Contemporary Educational Technology, 2026, **18**(2), ep643
ISSN: 1309-517X (Online)

OPEN ACCESS

Research Article

Primary school teachers' readiness for generation Alpha learning environments

Banu Kayınova [1*]
0000-0003-2647-3351

Tufan Adıgüzel [2]
0000-0001-6232-1246

[1] Department of Information Systems and Technologies, Faculty of Applied Sciences, Istanbul Gelisim University, Istanbul, TURKEY
[2] Department of Computer Engineering, Faculty of Engineering and Architecture, Istanbul Gelisim University, Istanbul, TURKEY
[*] Corresponding author: bkayinova@gelisim.edu.tr

Citation: Kayınova, B., & Adıgüzel, T. (2026). Primary school teachers' readiness for generation Alpha learning environments. *Contemporary Educational Technology, 18*(2), Article ep643. https://doi.org/10.30935/cedtech/18063

ARTICLE INFO

Received: 20 Oct 2025
Accepted: 20 Feb 2026

ABSTRACT

This study examined primary school teachers' readiness for the learning environments of generation Alpha, who are greatly influenced by technological advancements and globalization. Although teachers need to be prepared for this new learning ecosystem, existing research offers limited insight into elementary school teachers' preparedness to address the technologically and pedagogically evolving learning needs of generation Alpha in a globalizing context. Using a qualitative case study approach, we conducted semi-structured interviews with 34 teachers in Turkey. The findings revealed four key dimensions of readiness for generation Alpha learning environments: (1) student development guidance, (2) teacher characteristics, (3) learning environment development, and (4) technology in education. Project-experienced teachers showed advanced competence in promoting 21st century skills, adopting alternative assessment practices, and using learner-centered classroom management. They integrated diverse instructional technologies beyond content delivery and used diverse teaching strategies. Conversely, teachers without project experience showed limited technological integration and relied more on traditional classroom practices. Furthermore, digital citizenship awareness (online ethics and safety) was underdeveloped across all participants, highlighting an overlooked area in teacher preparedness for generation Alpha learners. This study contributes to the literature by identifying the key components of teacher readiness for generation Alpha and highlighting how project-based learning experience enhances pedagogical and technological competencies. The findings have implications for teacher training and educational policy reforms focused on equipping educators for 21st century learning environments.

Keywords: generation Alpha, education technology, learning environment, primary school teacher

INTRODUCTION

Technology is transforming education. In this context, traditional teaching approaches need to be re-evaluated for the new generation of students who have grown up with digital technologies (Shi et al., 2025). These students, born after 2010, are referred to as 'generation Alpha'. They are accustomed to acquiring information from multiple environments through the use of digital devices (Swargiary, 2024). However, most teachers who interact with this generation were introduced to such technologies later in life. Accordingly, the literature highlights the importance of teachers developing digital pedagogical competencies and restructuring learning environments in response to these changes (Bentri et al., 2022; Karthika & Rajeswari, 2025; Organisation for Economic Co-operation and Development [OECD], 2023).

Integrating technology into education has been associated with transformations in classroom management, interaction, evaluation, and teacher roles (International Society for Technology in Education [ISTE], 2024; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2023). Studies indicate that technology can be used not only for presentation purposes but also to enhance collaboration, production, and student interaction (Amemasor et al., 2025; Schulz et al., 2025). Despite extensive research on generation Alpha's characteristics and suitable pedagogical approaches, fewer studies have holistically addressed teachers' readiness for this new learning culture. Much of the existing literature has focused on specific aspects such as teachers' digital pedagogical competence, technology use strategies, and teacher-student interactions (Daribayeva, 2024; Fernando & Premadasa, 2024; Gavrilas et al., 2024; Klimashevska, 2023; Mawloood, 2023; Zeichner et al., 2024). Consequently, a limited number of studies have holistically addressed teachers' readiness for this new learning culture. Recent studies have increasingly focused on teachers' readiness to work with generation Alpha learners in artificial intelligence (AI)-supported learning environments and on how AI literacy relates to teachers' adoption intentions for tools such as ChatGPT (Karthika & Rajeswari, 2025; Kılıç et al., 2025). Therefore, this study aimed to examine teachers' readiness for generation Alpha learning environments in terms of classroom management, teaching strategies, measurement and evaluation approaches, and teacher roles inside and outside the classroom.

Generation Alpha and the Learning Environment

Generation Alpha is distinct from previous generations in terms of possessing high digital competence and the ability to seamlessly integrate technology into their lives (Gutiérrez Molero et al., 2025; Höfrová et al., 2024). This group also has a short attention span, high expectations of digital interaction, and a need for constant connection. Although learning cultures are changing owing to the ease of information access, generation Alpha may be more constructivist and independent learners and will likely grow up to be technology-dependent individuals (McCrindle, 2021; Ziatdinov & Cilliers, 2021). Current learning environments remain largely teacher-centered and knowledge-transfer-based (Bhardwaj et al., 2025; Wiklund-Engblom et al., 2025). Despite the individual learning tendencies of generation Alpha, the peer learning and collective interactive learning environments offered by social constructivism are gaining importance (Fernando & Premadasa, 2024; Ziatdinov & Cilliers, 2021). Accordingly, studies suggest that generation Alpha students tend to prefer collaborative and innovative learning environments that foster creative expression (Gutiérrez Molero et al., 2025; Konings, 2024). In this context, the literature suggests that technology-supported inquiry-based learning environments and project-based practices can support the development of critical thinking, problem-solving, and analytical skills (Barak & Dori, 2004; Huang et al., 2024) to support critical thinking, problem-solving, and analytical skills (Arifin et al., 2025). Given generation Alpha's short attention span, studies indicate that lessons incorporating drama, experiments, and interactive applications may increase students' curiosity and participation (Aini et al., 2024; Elver & Yılmaz, 2023).

This underscores the need to adopt application-based teaching methods (learning by doing and experimentation) that develop creative and critical thinking skills (drama, brainstorming, discussion, case study, station, and project-based learning [PBL]), group teaching methods (collaborative learning, gamification), and individual teaching methods (computer-assisted teaching) (Barak & Dori, 2004; Lee, 2023). Moreover, integrating AI tools into these methods can further personalize learning and support students' problem-solving and creativity (Holmes et al., 2019). Studies also highlight that learning experiences provided in virtual environments can support the development of students' information and communication technology (ICT) literacy skills, including accessing, managing, combining, evaluating, and producing information (Ng et al., 2023; Ramli & Borhan, 2024). For effective classroom management, studies suggest that integrating traditional and modern approaches may be beneficial. Although this model supports constructivist-based higher-level cognitive development, it also includes strategies for regulating student behavior, such as classroom contracts (Majeika et al., 2020). Taken together, these findings emphasize the importance of taking into account students' individual needs, personality traits, and educational expectations as learning environments move beyond traditional approaches.

Generation Alpha Teachers

Teachers' digital competencies are discussed through interrelated but conceptually distinct structures such as digital literacy, digital proficiency, and digital citizenship (DQ Institute, 2019; ISTE, 2024; Redecker, 2017; UNESCO, 2023). Digital citizenship is considered a high-level competency area encompassing teachers' ability to participate in digital environments safely, ethically, and responsibly, and to model these behaviors for their students (DQ Institute, 2019; ISTE, 2024). Digital literacy encompasses teachers' skills in accessing, evaluating, interpreting, and producing information through digital technologies; it forms the functional basis of digital citizenship behaviors (UNESCO, 2023). Digital competence, on the other hand, is a more comprehensive framework that integrates these two areas with pedagogical and professional practices, encompassing teachers' skills in designing technology-supported learning environments, effectively integrating digital tools into teaching strategies, managing digital classrooms, and conducting assessment and evaluation processes (Redecker, 2017). Although these concepts are clearly defined in the literature, how teachers reflect these competencies in the design and management of learning processes remains a significant problem area (Redecker, 2017; UNESCO, 2023). To encourage student participation, teachers' understanding of generation Alpha's learning preferences, the design of technology-supported teaching processes, and the restructuring of learning environments are important (Gutiérrez Molero, 2025; Ng et al., 2023). Studies suggest that, beyond following current practices, teachers may benefit from developing original and innovative teaching strategies (World Economic Forum [WEF], 2024). As digital technologies become increasingly embedded in educational practices, several international frameworks have articulated standards for teachers' technology integration competencies. For instance, UNESCO's ICT competency framework for teachers and the ISTE standards for educators emphasize roles such as designer, facilitator, collaborator, and digital citizen, highlighting teachers' responsibility to create student-centered, inquiry-driven, and ethically grounded digital learning environments (ISTE, 2024; Redecker, 2017; UNESCO, 2023). These frameworks underscore that effective teaching in contemporary classrooms requires not only technical proficiency but also pedagogical adaptability, professional collaboration, and reflective practice. Although these constructs and standards are conceptually well established, a persistent challenge concerns how teachers translate such competencies into the practical design and orchestration of learning processes (UNESCO, 2023). This issue becomes particularly salient in the context of generation Alpha learners, whose early and continuous exposure to digital ecosystems necessitates pedagogically meaningful, rather than merely instrumental, technology integration (Gutiérrez Molero, 2025; Ng et al., 2023). Recent perspectives further emphasize the importance of innovative and future-oriented instructional strategies in digitally enriched classrooms (WEF, 2024). PBL, as a student-centered and inquiry-driven approach, provides a relevant pedagogical lens for examining how digital competence is enacted in practice (Fitrah et al., 2025). However, existing literature has not comprehensively explored elementary school teachers' competencies across instructional strategies, classroom management approaches, assessment methods, and professional roles within this integrated framework. Comparing teachers who implement PBL with those who do not may therefore provide deeper insight into how digital competencies are operationalized in contemporary classrooms and help identify professional development needs.

Contemporary teaching methods such as PBL can develop student skills, such as group collaboration, information access, analysis, and problem-solving (Fitrah et al., 2025). Within the scope of process-oriented assessment methods, the use of alternative techniques such as rubrics, peer assessment, student diaries, portfolios, observation forms, and group assessments alongside surveys and tests is emphasized (Loureiro & Gomes, 2023; Xu et al., 2023). In particular, in PBL, pre-project tests can be used to determine students' readiness levels, and end-of-project tests, forum participation, mini-surveys, and other monitoring tools can be used to evaluate achievements (Lertsakulbunlue & Kantiwong, 2025). However, although teachers may acknowledge the importance of fostering independent learning processes and skills, research indicates that they often lack clarity regarding how these processes are implemented in practice (Ernst et al., 2023). Recent research has focused on how teachers respond to generation Alpha's expectations and learning characteristics, examining their ability to integrate digital technologies into the classroom (Gavrilas et al., 2024; Mawloood, 2023; Redecker, 2017; Tzafilkou et al., 2023), adapt to innovative classroom activities (Hikmatovich, 2022; Padmadewi et al., 2021), and participate in professional development activities (Klimashevska, 2023; Machynska et al., 2020). In addition, increasing attention is being given to how teachers adopt AI-powered

tools for personalized instruction, real-time analytics, and formative assessment (Tammets & Ley, 2023). Some works have defined the characteristics of generation Alpha students from teachers' perspectives and evaluated teachers' readiness (Coolsaet, 2024; Danilova, 2023; Daribayeva, 2024; Fernando & Premadasa, 2024; ISTE, 2024; Jukić & Škojo, 2021; Kohli & Arora, 2024; Senjaya et al., 2021; UNESCO, 2023; Zeichner et al., 2024). However, the existing literature has yet to holistically address elementary school teachers' competencies across teaching strategies, classroom management approaches, measurement and evaluation methods, and teacher roles both inside and outside the classroom. Through such investigation, teaching processes for generation Alpha learners could be better managed. Moreover, comparing teachers who use PBL involvement with those who do not can contribute to an accurate determination of teachers' professional development needs. Thus, this study considered the following research questions:

- What are teachers' levels of readiness in terms of generation Alpha learning environments?
- What are the differences in readiness between teachers who have used PBL involvement for at least three years and those who have not?

METHOD

Aiming to understand teachers' experiences in their natural environments, we followed a flexible, reflexive process for data collection, analysis, and interpretation (Hammersley & Atkinson, 1995; Maxwell, 2012). We therefore adopted a qualitative approach involving a holistic multiple-case design, which allowed for examining a specific phenomenon multidimensionally within its context and making comparisons (Creswell, 2013; Miles & Huberman, 2019; Stake, 2013; Yin, 2009). The two groups in this study—teachers who had used PBL involvement for at least three years and those who had not—were regarded as 'situations', and the similarities and differences between them were revealed (Stake, 1995). We used a semi-structured interview form for data collection to understand the situation and determine teachers' readiness for generation Alpha learning environments (Bogdan et al., 2016). Semi-structured interviews were preferred as they enable the researcher to follow a predetermined set of questions while also allowing participants to elaborate on their experiences in their own words, thus providing rich and in-depth data (Merriam & Tisdell, 2015). This method also allows for probing emerging issues during the interview process, contributing to a more comprehensive and contextual understanding of the phenomenon under investigation (Creswell, 2013). In contrast, structured instruments such as questionnaires may limit participants' responses to predefined categories and therefore were not considered sufficient for capturing teachers' experiential and perceptual readiness for generation Alpha learning environments (Patton, 2014).

Participants

We recruited 34 primary school (grade 1-grade 4) teachers from 32 public schools in the four provinces of Turkey's Marmara Region (Istanbul, Kocaeli, Bursa, and Yalova) during the second semester of the 2021-2022 academic year. We used the disproportionate sampling method (Neuman, 2014), and an equal chance of participation was considered. Following the 'one participant from each school' approach, we selected teachers based on specific characteristics such as classes taught, gender, age, seniority, and degree. The criteria for inclusion were the use of PBL involvement and no such use (Creswell & Poth, 2017). In this study, we examined the profiles of teachers who had engaged in PBL through the eTwinning platform for at least three years, focusing on both the number and duration of their project involvements. Teachers who had participated in only one project during the previous year were classified within the group identified as having limited or no recent project experience. Overall, the participants represented an academically well-qualified and professionally experienced group, most of whom were graduates of faculties of education with more than a decade of teaching experience. Their continuous participation in educational and professional development activities demonstrates both institutional stability and a strong commitment to lifelong learning. Almost all participants attended in-service training programs—predominantly organized by the Ministry of National Education (MoNE)—which they perceived as valuable for enhancing professional knowledge and staying abreast of pedagogical innovations. The competencies emphasized through these trainings, such as collaboration, empathy, problem-solving, and technological proficiency, indicate that participants associated professional development not only with technical improvement but also with interpersonal and reflective

Table 1. Demographic characteristics, in-service training, and project information

Variable	Category	Frequency (n)
Gender	Female	23
	Male	11
Age interval (birth year)	65-70	1
	71-75	11
	76-80	4
	81-85	10
	85-90	7
	91+	1
Educational background	Bachelor's degree	31
	Master's degree	3
Faculty	Education	31
	Other	3
Seniority	7 years or less	3
	7-10 years	2
	11-15 years	10
	16-20 years	6
	21 years and above	13
Project experience	None	15
	1 project	6
	5+ projects	1
	6-15 projects	9
	16-29 projects	1
	30+ projects	2
Project involvement duration	Never	15
	Last 1 year	7
	Last 3-5 years	12
In-service training	Received	32
	Not received	2
In-service training institution	MoNE	23
	Non-MoNE	4
	Both	6

growth. Although some teachers reported limited or no project engagement, many exhibited long-term involvement in collaborative initiatives like eTwinning, reflecting a professional tendency toward innovation, digital integration, and international cooperation in education. **Table 1** presents an overview of the participants' demographic characteristics, in-service training backgrounds, and project involvement details.

Data Collection

We used a two-section semi-structured interview form. The first section had seven questions concerning participants' demographic characteristics, projects, and in-service training. The second section had 18 questions, including five main questions and 13 sub-questions, focused on teachers' readiness. These questions were developed based on a literature review (Flick, 2022; Tracy, 2019) and feedback from six colleagues with 15-20 years of professional experience: a guidance counsellor, a Turkish language teacher (PhD student in the field), a teacher (PhD student in education), an eTwinning coordinator, a computer and instructional technology teacher (PhD student in educational technology), and an English teacher (an educational technologist with a PhD). We consulted four additional experts to construct the final form: a specialist in qualitative research methods with 15-20 years of professional experience, a specialist in education measurement and evaluation, and two specialists in educational programs and instruction. Then, during the first semester of the 2021-2022 academic year, we used convenience sampling to conduct a pilot study with four primary school teachers in Yalova Province. Two had between 11 and 20 years of experience and had never worked on PBL involvement, and two had 21 or more years of experience and had used PBL involvement for at least the previous three years. Ultimately, six new questions were added to the pilot interview form. The following are two examples of questions from the final interview form:

Question 2. How do you manage your classes? What do you do for this, and can you explain it with examples?

2.1. What do you do in the classroom to help students develop their learning skills?

2.2. What do you do to help students develop their learning skills in extracurricular activities?

Question 3. How do learner characteristics and technological change influence today's learning environments?

3.1. How do your students learn? What do they do to learn?

3.2. How and for what purpose do you use new-generation learning environments such as social networks, online learning, and mobile technologies in teaching-learning processes?

Following the development and refinement of the interview form, the data collection process was conducted in accordance with ethical principles and relevant legal permissions. Data collection took place during the 2020-2021 academic year, when COVID-19 related restrictions were still in effect. Therefore, face-to-face interviews were not possible, and all interviews were conducted via Zoom. Furthermore, online interviews provided logistical flexibility and enabled the participation of teachers located in different regions. Prior to participation, all participants were provided with written information about the purpose and procedures of the study, and written informed consent forms were obtained from all participants via WhatsApp before the interviews. During the interview, all participants stated that they did not object to audio recording, and recordings were only made after obtaining their explicit consent. The total interview time was approximately 40 hours. Considering ethical considerations, the identities and institutional information of the participants were kept confidential. Participants who had not participated in any project in the last year (T1, T2, T3) and participants who had participated in the project in the previous three years (PT1, PT2, PT3) were coded with pseudonyms. We transcribed the audio recordings using the Transcriptor program, which quickly converts audio recordings to text. Then we listened to the recordings again and corrected any misspelled or incomplete words and sentences; this resulted in a dataset of 778 pages.

Based on ethical considerations, participants' identities and institutional information were kept confidential. Participants who had not undertaken any projects for at least the last year (T1, T2, T3) and those who had undertaken projects for at least the previous three years (PT1, PT2, PT3) were coded with pseudonyms. We transcribed the recordings using Transkriptor, which rapidly converts audio recordings into text. We then replayed the audio recordings and corrected incorrectly or incompletely transcribed words and sentences, resulting in a 778-page data corpus. The 778-page data corpus consists solely of verbatim transcripts of the semi-structured interviews. It includes participants' full responses, illustrative examples, and detailed reflections related to their experiences and readiness for generation Alpha learning environments. The corpus does not contain coding outputs, summaries, or analytic interpretations, but represents the raw qualitative data used for subsequent analysis.

Data Analysis

We analyzed the data using content analysis. Following Bogdan and Biklen's (2007) steps for qualitative data analysis, the data were first converted into text in Microsoft Word and then organized and managed using MAXQDA 2020. First-cycle coding proceeded as follows:

(a) qualitative coding (coding of basic descriptive information such as participant characteristics, demographic information),

(b) in vivo coding (coding of terms or short phrases used by participants),

(c) simultaneous coding (coding expressions in the data content that require multiple codes simultaneously, indicate multiple meanings, are clear to the analyst, and have implicit meanings),

(d) process coding (coding the general conceptual or nested actions in the data, not what people possess but what they do),

(e) concept coding (gathering a series of codes obtained from the initial coding under a single concept), and

(f) emotion coding.

The determined codes were classified into subcategories, which were then reorganized under the upper categories, thus enabling generalization for similar contexts (Saldana, 2015). We finally obtained 130 suitable codes, 9 subcategories, and 4 upper categories.

Table 2. Upper and lower categories

Upper categories	Lower categories	Code frequencies
Student development guidance	Providing students with skills	9
	Measuring and evaluating the student	6
Teacher characteristics	Qualities a teacher should possess	11
	Aspects that are lacking and require improvement	7
Learning environment development	Instructional strategies	19
	Classroom management strategies	11
Technology in education	Purpose of using instructional technologies	9
	Instructional technologies used	5
	Digital citizenship	5
Total		82

Validity and Reliability

Given our qualitative approach, we preferred 'credibility' over 'internal validity', 'transferability' over 'external validity', 'consistency' over 'internal reliability', and 'confirmability' over 'external reliability' (Lincoln & Guba, 1985). To enhance *credibility*, we aimed to provide clear, understandable, and consistent explanations of how we arrived at the findings obtained from the interviews. To this end, we created a code system booklet explaining how the findings were reached and prepared coded section booklets of 1,477 pages. To enhance *transferability* (i.e., generalizability to similar environments and situations), we provided a detailed description of all research data. For *consistency*, we ensured a consistent reflection of the processes in which reliability was emphasized (from the creation of the data collection tool to the analysis stage). For *confirmability*, the collected data (audio recordings and transcripts) were retained for examination when necessary (Lincoln & Guba, 1985). Creating a holistic picture requires additional methods such as participant and colleague confirmation (Creswell & Poth, 2017). Before conducting the interviews, we shared the interview form with colleagues and field experts. Then, the interview questions were assessed through pilot interviews. Transcripts of the interviews were sent to participants via WhatsApp for their confirmation (Bogdan & Biklen, 2007). The results and comments on the data were confirmed by two participants, one of whom was a doctoral student in to make accurate coding decisions, we considered the research subject, theoretical framework, research questions, and study purpose (Saldana, 2015). The codes and categories were checked by a specialist with 20-25 years of experience in qualitative research. Finally, the interviews were conducted in a neutral manner, and the findings were interpreted accordingly.

FINDINGS AND DISCUSSION

This study addressed two research questions focusing on teachers' readiness for generation Alpha learning environments and the differences between teachers who have and do not have long-term PBL experience. Data analysis initially yielded 130 codes and 21 categories. Descriptor coding was performed on the participant information given in **Table 1**, producing 48 codes and 12 categories used for descriptive purposes. Then, 82 codes related to participants' readiness for generation Alpha learning environments were collected under nine subcategories, which were clustered into four upper categories (student development guidance, teacher characteristics, learning environment development, and technology in education). **Table 2** presents information on the upper and lower categories. The findings are also discussed below, explicitly referencing these research questions and highlighting patterns related to each upper category.

Teachers' Readiness for Generation Alpha Learning Environments

Student development guidance

The findings on student development guidance show that teachers are aware of the essential 21st century skills needed for generation Alpha students, with a particular emphasis on competencies related to creativity, communication, and technology, as well as the importance of monitoring students' development through appropriate assessment and evaluation practices. The upper category *student development guidance* had two subcategories: *providing students with skills* and *measuring and evaluating students.*

Table 3. Providing students with skills

Category	Codes	N	f	Percentage (%)
Providing students with skills	Creativity	7	17	23.29
	Using technology	7	11	15.07
	Communication skills	9	10	13.07
	Problem-solving skills	8	9	12.33
	Reading comprehension skills	7	8	10.96
	Analytical thinking	4	6	8.22
	Life skills	5	5	6.85
	21st century skills	4	5	6.85
	Self-regulation	1	2	2.74
Total		52	73	100

Table 3 presents information regarding the code, participant frequency, code frequency, and percentage values for the category of skills provided to students. Today, individuals are expected to develop skills such as creativity, critical thinking, communication, and technological literacy (Partnership for 21st Century Learning [P21], 2019). Accordingly, regarding the codes under the subcategory *providing students with skills*, four participants (PT3, PT8, PT18, PT22) said they primarily aim to provide their students with 21st century skills: *'So first of all, she/he needs to acquire 21st century skills'* (PT8). They also said they provide training to help students gain these skills to prepare them for future professions:

> We always talk about 21st century skills in terms of preparing for the future. We now see it as a necessity for students to have skills such as innovation, creativity, and entrepreneurship, and we are currently working to develop them (PT3).

Students today are expected to develop creativity, critical thinking, communication, and collaboration (P21, 2019). Accordingly, participants' statements relate to the characteristics of generation Alpha students. Regarding *creativity (f17)*, students should be taught that they are capable of creating, and teaching-learning processes should nurture creative expression (Kennedy, 2016). Some participants (T6, T7, T24, PT9, PT11, PT12, PT29) mentioned including practices that develop creative skills: *'I would like them to be more creative, to develop these aspects, and also to develop their exploration aspects. In other words, I try to do practices in that direction in my class'* (T24). Teachers also wanted their students to gain *communication skills (f10)*, with nine participants (T2, T5, T6, T20, T21, T31, PT10, PT22, PT23) explicitly mentioning it.

Generation Alpha students' communication skills can be strengthened by environments in which they play an active role in their learning and are encouraged to learn collaboratively (Redecker, 2017). Relatedly, participants remarked, *'I try to make them speak freely and raise their hands'* (T21), *'Sometimes I want them to discuss a topic by learning more about it'* (T2), and *'Those who have presentation skills and express themselves [can gain communication skills]'* (PT22). Apart from communication, 21st century students need to acquire critical thinking and problem-solving skills (OECD, 2023). Participants made no statements related to critical thinking, and only those with at least three years of PBL experience (PT4, PT9, PT11, PT18, PT22, PT23, PT29, PT30) referred to *problem-solving (f9)*: *'Problem-solving is one of the skills that education provides to the oldest students'* (PT4). Four participants (T2, T7, T24, PT18) specifically mentioned *analytical thinking (f6)*: *'You aim for the child to think analytically. With the process you do, you realize that the child has reached such a point by questioning'* (PT18). Since critical thinking requires problem-solving and analytical skills (Golden, 2023), we can assume that participants' remarks on problem-solving and analytical thinking were aimed at improving critical thinking. However, only participants who used PBL involvement mentioned these aspects—an expected finding given that PBL guides learners to find solutions to real-life problems (Solomon, 2003).

Some participants (T1, T2, T5, T7, T33, PT22, PT29) mentioned the need to develop *skills in using technology (f11)*. This aligns with the view that instructional technologies support the development of students' critical thinking skills in inquiry-based learning environments (Irvin et al., 2007; National Environment Agency–Singapore [NEA], 2012). Yet participants seemed to only emphasize ICT literacy in the context of developing critical thinking skills in virtual environments (Wilson et al., 2015). In addition to ICT literacy, five participants (T2, T5, T7, PT22, PT29) mentioned digital literacy, using language such as *'children born in the digital age'* (T2) and *'technology children'* (PT29). Regarding the skills noted by participants, measurement and evaluation

methods are needed to determine the extent to which students have acquired them. **Table 4** presents the assessment methods noted by participants.

Table 4. Student measurement and evaluation

Category	Codes	N	f	Percentage (%)
Measuring and evaluating the student	Surveys and tests	13	22	31.88
	Achievement evaluation scales	10	17	24.63
	Written exams	15	16	23.18
	Peer evaluations	3	5	7.24
	Rubrics	4	5	7.24
	Observation forms	4	4	5.70
Total		49	69	100

In addition to classical methods such as *written exams (f16)* and *achievement evaluation scales (f17*), participants used process-oriented evaluation methods, including *surveys and tests (f22), rubrics (f5), peer evaluation (f5)*, and *observation forms (f4)* (Brookhart, 2013). Since written exams are the most frequently used classical evaluation method (McMillan, 2018), it is unsurprising that 15 participants (T1, T5, T6, T7, T20, T24, T26, T27, T28, T32, T33, PT12, PT13, PT14, PT16) mentioned them: '*We already had written exams in the fourth grade; I was applying them*' (T6). In addition to written exams, student success is evaluated based on course participation (Holly et al., 2024). Correspondingly, 10 participants (T1, T2, T7, T25, PT3, PT10, PT12, PT23, PT29, PT30) indicated using *achievement evaluation scales (f17)*: '*We have achievement evaluation scales. We use them*' (PT10). It has been noted that process-oriented evaluation should be used to monitor the development of primary school students (Brookhart, 2013). The most frequently mentioned process-oriented evaluation methods were surveys and tests. Of the 13 participants who mentioned surveys and tests (T5, T6, PT27, PT32, PT3, PT4, PT8, PT9, PT14, PT15, PT18, PT22, PT30), two had worked on eTwinning projects for at least one year, and nine for at least three years. Only two participants who had not used PBL said they had used surveys and tests. Related to eTwinning projects, participants noted, *'We conduct pre-tests to measure the prior knowledge of the students and their parents before starting the project'* (PT4), and *'We conduct surveys, our students fill them out, we use Google Forms to prepare them'* (PT3). Teachers who use PBL are expected to conduct evaluation studies in accordance with project evaluation criteria throughout the project. Meanwhile, teachers who did not use PBL did not prefer using surveys and tests to monitor students' development. Regarding other evaluation techniques, four participants (T31, T34, PT12, PT30) said they used observation forms. Four participants with at least three years of PBL experience (PT10, PT11, PT12, PT30) reported using rubrics, while three participants with similar experience (PT10, PT12, PT29) reported using peer evaluation. Overall, generation Alpha teachers used alternative (n = 24) and classical (n = 25) assessment approaches. Participants who used alternative methods were mostly those who used PBL (n = 18). Teachers are expected to design and implement process-oriented assessment methods that provide formative and summative information about teaching (ISTE, 2024). Thus, we need to consider participants' perceptions of the characteristics today's teachers should possess. The observed difference in the use of alternative assessment methods can be explained by the nature of project-based initiatives such as eTwinning. These projects require teachers to monitor learning processes, document student progress, and evaluate both products and processes according to predefined criteria (European Education and Culture Executive Agency [EACEA], 2024). Consequently, teachers involved in such projects are more frequently exposed to assessment tools such as surveys, rubrics, peer evaluations, and observation forms. This continuous exposure encourages greater familiarity with and adoption of alternative, process-oriented assessment approaches, while teachers without experience in PBL tend to rely more on traditional assessment methods.

Teacher characteristics

The findings related to teacher characteristics indicate that teachers' readiness for generation Alpha learning environments is shaped both by the competencies they currently possess and by areas in which further professional development is needed. Accordingly, participants' views on the characteristics teachers should possess were grouped under two subcategories: *qualities teachers should possess* and *aspects that are lacking and must be developed.*

Table 5. Teacher qualities

Category	Codes	N	f	Percentage (%)
Qualities a teacher should possess	Willing to learn and teach	21	34	20.86
	Adapting to digitalization	19	28	17.18
	Up to date	19	25	15.34
	Open to innovation/change	9	21	12.88
	Sophisticated	6	10	6.13
	Technologically competent	10	10	6.13
	Guiding role	6	10	6.13
	Communication skills	7	8	4.91
	Well-equipped	7	8	4.91
	Sharing	4	6	3.68
	Energetic	2	3	1.84
Total		100	163	100

Table 6. Deficiencies and aspects needing improvement

Category	Codes	N	f	Percentage (%)
Aspects that are lacking and require improvement	Digital competencies	10	11	26.83
	Foreign language skills	9	9	21.95
	Lack of professional knowledge	6	7	17.07
	Insufficiency in the field of music	8	8	19.51
	Weakness in following new methods	4	4	9.76
	Not being up to date	1	1	2.44
	Communication skills	1	1	2.44
Total		39	41	100

Table 5 presents information regarding the code, participant frequency, code frequency, and percentage values for the category of teacher qualities. Considering developments brought about by the digital age, teachers should not only have pedagogical and field knowledge but also be digitally literate (Redecker, 2017). Nineteen participants (T1, T2, T5, T6, T7, T17, T19, T21, T25, T27, T28, T31, PT3, PT4, PT9, PT10, PT12, PT15, PT29) made remarks related to adapting to digitalization *(f28)*: *'To adapt to technology'* (T1), *'we have to move a lesson from a straight lecture, question-answer format to a bit of technology'* (PT15). Such statements overlap with the literature on adaptation to developing technologies (Ng, 2012). Regarding digital literacy in the sense of transcending traditional classroom paradigms (Spante et al., 2018), one participant said, *'Currently, we have come across different [new] forms of education with the pandemic, such as flipped education and distance education; it is necessary to be a teacher who can keep up with them'* (T6). Thus, to develop students' digital literacy skills, teachers should encourage learning on digital platforms, virtual environments, applied production areas, or in the field (ISTE, 2024). Meanwhile, seven participants (T17, T27, T28, T33, PT4, PT29, PT30) noted that teachers need to have *communication skills (f8)*, given that the communication they establish with students, parents, and colleagues also reflects their cultural competence.

Participants also commented on aspects that need improvement, as summarized in **Table 6**. The findings indicate that participants wanted to improve themselves the most in terms of *digital competencies (f11).* Regarding the improvement of digital competences, 10 participants (T1, T2, T7, T20, T25, T26, T27, T31, T32, T34) made related remarks such as, *'I could have been better at using Web 2.0 tools, I feel a little lacking in this regard'* (T1), and *'I don't know most of the Web 2.0 tools. I think I could get to know them better'* (T2). All participants who believed that teachers mostly need to develop in terms of *digital competencies* were teachers who did not use PBL. This finding reflects the challenge identified in the literature regarding the translation of digital competence into effective classroom practice (Redecker, 2017). Participants also noted a *lack of professional knowledge (f8).* In this regard, three participants (T2, PT3, PT11) talked about field knowledge (advanced theoretical, methodological, and factual knowledge) while three others (PT8, PT9, PT14) expressed views on educational (curriculum and pedagogical) field knowledge. Most participants who reported a lack of professional knowledge (PT2, PT3, PT8, PT9, PT11, PT14) had used PBL for at least three years. Since teachers' professional competence depends on both knowledge and self-efficacy (Bandura, 1997; Lee, 2009), participants may have felt inadequate due to their experiences or emotional states. Meanwhile, teachers also mentioned a *lack of foreign language skills (f9).* One participant said he could not follow the literature in his field owing to his lack of foreign language competence: *'We cannot follow foreign literature very much; in fact, a*

teacher should be able to follow the world literature related to his field; I am lacking in this sense' (T24). Educators are expected to collaborate with their colleagues and pursue their interests by participating in local and global networks (ISTE, 2024). In this context, participants' statements about the need to develop foreign language skills align with the literature.

Learning environment development

The findings on learning environment development show that teachers emphasized both classroom management approaches and teaching practices that support student engagement, motivation, and independent learning in generation Alpha learning environments. Accordingly, participants' views were grouped under categories reflecting traditional and contemporary approaches to classroom management, as well as strategies aimed at increasing learning opportunities.

Table 7. Instructional strategies

Category	Codes	N	f	Percentage (%)
Instructional strategies	Learning by doing and experiencing	18	42	12.07
	Teamwork	24	34	9.77
	Lecture/presentation	20	32	9.20
	Drama/dramatization	21	29	8.33
	Collaborative learning	19	29	8.33
	Interdisciplinary learning (STEM)	12	27	7.76
	Discovery learning	15	23	6.61
	Brainstorming	9	17	4.89
	Gamification	12	16	4.60
	Experiment/observation	13	14	4.02
	Question–answer	13	14	4.02
	Station technique	12	14	4.02
	Small-group work	9	10	2.87
	Peer instruction	9	10	2.87
	Flipped learning	5	6	1.72
	Case study	3	4	1.15
	Independent learning	3	4	1.15
	Discussion	2	2	0.57
	Other	12	21	6.03
Total		231	348	100

Table 7 presents information regarding the code, participant frequency, code frequency, and percentage values for the category of instructional strategies used by participants. In this category, the most frequently expressed code was *learning by doing and experiencing (f42)*; the least-expressed code was *discussion (f2).* Sahin and Ulucan (2023) offered suggestions regarding the classification of teaching methods and models. We classified the teaching methods and models obtained from participants' statements as follows:

- Traditional teaching methods: *lecture/presentation (f32)* and *question and answer (f14)*
- Practice-based teaching methods: *learning by doing and experiencing (f42)* and *experiment/observation (f14)*
- Methods that develop creative and critical thinking skills: *drama (f29)*, *interdisciplinary learning (STEM) (f27)*, *learning through discovery (f23)*, *brainstorming (f17)*, *station technique (f14)*, *case study (f4)*, and *discussion (f2)*
- Group teaching methods: *teamwork (f34)*, *co-operative learning (f29)*, *gamification (f16)*, *small-group work (f10)*, and *peer teaching (f10)*
- Individual teaching methods: *flipped learning (f6)* and *independent learning (f4)*

The teaching methods and models gathered under the category of 'Other' were as follows: *demonstration (f1)*, *fishbone (f4)*, *six thinking hats technique (f5)*, *5E model (f3)*, *PBL (f3)*, *blended learning (f1)*, *7E model (f2)*, *and inquiry-based learning (f2).* According to these classifications, participants preferred teaching methods that develop creative and critical thinking skills *(f116)*. Among application-based teaching methods, they attached the most importance to *learning by doing and experiencing (f42)*. Thus, generation Alpha teachers, apart from traditional teaching methods, also include other methods that differentiate teaching. As traditional methods

limit exploration, generation Alpha teachers need methods that develop creativity and support experiential learning (Elver & Yılmaz, 2023). Generation Alpha students require more interactive teaching methods that allow them to express creative ideas (Gutiérrez Molero, 2025 ;Höfrová et al., 2024). Their active participation should be ensured through drama, experiments, and interdisciplinary learning (Aini et al., 2024). The most frequently used methods for active participation were *drama/dramatizatio*n (*n* = 21) and *interdisciplinary learning* (*n* = 12). Some participants said they directed their students to explore using interdisciplinary learning to ensure active participation:

> We all calculated our own water footprint. Families calculated their own water footprint. They calculated their positive or negative contribution to nature. After that, we came back to rain harvesting, watched videos about it, and watched the technological developments regarding rain harvesting (PT30).

Similarly, some participants (*n* = 13) stated that experiment/observation supported active participation and fostered students' curiosity (Aini et al., 2024; Barak & Dori, 2004): '*We designed an experiment in science class. Each child had the task of doing an experiment; they investigated it themselves, and I did not intervene at all*' (PT13).

The fact that participants mostly used practice-based teaching methods that improved creative and critical thinking skills shows that they supported active participation. Teachers need to use various innovative and original teaching strategies to ensure active participation and meet students' needs (WEF, 2024). Participants differentiated teaching by including methods such as *interdisciplinary work*, *experiment/observation*, *drama/dramatization*, and *station techniques*: '*I use the station technique a lot in the classroom. While applying the station technique in a subject, I put QR codes on the stations … So, I try to include technology as well'* (PT29).

Since the integration of digital tools into learning environments is necessary for generation Alpha students (Ng et al., 2023), teachers must take the initiative in using different applications in their classrooms. However, only three participants (T24, T25, T28)—who did not use PBL—mentioned independent learning. Other participants talked about teamwork (*n* = 24) and collaborative learning (*n* = 19), which are important for the development of independent learning skills. Participants who mentioned using group work included teachers who had used PBL as well as those who had not. However, participants who said they had used collaborative learning only included those who had applied PBL. Although participants expressed few opinions about independent learning, they mentioned using methods that could form a basis for independent learning. The reason few participants mentioned independent learning could be that they are unaware of how to implement it (Ernst et al., 2023). This further supports prior research indicating that teachers may acknowledge the importance of student autonomy while lacking clarity in operationalizing it within classroom practice (Redecker, 2017).

In addition to teaching strategies, teachers also need effective classroom management strategies. As shown in **Table 8**, the code related to classroom management strategies most frequently mentioned by participants was *drawing attention (f23)*. The code least frequently expressed was *socializing (f3)*. Classroom management involves measures that teachers implement to create an environment that supports academic, social, and emotional learning (Evertson & Weinstein, 2006). Teachers can adopt traditional or contemporary classroom management approaches (Ng et al., 2023) when implementing such measures. In traditional classroom models, teachers use reactive (reward-punishment) and precautionary (class agreements) models by applying different methods to eliminate undesirable situations or behaviors in the classroom (Majeika et al., 2020). Only five participants (T1, T17, T27, T31, T32) mentioned using *rewarding (f7)* to deal with undesirable classroom behavior, indicating that they used the *reactive classroom model*. Eight participants (T17, T32, PT3, PT10, PT12, PT13, PT16, PT29) mentioned using a *class contract (f8)*, meaning they used the *precautionary classroom model*:

> We have a class contract. We wrote our rules at the beginning of the year, and they signed them. Our class rules are written in the class contract, and this contract is in the file of each of our students. If there is a violation of any rules, I ask them to take out their contract. They immediately look at their contract; it is a very effective method. I recommend it to everyone (S32).

Table 8. Classroom management strategies

Category	Codes	N	f	Percentage (%)
Classroom management strategies	Drawing attention	16	23	17.42
	Using materials	17	22	16.67
	Student centered	11	20	15.15
	Differentiating instruction	11	16	12.12
	Providing motivation	10	12	9.09
	Proactive teacher role	8	8	6.06
	Classroom contract	8	8	6.06
	Rewarding	5	7	5.30
	Feedback/correction	6	6	4.55
	Assignment of tasks/responsibility	4	6	4.55
	Socializing	3	4	3.03
Total		99	132	100

Although the aim of traditional classroom management is to control student behavior, contemporary classroom management requires structuring and directing the environment for teaching (Majeika et al., 2020). Thus, classroom management should not be considered only in relation to preventing certain behaviors and ensuring discipline. The new classroom management perspective emphasizes supporting students to achieve self-regulation through external intervention (Ernst et al., 2023). Eleven participants (T1, T7, T24, T25, T26, T31, T32, T34, PT4, PT18, PT30) made statements related to *student-centered (f20)* classroom management: *'I usually try to put students in a position where they are involved in the process in the classroom, where they manage the process, and I am just a guide and guide'* (T25). These 11 participants supported classroom management approaches based on self-regulation. Another strategy used by participants was to *differentiate teaching (f16)* by using different teaching methods:

> Working in different areas is an incredible blessing for children. Classes without walls, schools without walls, aware classes was a project. We work on musical instruments for a month, we work on rhythm for a month, there is rhythm in every lesson, we do mathematics, but we also work on rhythm while doing mathematics. We also do painting for a month. We write problems by painting (PT12).

Moreover, 17 participants (T1, T2, T5, T6, T7, T17, T19, T20, T24, T27, T31, T32, T33, PT4, PT12, PT15, PT30) mentioned the *necessity of using materials (f22)*, emphasizing the importance they attached to differentiating teaching: *'We put a stick in the dish sponge. That's how we did the tens'* (T31). To design teaching in accordance with students' needs, learning styles, and learning speeds, it must change based on constant evaluations of students (ISTE, 2024). Participants who said they differentiated teaching did not indicate that they frequently changed the learning environment by considering the individual differences of their students or by making continuous evaluations. The only view expressed by participants regarding the principle of continuity in classroom management was *feedback/correction (f6)*.

All participants who mentioned code *(f6)* (T7, T17, PT12, PT13, PT16, PT22) were teachers who had been using PBL. Teachers can create hybrid classroom management approaches by blending traditional and contemporary approaches. In this model, agreements can be made with students and even parents to address negative situations in the classroom. Students can be continuously motivated and developed, and they can discover and develop high-level learning skills on the basis of constructivism (Majeika et al., 2020; Ng et al., 2023). Therefore, participants adopted a traditional understanding to foster desirable behaviors in the classroom, whereas they adopted mixed classroom management approaches to develop mental skills.

Technology in education

The findings on technology in education indicate that teachers view instructional technologies as a crucial component of generation Alpha learning environments, particularly for constructing knowledge and supporting skill development. At the same time, differences emerged between teachers who had and did not have long-term PBL experience, particularly in terms of the variety and intensity of technology use. Accordingly, participants' opinions on instructional technologies, the purpose of using them, and the points

to be considered while using them were grouped into three subcategories: *purpose of use of instructional technologies, used instructional technologies,* and *digital citizenship*.

Table 9. Purpose of using instructional technologies

Category	Codes	N	f	Percentage (%)
Purpose of using instructional technologies	Producing audiovisual materials	20	47	28.48
	Ensuring permanence of learning and knowledge	19	26	15.75
	Accessing information	17	24	14.54
	Evaluation	15	21	12.72
	Differentiating learning	11	15	9.09
	Coding	7	12	7.27
	Saving time	5	8	4.84
	Reinforcement	5	7	4.24
	Interaction with colleagues	4	5	3.03
Total		103	165	100

Regarding the purpose of using instructional technologies, the most frequently cited code in **Table 9** is *producing audiovisual materials (f47)*; the least expressed code is *interaction with colleagues (f5)*. The use of instructional technologies in learning-teaching processes can be viewed from two perspectives:

(1) using instructional technologies to transfer information from teacher to student and

(2) using technology for the student's construction of knowledge.

In the second approach, students use technology to construct knowledge; information is not presented directly to them. Instead, the student is expected to produce material or perform a study in line with their knowledge of technology use. Moreover, the first use does not sufficiently contribute to the effective use of educational technologies (Ng et al., 2023). Accordingly, participants' statements regarding the second use were examined first. We determined that they attached the most importance to *producing audiovisual materials (f47)* to structure knowledge. Some participants said they used Web 2.0 tools to produce audiovisual materials in and out of class: *'Using the Plotagon tool, students made animations that summarized the stories they read'* (T6). Participants' statements regarding *coding (f12)* also support the constructivist approach: *'We started with coding. They already use Cod.org; it is very comfortable'* (PT30). Only two participants also mentioned that they produced audiovisual materials to convey information to students: *'I can prepare infographics through Canva, containing pictures and short explanations on a topic'* (PT3). Of the 20 participants who produced audiovisual materials, only two mentioned that they produced audiovisual materials to convey information to students.

Coding (n = 7) and audiovisual material production (n = 18) were evaluated as being used to structure students' knowledge; thus, 25 participants used instructional technologies to structure knowledge. Regarding the use of instructional technologies to transfer information to students, *access to information (f24)* had the highest frequency among participants (n = 17). Some participants mentioned using teaching technologies to access and present information: *'I use them more for students to gain information; I use them to access information'* (T28); *'This means presenting information to the student in a way. I cannot say that it can improve the classroom environment by using plenty of technology in the classroom, but I can say that it differentiates it'* (PT15). Although instructional technologies that support knowledge construction may be more beneficial, studies show that using technology to address different learning styles positively affects learning (Fernando & Premadasa, 2024; Fitrah et al., 2025; Jukić & Škojo, 2021; Kohli & Arora, 2024). When lessons are presented to students without any visual stimuli, knowledgeable students can create visual and verbal representations in their minds; however, less knowledgeable students cannot. Thus, both knowledgeable and less knowledgeable students learn better from designed materials (Mayer, 2003). As one participant noted, *'In my class, not all children are at the same level; there are children at very low levels, middle levels, and children at higher levels. There is no book or any resource that will provide this, so I prepare it myself'* (T31). Considering that individual differences are not limited to learning styles, teachers find it difficult to identify individual differences among all students in their classes and plan their teaching processes accordingly (Konings, 2024). Participants did not mention doing any work to determine learning styles. Consequently, a teacher who believes that students have diverse learning styles must operate on the assumption that the students will

learn better when audiovisual materials are designed for them. Participants who expressed opinions regarding using technology for the purpose of *differentiating learning (f15)* support this situation: *'I try to appeal to more than one sense organ'* (PT4).

Instructional technologies contribute to learning for many reasons (Holmes et al., 2019), including the following: attracting attention: *'The most important thing is that it attracts students' attention'* (T25); saving time: *'The underlying factor is time, and I do these to save time'* (T25); making learning permanent: *'So, our purpose in using it here may vary from person to person. My aim is to ensure more permanent learning'* (T26); *'To reinforce what we have learned. In other words, I first explain the teaching topic, then I use a game or a puzzle tool related to that topic for reinforcement purposes'* (PT14); providing safe observations: *'I look at their evaluations, how many questions they have answered, which questions have not been answered, their deficiencies'* (T28); and concretizing abstract concepts*: 'It makes it easier for children to understand. In other words, I think it helps them learn. Because they learn with more concrete things, I think I help them learn better'* (T2). Thus, participants indicated that they used instructional technologies for the purposes of *saving time (f8)*, *ensuring the permanence of learning and knowledge (f26)*, *reinforcement (f7)*, and *evaluation (f21)*. Participants also noted using social media platforms for *interaction with colleagues (f5)*: '*There are class teachers who have Instagram accounts that I follow, especially those who are at the forefront of teaching with games; I follow their activities'* (T17). Regarding the expectation that teachers use collaborative tools to interact with colleagues and students in virtual environments and enhance authentic, real-world learning experiences (ISTE, 2024), the participants did not use collaborative tools to interact with colleagues and students; rather, colleague interaction was limited to social media platforms. The statements of 57 participants regarding the codes *learning and ensuring the permanence of knowledge (n* = 19), *access to information* (*n* = 17), *differentiation of learning* (*n* = 11), *saving time* (*n* = 5), and *reinforcement* (*n* = 5) showed that they used instructional technologies to transfer information from teacher to student. The statements of 25 participants, including those related to *producing audiovisual materials* (*n* = 18) and *coding* (*n* = 7), were aimed at using technology to structure knowledge. This indicates that most participants preferred to use instructional technologies to transfer information to students. However, digital competence frameworks emphasize the importance of using technology to support knowledge construction rather than solely information transmission (ISTE, 2024; Redecker, 2017).

Participants' statements regarding the instructional technologies they used are summarized in **Table 10**. In the subcategory of *instructional technologies used*, the code most frequently mentioned by participants was *Web 2.0 tools (f254)*, whereas the code least frequently mentioned was *online education platforms (f18).* Aside from four participants (T24, T25, T27, T32), the participants (T1, T2, T5, T6, T7, T17, T26, PT3, PT4, PT8, PT9, PT10, PT11, PT12, PT13, PT14, PT15, PT16, PT18, PT22, PT23, PT29, PT30) who mentioned using Web 2.0 tools were teachers who had been using PBL. The four participants who did not use PBL said they used a limited number of Web 2.0 tools: *'There are application sites such as Wordwall, which are competitions about homophones. I have sent some from them'* (T24); *'I used Kahoot for gaming purposes. Similarly, I still use Wordwall now'* (T25); *'I prepared a wheel of fortune from programs; I think it was Wordwall. We made concept maps from Canva'* (T27); *'There was Kahoot, for example; we used it for a while'* (T32). Furthermore, their use was not continuous: *'As I said, I do not dare to use it because I am not very good at it; I need to improve myself in this regard'* (T32).

Table 10. Instructional technologies used

Category	Codes	N	f	Percentage (%)
Instructional technologies used	Web 2.0 tools	27	254	57.72
	Social media apps	33	85	19.31
	Virtual classroom apps	31	58	13.18
	Tools that develop analytical thinking skills	9	25	5.68
	Online education platforms	15	18	4.09
Total		115	440	100

The Web 2.0 tools mentioned by participants are classified according to their use purposes (Berger & Trexler, 2010; Solomon & Schrum, 2007, 2014), as follows:

- Animation tools: *Avatar Maker, Bitmoji, Cartoon Maker, Chatterpix, Powtoon, Voki, Plotagon, Toontastic, Tweencraft*

- Survey/form tools: *Google Forms, Jotform, Slido, Survey Monkey*
- Augmented reality apps: *Quiver*
- Puzzle/word game tools: *Cram, Crossword, Jigsaw, Learningapps, Tarsia, Wheel Decide, Wordmint, Wordwall*
- Digital story tools: *Book Creator, Storyjumper*
- Digital board tools: *Block Posters, Linoit, Padlet, Postermywall, Sketch Toy*
- Digital classroom management tools: *ClassDojo, Google Classroom*
- Cartoon tools: *Pixton, ToonyTool*
- Visual design/video tools: *Canva, Logo Maker, Inshot, Graphicsprings, Motionportrait, Scribus, Tinkercad, Videoshow*
- Collaborative tools: *Canva, Google Forms, Google Workspace, Padlet, Zumpad*
- Concept/mind map tools: *Bubbl.Us, Mindmeister, Popplet*
- Word cloud tools: *Wordart*
- Gamified assessment tools: *Baamboozle, Kahoot, Mentimeter, Plickers, Quizizz, Quizlet, Socrative*
- Presentation tools: *Emaze, Genially, Nearpod, Wakalet*
- Flipped classroom tools: *Answergarden, Flipgrid*

Based on this classification, most participants who applied PBL used the following: animation tools: *'They made the characters talk about our heroes through oral and written history in Chatterpix'* (PT22); puzzle/word game tools: *'They use Learningapps very professionally; I mean there is no application they do not use in Learningapps; they use Wordwall the most'* (PT12); visual design/video tools: *'Now, to put it simply, we all use it a lot, especially for teachers who do projects; Canva is a program we use every minute. Canva poster preparation, e-book preparation; they do it themselves; I don't even say that anymore'* (PT30); gamified measurement and evaluation tools: *'I use Plickers. I can use it in the classroom. There are cards in Plickers that match each student's number; there are QR codes on the cards'* (PT15). Nine participants (PT9, PT10, PT11, PT12, PT13, PT15, PT18, PT22, PT30) who had applied PBL said they used applications *(f25)* that develop analytical thinking skills, in addition to Web 2.0 tools: *'Scratch in coding'* (PT22) and *'AutoCAD'* (PT13).

PBL participants attached importance to using educational technologies throughout the project process. However, the use of communication technology tools should also ensure real interaction and collaboration between project partner students (Fernando & Premadasa, 2024; Huang et al., 2024). Accordingly, participants' statements demonstrated that collaborative tools were used more for planning or design purposes throughout the project process: *'Regarding collaborative tools, we use Google Forms more because surveys need to be done'* (PT8). Another participant similarly said, *'All partners matched two by two. This was a collaborative study. Students participated but did not use the collaborative tools themselves. I collected the work in the common area, on Padlet'* (PT29). In summary, collaborative tools were used by teachers who had applied PBL, but students did not use collaborative tools effectively. Generation Alpha students mostly use instructional technologies for games, entertainment, and access to information (Šramová & Pavelka, 2023). Other Web 2.0 tools noted by participants included *social media applications (f85)*. Some participants said they used social media to disseminate project activities: *'I have a YouTube channel where I share the projects we do with children'* (PT11). Participants who used PBL indicated using social media for their own professional development or for communication with their colleagues or parents: *'I do not have a network that I use with students, but we have a communication channel via WhatsApp that we run together with parents'* (T24). Another learning environment in which social learning is thought to occur is *virtual classroom applications (f58).* The virtual classroom applications used before and after the pandemic were limited to, Google Classroom, and ClassDojo: *'We used Google Classroom last year. I was sending homework from there'* (PT8)*; 'During the pandemic period, I also used classroom management tools in distance education, such as ClassDojo'* (PT29)*.*

PBL participants attached importance to using educational technologies throughout the project process. However, the use of communication technology tools should also ensure real interaction and collaboration between project partner students (Fernando & Premadasa, 2024; Huang et al., 2024). Accordingly, participants' statements demonstrated that collaborative tools were used more for planning or design

purposes throughout the project process: *'Regarding collaborative tools, we use Google Forms more because surveys need to be done'* (PT8). Another participant similarly said, *'All partners matched two by two. This was a collaborative study. Students participated but did not use the collaborative tools themselves. I collected the work in the common area, on Padlet'* (PT29). In summary, collaborative tools were used by teachers who had applied PBL, but students did not use collaborative tools effectively. Generation Alpha students mostly use instructional technologies for games, entertainment, and access to information (Šramová & Pavelka, 2023). Other Web 2.0 tools noted by participants included *social media applications (f85)*. Some participants said they used social media to disseminate project activities: *'I have a YouTube channel where I share the projects we do with children'* (PT11). Participants who used PBL indicated using social media for their own professional development or for communication with their colleagues or parents: *'I do not have a network that I use with students, but we have a communication channel via WhatsApp that we run together with parents'* (T24). Another learning environment in which social learning is thought to occur is *virtual classroom applications (f58).* The virtual classroom applications used before and after the pandemic were limited to, Google Classroom, and ClassDojo: *'We used Google Classroom last year. I was sending homework from there'* (PT8)*; 'During the pandemic period, I also used classroom management tools in distance education, such as ClassDojo'* (PT29). Given that virtual classrooms should be used for collaborative purposes (Mawloood, 2023), participants used virtual classroom applications mostly for presenting course content and student-content interaction. Similarly, the fact that the *online education platforms used (f18)* by participants were limited to Morpa and Okulistik indicates they preferred student-content interaction more: *'I use Morpa mostly for its lectures; Okulistik is one of the ones we use in lectures'* (T31); '*Mostly Okulistik and Morpa Campus'* (PT30); *'The Morpa activities and tests that I follow'* (T19).

The skills that teachers wanted their students to acquire were also evaluated within the framework of the *digital citizenship* subcategory. As shown in **Table 11**, the code most frequently expressed by participants was *e-security (f48)*, and the least-expressed code was *cyberbullying (f3)*. Digital citizenship is grouped under eight headings: digital citizen identity, screen time management, cyberbullying management, cybersecurity management, privacy management, digital footprints, digital empathy, and critical thinking (DQ Institute, 2019). Accordingly, participants' statements regarding digital citizenship support the literature: managing digital citizen identity: *'What do we pay attention to in the projects? The faces of the students should not be clearly visible, and the images and the music used should not contain copyright. And the videos made should not be available to the public'* (PT29); screen time management: *'Especially Internet use, mass media should be limited to a certain period of time'* (T34); cyberbullying management: *'They learned that they should be polite and not use hurtful and bad words in the comments'* (T2); cyber security management: *'We definitely talk to students at the beginning of every project about creating a secure password, a secure username, what they can and cannot share'* (PT10); privacy management: *'They learned that they should not share their personal information'* (T2); digital footprint: *'I emphasized the need to protect personal data'* (T2): digital empathy: *'Expressing feelings is very important. Being able to express feelings correctly. How did you feel when this behavior was done to you? How would you feel if you were in their place? Empathy'* (PT29); critical thinking: *'Our project was about media literacy; they gained awareness about the need to check whether all information on the Internet is correct; the dates should be paid attention to; they realized that they need to check all information, question whether the information is correct and then share it'* (T2). In line with the view that applications made with digital tools need to be safe, legal, and ethical (ISTE, 2024), participants who used PBL noted the following: *'One of the most important rules of projects is that we must comply with e-security rules'* (PT8); *'E-security is a principle that we strictly adhere to in eTwinning'* (PT12); *'Copyright is very important at this point. For this, I recommend free music sites, free image sites'* (PT29).

Table 11. Digital citizenship

Category	Codes	N	f	Percentage (%)
Digital citizenship	e-security	28	48	48.48
	Copyright	17	20	20.20
	Conscious use	9	17	17.17
	Learning ethical principles	8	11	11.11
	Cyberbullying	3	3	3.03
Total		65	99	100

Differences Between Teachers Who Used PBL and Those Who Did Not

The differences between teachers who used PBL and those who did not were examined across four analytical dimensions: student development guidance, teacher characteristics, learning environment development, and technology use. The code matrix analysis revealed no participant-based density differences between the two groups in the categories of student development guidance, teacher characteristics, and learning environmental development. This finding suggests that core pedagogical orientations—such as supporting student growth and fostering structured learning environments—may not be exclusively associated with the adoption of PBL but rather reflect broader professional teaching competencies. From a constructivist perspective, such similarities may indicate that foundational instructional competencies transcend specific methodological preferences (UNESCO, 2023). A distinction emerged, however, in the technology use category. Teachers who implemented PBL articulated more intensive and detailed accounts of integrating technological tools into instructional processes. This pattern may indicate that PBL environments inherently encourage more dynamic and interactive uses of digital technologies, particularly to facilitate collaboration, inquiry, and student-centered learning processes. This interpretation aligns with digital pedagogy perspectives, suggesting that student-centered approaches foster more pedagogically embedded technology integration (ISTE, 2024; Redecker, 2017). The two-case model analysis further showed that several codes—including Web 2.0 tools, social media applications, virtual classroom applications, audiovisual materials, e-security awareness, experiential learning, group work, willingness to learn and teach, access to information, and narration/presentation—were common to both groups. These shared patterns suggest that contemporary educational practices increasingly integrate technological and collaborative elements irrespective of formal methodological preferences. Consistent with international technology integration frameworks, teachers are expected to act not only as technology users but also as designers and facilitators of learning environments (ISTE, 2024). These shared patterns and all other data related to the findings are presented in **Appendix A** (see **Figure A1**).

CONCLUSION

This study identified four key categories related to teachers' readiness for generation Alpha learning environments: student development guidance, teacher characteristics, learning environment development, and technology in education. We found that generation Alpha teachers aim to equip their students with essential 21st century skills for future professions, including *creativity*, *communication*, *problem-solving*, *analytical thinking*, *using technology*, and *life skills*. Participants described various classroom practices used to foster these competencies. Notably, teachers who had PBL involvement for at least the last three years placed greater emphasis on problem-solving, 21st century skills, and the use of alternative, process-oriented assessment methods. Beyond classical evaluation, these teachers reported using surveys/tests, rubrics, peer evaluation, and observation forms, with surveys/tests being the most commonly applied tools. In contrast, teachers who did not employ PBL reported limited use of process-oriented assessment, largely due to insufficient knowledge, indicating a need for further investigation.

Participants who emphasized openness to innovation and technological competence were exclusively teachers involved in PBL, with experience in 5-30 eTwinning projects, suggesting that such projects support the adoption of innovative pedagogical approaches. While all participants agreed that teachers should adapt to digitalization and value continuous personal and professional development, only a few explicitly support independent learning processes. Notably, the need to further develop digital competencies was primarily expressed by teachers who did not use PBL. In addition, generation Alpha teachers highlighted the importance of strengthening teachers' professional knowledge, particularly identifying music as the area most in need of pedagogical content development.

Participants guiding students toward independent learning, reflecting contemporary approaches grounded in self-regulation, emphasized the importance of increasing motivation to support learning. Using a reactive model based on reward and punishment, and a precautionary model involving agreements between students and teachers, were common undesirable classroom behaviors. Participants also reported enhancing learning opportunities by assigning responsibilities inside and outside the classroom, promoting interdisciplinary work, and integrating materials and technology. Furthermore, alternative teaching

methods—such as learning by doing, PBL, and inquiry-based learning—were highlighted, with learning by doing emphasized more frequently by teachers involved in PBL. Notably, independent learning was mentioned by only three participants who had not used PBL.

Web 2.0 tools were the most commonly employed technologies, predominantly by teachers who had used PBL. Participants emphasized the role of technology in achieving project-related gains. However, collaborative tools were used only by teachers with at least three years of experience in PBL and were mainly limited to planning or designing project activities, rather than facilitating collaborative production or professional interaction. When comparing teachers who had and had not used PBL, no participant-based density was observed in the upper categories of student development guidance, teacher characteristics, or learning environment development, although teachers with PBL experience demonstrated greater intensity in instructional technology use.

Implications

PBL processes can promote teachers' personal development, helping them to further support their generation Alpha students. These teachers also need to further develop abilities such as foreign language skills to participate in international projects, training, and collaboration. Teacher training and in-service training programs should adopt a holistic framework encompassing all dimensions of 21st century skills, such as critical thinking, collaboration, creativity, and communication, and how these skills can be integrated with instructional technologies should be addressed through concrete lesson scenarios. PBL should move beyond being solely a voluntary practice and be supported by structured mentoring and coaching models for teachers; experienced project-based teachers should be paired with inexperienced teachers to create in-school learning communities.

In addition to taking the initiative for their own development, teachers must implement innovative teaching strategies in line with their students' needs. Such strategies should focus more on independent learning skills such as interdisciplinary work, small-group work, peer teaching, discovery learning, flipped learning, PBL, and inquiry-based learning. Education policies should include provisions encouraging teachers' participation in project-based and inquiry-based teaching practices, and participation in these practices should be linked to professional development points and career advancement. When developing school-based development plans, regular needs analyses should be conducted to identify the pedagogical and technological needs of teachers regarding the generation Alpha student profile, and targeted support programs should be developed based on these analyses. Furthermore, considering curriculum intensity and time constraints, program arrangements should be made to provide teachers with flexibility to implement interdisciplinary and small-group-based practices, and structural barriers to such practices should be reduced.

Generation Alpha teachers who use PBL involvement should aim to use teaching technologies to ensure permanent learning, access information, save time, and reinforce, evaluate, and structure their students' knowledge. Those who do not use PBL involvement need to possess sufficient knowledge and skills to integrate teaching technologies into the learning environment. Moreover, developing the digital literacy skills of these teachers could foster their use of PBL. Thus, generation Alpha teachers require more knowledge and skills related to technology use and integration. Technology integration should be prioritized in future professional development. Furthermore, all teachers should be encouraged to use collaborative technologies, not only for planning and design but also for collaborative product development. Meanwhile, generation Alpha teachers can promote student learning by taking virtual classrooms and social media applications beyond content presentation and enhancing student-student, student-content, and teacher-student interactions through collaborative work. Lastly, teachers can support their students' digital literacy skills by frequently encouraging them to step out of their comfort zones.

Limitations and Future Research

This study is limited in that sufficient data regarding generation Alpha teachers' understanding of traditional and contemporary classroom management cannot be obtained. Identifying such understanding could help improve the classroom management of the teachers of generation Alpha students. This study also failed to determine whether teachers designed instruction in accordance with students' needs, learning styles,

and learning pace. Research on proactive teacher roles could support the more effective management of generation Alpha classrooms based on self-regulation. Finally, future research can investigate why teachers who do not use PBL participate less in process-oriented evaluation methods; such work could inform the development of professional development programs.

Author contributions: BK: conceptualization, methodology, investigation, data curation, formal analysis, writing – original draft; **TA:** conceptualization, supervision, validation, writing – review & editing. This article is derived from the doctoral dissertation of Banu Kayınova. Both authors approved the final version of the article.

Funding: The authors received no financial support for the research and/or authorship of this article.

Ethics declaration: This study was approved by the Institutional Review Board at Bahcesehir University on 3 June 2022. Informed consent was obtained from all participants prior to data collection. Sensitive and confidential personal data were anonymized and stored securely to protect participant privacy.

AI statement: The authors used ChatGPT (OpenAI) for language editing and minor revisions in response to peer review comments only. The authors take full responsibility for the content of the manuscript.

Declaration of interest: The authors declared no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

REFERENCES

Aini, R. Q., Supriya, K., Dunlop, H., Edwards, B., Maas, S., Roberts, J., Summersill, A., Zheng, Y., Brownell, S., & Barnes, M. E. (2024). Conflict reducing practices in evolution education are associated with increases in evolution acceptance in a large naturalistic study. *PLoS One, 19*(12), Article e0313490. https://doi.org/10.1371/journal.pone.0313490

Amemasor, S. K., Oppong, S. O., Ghansah, B., Benuwa, B.-B., & Essel, D. D. (2025). A systematic review on the impact of teacher professional development on digital instructional integration and teaching practices. *Frontiers in Education, 10*. https://doi.org/10.3389/feduc.2025.1541031

Arifin, Z., Sukarmin, S., Saputro, S., & Kamari, A. (2025). The effect of inquiry-based learning on students' critical thinking skills in science education: A systematic review and meta-analysis. *Eurasia Journal of Mathematics, Science and Technology Education, 21*(3), Article em2592. https://doi.org/10.29333/ejmste/15988

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman & Co.

Barak, M., & Dori, Y. J. (2004). Enhancing undergraduate students' chemistry understanding through project-based learning in an IT environment. *Science Education, 89*(1), 117-139. https://doi.org/10.1002/sce.20027

Bentri, A., Hidayati, A., & Kristiawan, M. (2022). Factors supporting digital pedagogical competence of primary education teachers in Indonesia. *Frontiers in Education, 6*. https://doi.org/10.3389/feduc.2022.929191

Berger, P., & Trexler, K. (2010). *Choosing Web 2.0 tools for learning and teaching in a digital world*. Bloomsbury Publishing. https://doi.org/10.5040/9798400626074

Bhardwaj, V., Zhang, S., Tan, Y. Q., & Pandey, V. (2025). Redefining learning: Student-centered strategies for academic and personal growth. *Frontiers in Education, 10*. https://doi.org/10.3389/feduc.2025.1518602

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: An Introduction to theory and methods*. Allyn & Bacon.

Bogdan, R. C., Taylor, S. J., & DeVault, M. (2016). *Introduction to qualitative research methods. A guidebook and resource* (4th ed.). John Wiley & Sons.

Brookhart, S. M. (2013). *How to create and use rubrics for formative assessment and grading*. ASCD.

Coolsaet, D. (2024). The impact of technological advancements on higher education: A study of generation Alpha's educational prospects. *International Journal of Software Engineering and Computer Science, 4*(1), 58-67. https://doi.org/10.35870/ijsecs.v4i1.2147

Creswell, J. W. (2013). *Qualitative inquiry & research design: Choosing among five approaches* (3rd ed.). SAGE.

Creswell, J. W., & Poth, C. N. (2017). *Qualitative inquiry & research design: Choosing among five approaches* (4th ed.). SAGE.

Danilova, L. N. (2023). Образовательный запрос поколения Альфа [Educational needs of generation Alpha]. *Developmental Psychology, 12*(1), 58-67. https://doi.org/10.18500/2304-9790-2023-12-1-58-67

Daribayeva, A. Z. (2024). Interactive methods in the educational process as a factor in increasing students' cognitive activity. *Journal of Academic Research in Social Sciences, 7*(3), 45-52.

DQ Institute. (2019). *Standard for digital intelligence (DQ)*. DQ Institute. https://www.dqinstitute.org/global-standards/

EACEA. (2024). eTwinning project quality and evaluation criteria. *European Education and Culture Executive Agency*. https://school-education.ec.europa.eu/en/etwinning/labels/etwinning-national-quality-label

Elver, K., & Yılmaz, M. F. (2023). Evaluation of theses written on the field of creative drama, an education method used on the primary school education: A bibliographical study. *Primary Education, 19*, 16-34.

Ernst, H. M., Wittwer, J., & Voss, T. (2023). Do they know what they know? Accuracy in teacher candidates' self-assessments and its influencing factors. *British Educational Research Journal, 49*(4), 649-673. https://doi.org/10.1002/berj.3860

Evertson, C. M., & Weinstein, C. S. (2006). Classroom management as a field of inquiry. In C. M. Evertson, & C. S. Weinstein (Eds.), *Handbook of classroom management: Research, practice, and contemporary issues* (pp. 3-15). Lawrence Erlbaum Associates Publishers.

Fernando, P. A., & Premadasa, H. K. S. (2024). Use of gamification and game-based learning in educating generation Alpha: A systematic literature review. *Educational Technology & Society, 27*(2), 114-132.

Fitrah, M., Sofroniou, A., Setiawan, C., Widihastuti, W., Yarmanetti, N., Jaya, M. P. S., Panuntun, J. G., Arfaton, A., Beteno, S., & Susianti, I. (2025). The impact of integrated project-based learning and flipped classroom on students' computational thinking skills: Embedded mixed methods. *Education Sciences, 15*(4), Article 448. https://doi.org/10.3390/educsci15040448

Flick, U. (2022). *An introduction to qualitative research*. SAGE. https://doi.org/10.4135/9781036231712

Gavrilas, L., Holotescu, C., Grosseck, G., & Andone, D. (2024). Exploration of the prospective utilization of educational robotics by preschool and primary education teachers. *Education and Information Technologies, 29*(5), 6135-6154.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment, 1*(1), Article 20. https://doi.org/10.1145/950566.950595

Golden, B. (2023). Enabling critical thinking development in higher education through the use of a structured planning tool. *Irish Educational Studies, 42*(4), 949-969. https://doi.org/10.1080/03323315.2023.2258497

Gutiérrez Molero, S., Heredia Ponce, H., & Romero Oliva, M. F. (2025). Competencia digital en jóvenes de la generación alfa: Retos y oportunidades en la sociedad tecnológica [Digital competence in young people of the alpha generation: Challenges and opportunities in the technological society]. *International Journal of Educational Research and Innovation, 24*, 1-18. https://doi.org/10.46661/ijeri.12002

Hammersley, M., & Atkinson, P. (1995). *Recording and organizing data. Ethnography: Principles in practice*. Routledge.

Hikmatovich, K. I. (2022). The significance of teachers' psychological readiness for innovative classroom activities and its socio-psychological background. *American Journal of Social Sciences and Humanity Research, 2*(6), 139-145. https://doi.org/10.37547/ajsshr/Volume02Issue06-21

Höfrová, A., Balidemaj, V., & Small, M. A. (2024). A systematic literature review of education for generation Alpha. *Discover Education, 3*, Article 125. https://doi.org/10.1007/s44217-024-00218-3

Holly, C., Porter, S., Vitale, T. R., & Echevarria, M. (2024). Grading participation in the classroom: The assumptions, challenges, and alternatives. *Teaching and Learning in Nursing, 19*(1), 27-33. https://doi.org/10.1016/j.teln.2023.06.020

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Huang, H. W., Mills, D. J., & Tiangco, J. A. N. Z. (2024). Inquiry-based learning and technology-enhanced formative assessment in flipped EFL writing instruction: Student performance and perceptions. *SAGE Open, 14*(2), Article 21582440241236663. https://doi.org/10.1177/21582440241236663

Irvin, J. L., Meltzer, J., & Dukes, M. (2007). Student motivation, engagement, and achievement. In J. L. Irvin, J. Meltzer, & M. Dukes (Eds.), *Taking action on adolescent literacy: An implementation guide for school leaders* (pp. 27-50). ASCD.

ISTE. (2024). ISTE standards 2024 (version 4.02). *International Society for Technology in Education*. https://cms-live-media.iste.org/ISTE_STANDARDS_2024_v02.pdf

Jukić, R., & Škojo, T. (2021). The educational needs of the alpha generation. In *Proceedings of the 44th International Convention on Information, Communication and Electronic Technology* (pp. 564-569). IEEE. https://doi.org/10.23919/MIPRO52101.2021.9597106

Karthika, M., & Rajeswari, P. (2025). Shaping teachers for generation Alpha AI readiness and the future of sustainable education. *Mukt Shabd Journal, 14*(10), 327-335.

Kennedy, M. M. (2016). How does professional development improve teaching? *Review of Educational Research, 86*(4), 945-980. https://doi.org/10.3102/0034654315626800

Kılıç, E., Almasri, F., & Çelik, H. E. (2025). Are pre service teachers ready to teach the Alpha generation? The impact of pre service teachers' ChatGPT literacy levels on behavioral intentions toward ChatGPT 4.0. *Computers and Education: Artificial Intelligence, 9*, Article 100486. https://doi.org/10.1016/j.caeai.2025.100486

Klimashevska, H. (2023). Сутність готовності до креативної професійної діяльності майбутніх учителів початкових класів [The essence of readiness for creative professional activities of future primary teachers]. *Bulletin of Luhansk Taras Shevchenko National University, 1*(355), 52-61. https://doi.org/10.12958/2227-2844-2023-1(355)-52-61

Kohli, A., & Arora, S. (2024). An unconventional education landscape for unconventional "generation Alpha". *International Journal for Multidisciplinary Research, 6*(5). https://doi.org/10.36948/ijfmr.2024.v06i05.28938

Konings, R. (2024). *Mapping domain-specific school diversity models and their implications: When and why all students can belong and achieve* [PhD thesis, KU Leuven].

Lee, J. A. (2009). *Teachers' sense of efficacy in teaching English, perceived English language proficiency, and attitudes toward the English language: A case of Korean public elementary school teachers* [Unpublished PhD thesis]. The Ohio State University.

Lee, K.-W. (2023). Effectiveness of gamification and selection of appropriate teaching methods of creativity: Students' perspectives. *Heliyon, 9*(10), Article e20420. https://doi.org/10.1016/j.heliyon.2023.e20420

Lertsakulbunlue, S., & Kantiwong, A. (2025). Evaluating the dependability of peer assessment in project-based learning for pre-clinical students: A generalizability theory approach. *BMC Medical Education, 25*(1), Article 260. https://doi.org/10.1186/s12909-025-06772-0

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE.

Loureiro, P., & Gomes, M. J. (2023). Online peer assessment for learning: Findings from higher education students. *Education Sciences, 13*(3), Article 253. https://doi.org/10.3390/educsci13030253

Machynska, N., Derkach, Y., & Pankevych, Y. (2020). Types and forms of professional development of a preschool teacher in in-service training. *Continuing Professional Education: Theory and Practice*, (2), 72-77. https://doi.org/10.28925/1609-8595.2020.2.10

Majeika, C. E., Wilkinson, S., & Kumm, S. (2020). Supporting student behavior through behavioral contracting. *Teaching Exceptional Children, 53*(2), 132-139. https://doi.org/10.1177/0040059920952475

Mawloood, D. M. (2023). Examining e-readiness of teachers in EFL classes. *Journal of Language Studies, 7*(3), 145-162. https://doi.org/10.25130/lang.7.3.7

Maxwell, J. A. (2012). *Qualitative research design: An interactive approach*. SAGE.

Mayer, R. E. (2003). The promise of multimedia learning: Using the same instructional design methods across different media. *Learning and Instruction, 13*(2), 125-139. https://doi.org/10.1016/S0959-4752(02)00016-6

McCrindle, M. (2021). *Generation Alpha*. Hachette UK.

McMillan, J. H. (2018). *Classroom assessment: Principles and practice for effective standards-based instruction* (7th ed.). Pearson.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Miles, M. B., & Huberman, A. M. (2019). *Qualitative data analysis: An expanded sourcebook* (3rd ed.). SAGE.

NEA. (2012). Preparing 21st-century students for a global society: An educator's guide to "the four Cs". *ICDST*. https://dl.icdst.org/pdfs/files3/0d3e72e9b873e0ef2ed780bf53a347b4.pdf

Neuman, W. L. (2014). *Social research methods: Qualitative and quantitative approaches* (7th ed.). Pearson.

Ng, D. T. K., Leung, J. K. L., Su, J., Ng, R. C. W., & Chu, S. K. W. (2023). Teachers' AI digital competencies and twenty-first-century skills in the post-pandemic world. *Educational Technology Research and Development, 71*, 137-161. https://doi.org/10.1007/s11423-023-10203-6

Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education, 59*(3), 1065-1078. https://doi.org/10.1016/j.compedu.2012.04.016

OECD. (2023). *OECD digital education outlook 2023: Towards an effective digital education ecosystem*. OECD Publishing. https://doi.org/10.1787/c74f03de-en

P21. (2019). Framework for 21st-century learning. *Bettelle for Kids*. https://static.battelleforkids.org/documents/p21/P21_Framework_Brief.pdf

Padmadewi, N. N., Artini, L. P., & Jayanta, I. N. L. (2021). Teachers' readiness in promoting 21st-century skills in teaching students at a bilingual primary school. In *Proceedings of the 5th Asian Education Symposium 2020* (161-166). Atlantis Press. https://doi.org/10.2991/assehr.k.210715.034

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice* (4th ed.). SAGE.

Ramli, A. A., & Borhan, M. T. (2024). Bridging digital tools and scientific literacy: A systematic review on inquiry-based learning approaches. *International Journal of Modern Education, 8*(4), 687-707. https://doi.org/10.35631/IJMOE.623047

Redecker, C. (2017). *European framework for the digital competence of educators*. Publications Office of the European Union. https://doi.org/10.2760/159770

Sahin, Y., & Ulucan, P. (2023). Using conditions of various teaching methods and techniques of primary school teachers. *ODU Journal of Social Sciences Research, 13*(1), 995-1030.

Saldana, J. M. (2015). *The coding manual for qualitative researchers* (3rd ed.). SAGE.

Schulz, L., Kürzinger, A., & Böttinger, T. (2025). Communication and collaboration in digital learning environments in elementary schools: Findings from a videographic research project. *Learning Environments Research, 28*(2), 271-287. https://doi.org/10.1007/s10984-025-09537-0

Senjaya, P., Purba, J. T., Parani, R., & Tukiran, M. (2021). Teacher perception of ICT and Alpha generation student. *Jurnal Studi Guru dan Pembelajaran, 4*(3), 740-748. https://doi.org/10.30605/jsgp.4.3.2021.1508

Shi, Y. R., Sin, K. F. K., & Wang, Y. Q. (2025). Teacher professional development of digital pedagogy for inclusive education in post-pandemic era: Effects on teacher competence, self-efficacy, and work well-being. *Teaching and Teacher Education, 168*, Article 105230. https://doi.org/10.1016/j.tate.2025.105230

Solomon, G. (2003). Project-based learning: A primer. *Technology and Learning-Dayton, 23*, Article 20.

Solomon, G., & Schrum, L. (2007). *Web 2.0: New tools, new schools*. ISTE.

Solomon, G., & Schrum, L. (2014). *Web 2.0: How-to for educators* (2nd ed.). ISTE.

Spante, M., Hashemi, S. S., Lundin, M., & Algers, A. (2018). Digital competence and digital literacy in higher education research: Systematic review of concept use. *Cogent Education, 5*(1), Article 1519143. https://doi.org/10.1080/2331186X.2018.1519143

Šramová, B., & Pavelka, J. (2023). Generation Alpha media consumption during COVID-19 and teachers' standpoint. *Media and Communication, 11*(4), 227-238. https://doi.org/10.17645/mac.v11i4.7158

Stake, R. E. (1995). *The art of case study research: Perspective in practice*. SAGE.

Stake, R. E. (2013). *Multiple case study analysis*. Guilford Press.

Swargiary, K. (2024). *The impact of digital learning environments on cognitive, social, and emotional development in generation Alpha children: A comparative analysis*. SSRN. https://doi.org/10.2139/ssrn.4904338

Tammets, K., & Ley, T. (2023). Integrating AI tools in teacher professional learning: A conceptual model and illustrative case. *Frontiers in Artificial Intelligence, 6*. https://doi.org/10.3389/frai.2023.1255089

Tracy, S. J. (2019). *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact* (2nd ed.). Wiley-Blackwell.

Tzafilkou, K., Perifanou, M., & Economides, A. A. (2023). Assessing teachers' digital competence in primary and secondary education: Applying a new instrument to integrate pedagogical and professional elements for digital education. *Education and Information Technologies, 28*(12), 1-24. https://doi.org/10.1007/s10639-023-11848-9

UNESCO. (2023). UNESCO's ICT competency framework for teachers. *United Nations Educational, Scientific and Cultural Organization*. https://www.unesco.org/en/digital-competencies-skills/ict-cft

WEF. (2024). *Shaping the future of education, skills, and work in the age of AI*. World Economic Forum.

Wiklund-Engblom, A., Bergström, P., & Lindfors, M. (2025). Exploring teaching practices in an innovative learning environment: A pragmatic view on the student-centred ideal in future classrooms. *Postdigital Science and Education, 7*(3), 834-854. https://doi.org/10.1007/s42438-025-00570-z

Wilson, D., Jones, D., Bocell, F., Crawford, J., Kim, M. J., Veilleux, N., Floyd-Smith, T., Bates, R., & Plett, M. (2015). Belonging and academic engagement among undergraduate STEM students: A multi-institutional study. *Research in Higher Education, 56*(7), 750-776. https://doi.org/10.1007/s11162-015-9367-x

Xu, X., Shen, W., Islam, A. Y. M. A., & Zhou, Y. (2023). A whole learning process-oriented formative assessment framework to cultivate complex skills. *Humanities and Social Sciences Communications, 10*(1), 1-15. https://doi.org/10.1057/s41599-023-02200-0

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). SAGE.

Zeichner, K. M., Darling-Hammond, L., Berman, A. I., Dong, D., & Sykes, G. (2024). *Evaluating and improving teacher preparation programs: Consensus report*. National Academy of Education. https://doi.org/10.31094/2025/2

Ziatdinov, R., & Cilliers, J. (2021). Generation alpha: Understanding the next cohort of university students. *European Journal of Contemporary Education, 10*(3), 783-789. https://doi.org/10.13187/ejced.2021.3.783

APPENDIX A

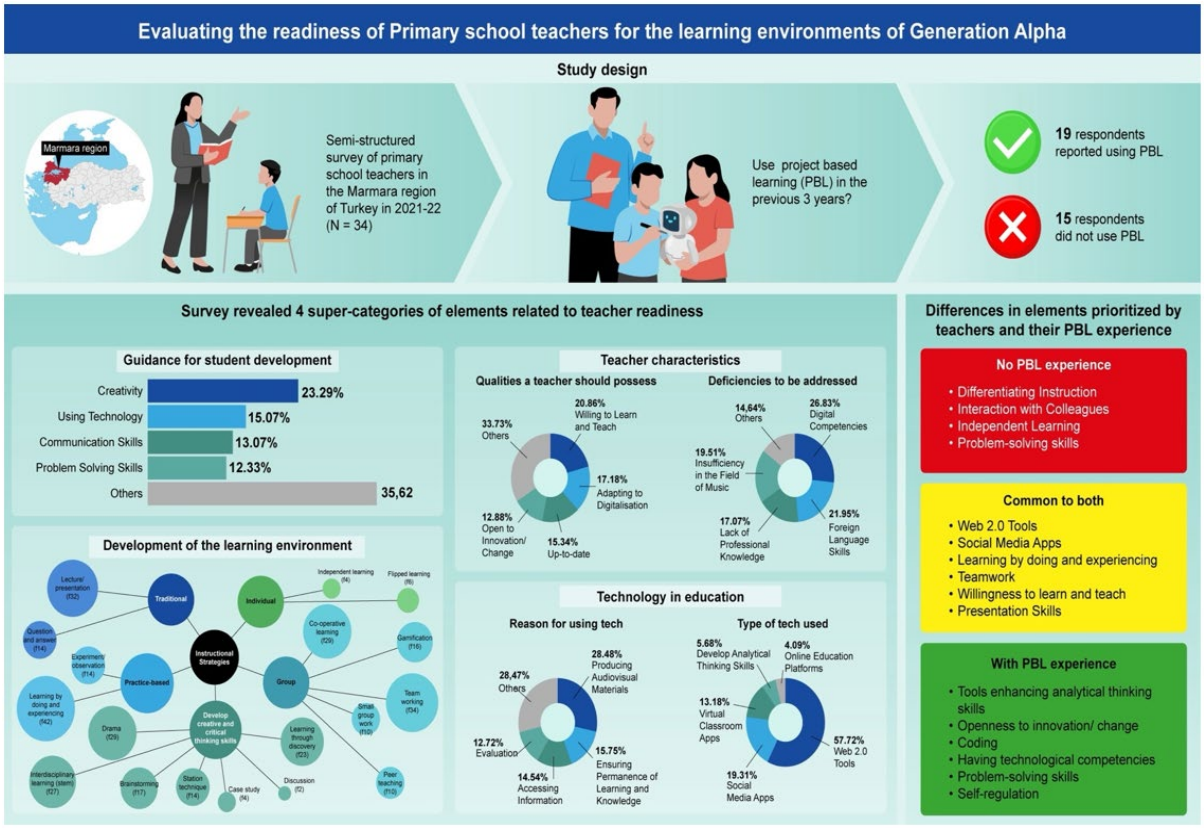

Figure A1. Comprehensive overview of teachers' readiness for generation Alpha learning environments (Source: Reprinted with permission from Wiley. Copyright fee for this figure was paid by the authors. Permission document is provided.)