points or badges (Gupta and Goyal, 2022; Ohn and Ohn, 2020; Khaldi et al., 2023).

5.3 Pedagogical implications: integrating Code.org into teacher training

Beyond acceptance and motivation, the convergent results highlight a practical question for teacher education: how engagement with Code.org translates into instructional readiness under curriculum and classroom constraints. Quantitatively, participants rated Code.org as highly relevant for teacher training ($M = 4.47$) and were likely to use it in the future ($M = 4.36$), yet they expressed lower confidence regarding student acceptance ($M = 3.32$) and reported moderate concern about time constraints in lesson planning ($M = 3.77$). Qualitatively, these concerns were elaborated through themes of beginner readiness, the need for scaffolding, and uncertainty about alignment with Kazakhstan's national curriculum expectations, suggesting that readiness is mediated by pedagogical integration rather than platform appeal alone. Prior work similarly warns that gamified engagement may remain superficial if not aligned to clear learning objectives and curriculum structures (Ohn and Ohn, 2020; Khaldi et al., 2023; Prieto-Andreu et al., 2022).

Therefore, teacher-education programs may benefit from (i) localized lesson plans mapping Code.org modules to national curriculum outcomes, (ii) structured pedagogical routines for novice programmers (guided tutorials, step-wise success criteria), (iii) differentiated extensions for advanced learners to prevent repetitive experiences, and (iv) practical time-management strategies such as blended sequencing (home practice + in-class facilitation) to reduce lesson-planning load. These recommendations directly reflect the study's integrated evidence (survey concerns + focus-group suggestions) and support a clearer engagement-to-readiness pathway for pre-service teachers.

5.4 The Kazakhstani context: challenges and opportunities

The findings also indicate that implementation in Kazakhstan is shaped by contextual moderators—particularly infrastructure and access—that can constrain even highly accepted platforms. The moderate quantitative concern for technical issues ($M = 3.21$) converged with qualitative reports of connectivity/device barriers, supporting the argument that equitable adoption requires technical readiness and institutional support, especially outside well-resourced settings. This aligns with literature emphasizing that gamified and technology-based instruction depends on reliable infrastructure and support systems to avoid widening digital inequities (Kalogiannakis et al., 2021; Khaldi et al., 2023).

Participants' repeated recommendation for an offline or low-bandwidth mode suggests a concrete adaptation pathway for similar contexts. In parallel, professional learning that targets both technical integration and pedagogy (classroom orchestration, differentiation, curriculum mapping) may be necessary to realize the promise of national STEM and digital-literacy reforms in teacher preparation. Thus, Code.org's potential contribution to Kazakhstan's modernization agenda is most likely to be realized when platform design affordances are matched with localized curriculum resources and system-level implementation supports.

5.5 Future research directions

Future research should extend this convergent mixed-methods approach in three ways. First, longitudinal designs are needed to test whether high initial acceptance and motivation persist and translate into actual classroom implementation and teaching practice. Second, multi-site studies across universities and regions could examine how infrastructure differences shape adoption and equity, clarifying implementation conditions in Kazakhstan. Third, studies that include learning or performance indicators (e.g., computational thinking outcomes, lesson-design quality) alongside motivation/acceptance measures would strengthen evidence about how gamified teacher preparation impacts instructional competence beyond perceptions (Balalle, 2024; Prieto-Andreu et al., 2022; Khaldi et al., 2023).

5.6 Limitations

Although the intervention generated valuable insights, several limitations must be acknowledged. The relatively small sample size of 40 participants limits the generalizability of the findings. In addition, reliance on self-reported data introduces the possibility of response bias, as participants may have provided socially desirable rather than fully accurate responses. Finally, the four-week duration allowed for meaningful exploration of Code.org's features but was not sufficient to evaluate long-term effects on teaching effectiveness or sustained use of gamified tools. Future research should therefore consider longitudinal studies to assess the lasting impact of gamification in teacher training programs.

6 Conclusion

This study investigated the educational value of integrating Code.org into pre-service teacher education in Kazakhstan through a convergent parallel mixed-methods design. The findings show that Code.org is not only perceived positively but also offers a practical pathway for strengthening teacher preparation in computational thinking and digital literacy. High ratings for usability and instructional relevance indicate that the platform can support competency-oriented training when embedded within structured coursework. At the same time, the results identify conditions that determine whether engagement translates into instructional readiness: participants' concerns about student preparedness, lesson-planning time, and infrastructure signal that successful implementation requires more than platform access.

Interpreted through TAM, the strong perceptions of ease of use and usefulness suggest favorable adoption potential; however, contextual barriers (connectivity, devices, time constraints) may prevent acceptance from becoming sustained classroom practice without institutional support. Interpreted through SDT, gamified features appear effective for initiating engagement, but qualitative "wear-off" among more experienced participants indicates that long-term motivation depends on maintaining autonomy and optimal challenge. This implies that teacher education programs should use differentiated pathways (e.g., advanced options and project-based tasks), explicit scaffolding for novices, and collaborative teaching scenarios to sustain intrinsic motivation while preserving the benefits of gamified feedback.

For policy and practice in Kazakhstan, the study provides actionable guidance: teacher training institutions should (i) align Code.org modules with national curriculum outcomes through localized mapping and lesson templates, (ii) include targeted professional development on classroom orchestration and time-efficient planning, and (iii) address equity of access through infrastructure investments and low-bandwidth/offline-ready delivery models. In this way, gamified programming environments can contribute to national STEM and digital-literacy goals by strengthening both teacher confidence and practical implementation capacity, rather than remaining a short-term engagement tool.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Conclusion of the Ethical Committee of L. N. Gumilyov Eurasian National University for the Examination of the Research Works Dated 02.09.2024, No 007. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AD: Investigation, Software, Supervision, Validation, Writing – original draft, Writing – review & editing. AM: Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. MS: Conceptualization, Data curation, Funding acquisition, Validation, Visualization, Writing – original draft, Writing – review & editing.

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