**Discover** Education

Research

# Evaluating technology integration in education: a framework for professional development

**Yacoub Siyam**[1] · **Nur Siyam**[2] · **Malak Hussain**[3] · **Omar Alqaryouti**[3]

Received: 8 December 2024 / Accepted: 3 March 2025
Published online: 07 March 2025


**Abstract**
The integration of technology in education is essential for enhancing learning experiences and preparing students for a technology-driven world. However, many teachers lack the necessary skills and confidence to effectively incorporate technology into their classroom practices. This paper investigates the impact of technology-related professional development (PD) on teachers' self-reported technology competencies and their application of technology in classroom practices, addressing the critical need for effective PD programs that can bridge this gap. The study involved the development and administration of a self-reported Information and Communication Technology (ICT) competencies survey, the observation of classroom practices using a custom-developed observation tool, and the implementation of a comprehensive PD program followed by a subsequent reassessment using the same instruments. The findings demonstrate significant improvements in teachers' self-reported competencies and classroom practices following the PD sessions. The validated self-rating technology skills survey and classroom observation tool proved to be reliable and effective measures for assessing teachers' ICT competencies and the integration of technology in teaching. The study underscores the necessity of well-designed PD programs that incorporate active learning, collaboration, and sustained support to enhance teachers' technology integration skills.

**Keywords** Professional development · Technology integration · ICT competencies · Classroom practices

## 1 Introduction

The integration of technology in education has undergone a transformative journey over the years. The 1990s marked a notable shift with the widespread adoption of the internet in educational contexts. This period saw the emergence of online learning platforms connecting students and educators across geographical boundaries. The evolution of technology continued into the twenty-first century, characterized by the rise of mobile devices, cloud computing, and the ubiquity of high-speed internet. These advancements facilitated learning anytime, anywhere, and contributed to the development of blended and flipped learning models. In recent years, the integration of technologies such as artificial intelligence, virtual reality, and augmented reality has further enriched educational experiences [1, 2].

The progression of technology has resulted in a heightened emphasis on its integration into educational policies and practices, highlighting the escalating significance of science and technology in contemporary society [3]. Furthermore, the role of technology in education is evident in the implementation of advanced pedagogical practices within existing

✉ Nur Siyam, nur.siyam@gmail.com | [1]Zarqa University, Zarqa, Jordan. [2]Higher Colleges of Technology, P.O. Box 7947, Sharjah, Dubai, United Arab Emirates. [3]The British University in Dubai, Dubai, United Arab Emirates.

educational structures and curricula [4]. The integration of educational technologies in teacher training is considered a current priority, emphasizing the need for technological and pedagogical fluency in pre-service teacher education [5].

The integration of information and communication technology (ICT) in education has significant potential to enhance learning outcomes through innovative instructional practices [6]. However, despite the increased accessibility and potential applications of ICT, its effective use by educators remains limited, largely due to a lack of competency and expertise [7]. This disconnect highlights that the educational use of ICT does not occur organically with technological advancements; instead, it requires deliberate and systematic efforts to train educators [8]. Consequently, professional development programs are essential to enhance teachers' ICT competencies, ensuring they possess the skills necessary to implement technology effectively in their pedagogy [8]. Further, these programs must be rigorously evaluated to verify their impact on improving instructional practices and student outcomes [9].

Studying the characteristics of effective technology-related professional development (PD), examining its impact on teachers, and understanding how this impact can be assessed are crucial because they collectively ensure that PD initiatives are both meaningful and measurable, ultimately aiming to improve students' learning and achievement. Professional development programs play a crucial role in enhancing teachers' beliefs, self-efficacy, and practices in utilizing technology in meaningful ways [10]. These programs can decrease teachers' self-concerns and increase their impact-concerns, leading to a more confident and effective use of technology in educational settings [11]. Furthermore, despite adequate technology access, effective professional development remains a significant challenge in increasing the level of technology integration in classrooms [12]. This highlights that systematic training efforts must address the gap between access to technology and its pedagogical application, as educational technology does not inherently lead to effective integration without intentional professional learning opportunities [13]. Parker et al. [14] identified best practices in teacher professional development, such as active learning, opportunities to reflect on teaching practices, a focus on content knowledge, proximity to classroom practices, and sufficient time to learn and implement what has been learned.

The research gaps in the impact of technology-related professional development on teachers' practices in the classroom and the use of technology are evident. These gaps include the need for a more targeted focus on the knowledge required for integrating technology into specific educational domains, the translation of professional development opportunities into effective classroom integration, and the perceived incompatibility between educational goals and technology integration [12, 15, 16]. Addressing these gaps is crucial for enhancing the effectiveness of technology-related professional development and improving the integration of technology in educational settings.

In light of these acknowledged gaps, it is paramount to study the impact of technology-related professional development on teachers' ICT skills and their application in the classroom. Recognizing and addressing these gaps is not merely an academic exercise but a strategic imperative for advancing the effectiveness of technology-related professional development initiatives and fostering an improved integration of technology within educational settings.

This study aims to study the impact of technology-related professional development sessions on teachers' self-reported technology competencies and their use of technology inside the classroom. Towards this aim, a professional development program was designed and delivered. Moreover, a self-rating technology skills survey for teachers was developed to provide insights into teachers' confidence levels and perceived proficiency in technology. Also, a classroom observation tool aligned with the UAE inspection framework but tailored to focus on technology utilization was developed. This observation tool was utilized to assess how teachers integrate technology into their classrooms. In summary, this work aims to achieve the following objectives:

1. Develop a self-rating technology skills survey for teachers.
2. Develop a classroom observation tool focused on the effectiveness of technology utilization.
3. Identify the elements of effective technology related professional development for teachers.
4. Evaluate the effectiveness of technology related professional development on teachers' self-reported technology competencies and the use of technology in the classroom.

This research addresses the pivotal role of technology in education and underscores the significance of teachers' ICT skills. Given the substantial investments schools make in training teachers, ensuring the effectiveness of these sessions becomes crucial. The research aims to evaluate how such professional development influences classroom practices and self-reported competencies, ensuring that training efforts align with educational goals. By examining the practical outcomes of training, the study contributes to the broader mission of enhancing teaching and learning experiences through the thoughtful integration of technology in the classroom.

The potential contributions of this research to the field of education are manifold. Firstly, the findings can offer valuable insights into the effectiveness of current professional development models, informing educators, administrators, and policymakers about the strategies that yield optimal results in enhancing teachers' ICT skills and classroom practices. Additionally, the study can contribute to the ongoing discourse on the alignment between professional development investments and educational outcomes, shedding light on best practices and areas for improvement.

## 2 Literature review

This literature review examines several key aspects related to effective technology-related PD, including theoretical frameworks, characteristics of successful PD programs, and assessment methods for technology integration in education.

Teachers' technology competency plays a pivotal role in shaping students' digital literacy and equipping them with the necessary skills for the digital age. As educators integrate technology into their teaching practices, they not only enhance their own instructional effectiveness but also model digital behaviors and skills for their students. This influence is particularly important in the context of 21st-century skills, which include digital literacy, collaboration, critical thinking, and problem-solving. Research has shown that teachers who demonstrate proficiency in using technology can inspire students to adopt these competencies, ensuring that students are well-prepared for future challenges in an increasingly digital world. In this regard, teachers act as role models in fostering the development of students' digital skills [17]. This underscores the need for continuous PD to ensure that teachers are adequately prepared to integrate technology into their teaching and to guide students in acquiring the essential digital skills required in the twenty-first century.

Central to the discussion are constructs such as Technological Pedagogical Content Knowledge (TPACK), SAMR (Substitution, Augmentation, Modification, and Redefinition) the Technology Acceptance Model (TAM), and the Barrier to Technology Integration Model. The TPACK framework, developed by Mishra and Koehler [18], encompasses the knowledge teachers need when designing and implementing curriculum and instruction using digital technologies [19]. TPACK integrates content, pedagogy, and technology, emphasizing their intersections to effectively enhance teaching and learning [20]. The SAMR model explores different levels of technology integration in teaching and assessment, from basic substitution to transformative educational practices [21]. The Technology Acceptance Model (TAM) explores how teachers' beliefs about technology, particularly its ease of use and perceived usefulness, influence their attitudes and intentions to use technology in educational settings [22, 23]. The Barrier to Technology Integration Model addresses factors such as access, beliefs, time, and professional development that impede technology integration in classrooms [24, 25].

The UAE's School Improvement Framework, established to elevate educational quality to international standards, plays a significant role in this study. The UAE School Inspection Framework evaluates schools based on various performance standards, including student achievement, personal and social development, teaching and assessment, curriculum, and leadership and management [26]. This comprehensive approach emphasizes innovation, inclusive education, entrepreneurship, and national culture, with performance standards designed to measure educational quality [27].

Effective PD programs for educators are critical for enhancing Teacher Digital Competence (TDC), which refers to the knowledge, skills, and attitudes required by teachers to integrate technology into their teaching practices. TDC encompasses several dimensions, including pedagogical knowledge, technology integration, and student engagement, all of which are essential for fostering an effective learning environment in the digital age. According to the European Framework for the Digital Competence of Educators (DigCompEdu), TDC involves the ability of teachers to use digital tools not only for administrative tasks but to enhance teaching, support learning, and engage students in innovative ways. This includes the use of digital resources to design interactive lessons, assess student progress, and encourage collaborative learning. In line with this framework, effective PD programs provide teachers with both technical proficiency in using digital tools and the pedagogical skills to integrate these tools into their teaching practices [28].

Research indicates a consensus on the theoretical foundations that support effective teacher professional development programs [29]. Key characteristics of successful PD include content alignment, active learning, collective participation, duration, and support. Content alignment ensures that PD is relevant to teachers' specific content areas and aligns with school curricula and policies [30]. Active learning engages teachers in hands-on activities, discussions, and collaborative problem-solving, leading to greater engagement and knowledge retention [31, 32]. Collective participation involves teachers sharing experiences and collaboratively developing solutions, enhancing the effectiveness of PD [30]. Continuous, high-quality programs are more effective than one-time workshops, with extended durations and numerous contact hours proving essential [33, 34]. Ongoing support from experts and coaches further facilitates teachers' learning within their practice contexts [30].

Assessing the impact of technology-related PD is crucial for understanding its effectiveness. Classroom observation tools and self-reported ICT competencies surveys are commonly used methods. Classroom observation provides a clear view of teaching practices and helps understand how teachers operate in real settings [35]. Recent tools focus on evaluating the use and impact of technology in classrooms, considering variations in pedagogy, learning context, and technology access [36, 37]. The Classroom Environment Evaluation Scale (CEES) evaluates various dimensions of the classroom environment, including manageability, accessibility, teacher support, and student involvement [38]. Self-reported ICT competencies surveys, such as those developed by Tondeur et al. [39] and Lubuva et al. [40], assess teachers' abilities to integrate technology in instructional design and student learning.

## 3 Methodology

The study involves the development and administration of a self-reported ICT competencies survey, observation of classroom practices using a custom-developed observation tool, the implementation of the PD program, and a subsequent reassessment using the same instruments.

The research is guided by four primary questions and corresponding hypotheses, each aimed at exploring different aspects of the PD's impact on teachers' technological integration in their teaching practices.

1. How effectively does the developed ICT competencies survey, which is based on the UAE school inspection framework, measure teachers' ICT competencies?

**H1**: The developed survey instrument will demonstrate high internal consistency, indicating reliability.

2. How effectively does the developed classroom observation tool, which is based on the UAE school inspection framework, assess the utilization and impact of technology in teaching practices?

**H2**: The developed observation tool will demonstrate high inter-rater reliability, indicating reliability.

3. What are the essential elements and strategies that contribute to the effectiveness of technology-related professional development programs for teachers?

4. What is the overall impact of technology-related professional development on teachers' technology-integrated classroom practices and self-reported ICT competencies?

**H3**: Teachers will report a statistically significant improvement in their self-reported ICT competencies after participating in technology-related professional development.

**H4**: There will be a statistically significant difference in observed classroom practices before and after technology-related professional development, indicating a positive change.

Figure 1 Summarizes the research design.

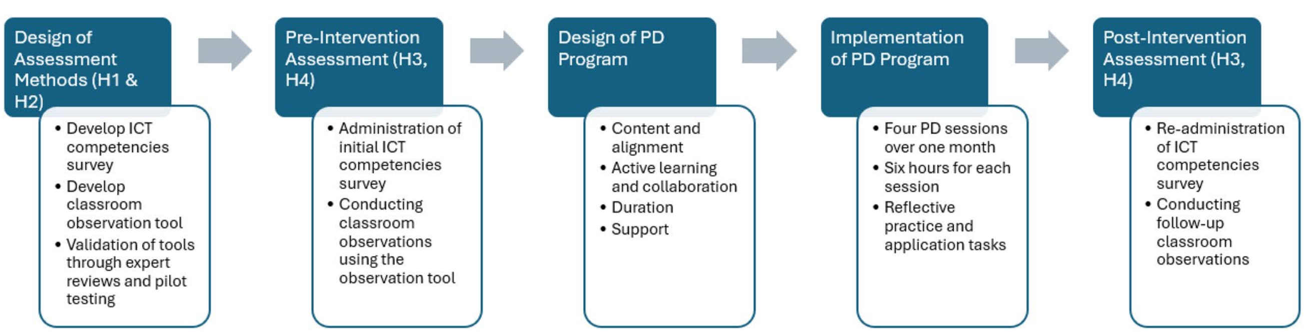



**Fig. 1** Research procedures

### 3.1 Research design

The study adopts a quasi-experimental design with a pre-post approach, where the same group of teachers serves as their own control [41, 42]. This design allows for the assessment of changes in teachers' ICT competencies and classroom practices by comparing pre-intervention and post-intervention data.

### 3.2 Participants

The study participants include teachers from a private school in the United Arab Emirates, selected through convenience sampling. Convenience sampling involves collecting data from members of the population who are readily available to provide it [43]. All elementary teachers in the school were invited to participate in the research. The participation rate was 80%. Inclusion criteria ensure that participants have varying levels of initial ICT competency and experience with technology in teaching. Informed consent forms were obtained from the school's principal and the participating teachers.

A total of 24 teachers have participated in this study. The sample consisted entirely of females. Fourteen teachers (58.3%) were 30 to 39 years old, while seven teachers (29.2%) were at least 40 years, and three teachers (12.5%) were under 30.

Six teachers (25.0%) were Jordanian, four (16.7%) were Syrian, and other teachers are from different countries as shown in the table. Thirteen teachers (54.2%) had 4 to 10 years of teaching experience, while nine (37.5%) had more than 10 years, and only two teachers (8.3%) had less than 4 years of teaching experience.

### 3.3 Instruments

Two instruments were developed for this study: a self-reported ICT competencies survey and a classroom observation tool. The study instruments were designed based on the UAE's School Inspection Framework [26], which outlines key indicators for evaluating teaching practices and student outcomes. The elements relevant to teachers' competencies and classroom practices were selected from this framework, and the technology component was integrated into them to ensure alignment with Technological Pedagogical Content Knowledge (TPACK).

To align the instruments with the TPACK framework, we mapped each element of the self-reported ICT competencies survey and classroom observation tool to the relevant TPACK domains: Technology Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Knowledge (TPK). This process began with selecting elements from the UAE School Inspection Framework, which considers five main key indicators: teaching, attainment, assessment and progress, learning skills, and behavior for learning.. For example, T1 (Technology Integration in Lesson Planning), which is part of the "Teaching" indicator, was aligned with TK to assess teachers' ability to select and use technology in lesson planning, while also being aligned with PCK to evaluate how technology enhances both teaching strategies and content delivery. Similarly, P1 (Technology-Enhanced Assessment), which is part of the "Assessment and Progress" indicator, was mapped to TPK, reflecting how technology is used to enhance assessment practices. Questions related to pedagogical strategies, classroom management, and student engagement were aligned with PK, while questions assessing how technology supports content delivery were mapped to CK. The integration of technology into pedagogy and content was further explored through PCK, particularly with questions about differentiated instruction. This ensured that all aspects of technology integration were comprehensively covered, from the use of digital tools in lesson planning to how technology enhances teaching and learning. The mapping of each element to the UAE inspection framework and TPACK domains is detailed in Table 1.

The observation tool comprised of 13 elements shown in Table 1, each accompanied by a detailed description of its manifestation in the classroom setting. Each element was assessed using a Likert scale ranging from 1 to 5, where 1 indicated a weak performance and 5 indicated an outstanding performance.

On the other hand, the survey comprised of 27 elements mapped to the elements on Table 1. Like the observation tool, each element was accompanied by a description of the competency targeted, with sentences that start with "I am able to…". Each element was assessed using a Likert scale ranging from 1 to 5, where 1 indicated strong disagreement and 5 indicated strong agreement.

**Table 1** Study instruments indicators and elements

| Indicator | Code | Element | TPACK domain(s) |
|---|---|---|---|
| Teaching | T1 | Technology Integration in Lesson Planning | TK, PCK |
| | T2 | Teacher Knowledge of Technology Pedagogy | TPK, PCK |
| | T3 | Teacher knowledge of students and how they learn using technology | PK, TPK |
| | T4 | Technology and the Learning Environment | TK, TPK |
| Attainment | A1 | Acquiring and Applying Knowledge, Skills, and Understanding with the aid of Technology | TK, CK |
| Assessment and progress | P1 | Technology-Enhanced Assessment | TPK |
| | P2 | Feedback Through Technology | TPK |
| Learning skills | L1 | Technology-Enhanced Interactions, Collaboration, and Questioning | PK, TPK |
| | L2 | Technology-Facilitated Engagement, Responsibility, and Reflection | PK, TPK |
| | L3 | Technology-Facilitated Connections | TK, PK |
| | L4 | Technology-Enhanced Innovation, enterprise, enquiry, critical thinking | TPK, PCK |
| Behavior for learning | B1 | Digital Positive Behavior Reinforcement | TK, PK |
| | B2 | Practicing Digital Citizenship | PK, PCK |

#### 3.3.1 Instruments validation

To validate the survey and observation tool in the context of a limited sample size, a multi-faceted approach was employed. Initially, content validity was ensured by utilizing the UAE School Inspection Framework as a foundational reference to align the instruments with established educational standards and practices within the region.

For face validity, the tools were pilot tested with a small group of teachers who were asked specific questions regarding the clarity, relevance, and comprehensiveness of each item in the survey. Teachers were prompted to identify any ambiguous language, suggest any additional elements they felt were missing, and rate the practical applicability of the items in their classrooms. Similarly, two experts were consulted to evaluate the alignment of the instruments with theoretical constructs and practical relevance. The expert had extensive experience in schools evaluation and inspection. The experts were asked to review whether each item in both the survey and the observation tool accurately represented the construct it was intended to measure, if the language used was appropriate for the target audience, and if the overall structure of the tools was logical and comprehensive.

The feedback from these consultations was used to iteratively refine the instruments, ensuring that they accurately represented the intended constructs and were easily understood and applicable in real classroom settings. This methodological rigor, coupled with the alignment with the UAE School Inspection Framework, compensates for the small sample size, providing a robust foundation for the instruments' validity without relying solely on statistical analysis.

### 3.4 Professional development program

The program focused on the integration of iPads and Apple tools in education and aimed to enhance teachers' digital competencies by addressing both the technical skills and pedagogical strategies necessary for effective technology use in the classroom. The program was specifically designed to improve Teacher Digital Competence (TDC) across key dimensions, such as pedagogical knowledge, technology integration, and student engagement. These dimensions are fundamental to enabling teachers to effectively incorporate digital tools into their teaching practice and to foster student-centered learning environments. The following key elements and strategies were incorporated into the program:

- Content and Alignment: Two distinct professional development (PD) programs were developed: one tailored for English-medium subjects (English, math, and science) and the other for Arabic-medium subjects (Arabic, Islamic education, social education). Each PD program was designed to include subject-specific examples as well as technical and pedagogical aspects to ensure that the training was relevant and relatable for all participating teachers. Apple tools like Pages and Keynote were incorporated into both tracks to allow teachers to integrate these tools into their lesson planning and content delivery. This alignment ensured that both the content knowledge (CK) and pedagogical strategies (PK) were enhanced through the use of technology, helping teachers create more engaging and interactive lessons.

- Active Learning and Collaboration: The PD program was designed to foster active learning and hands-on participation from teachers. Teachers were given opportunities to engage directly with the iPads and Apple tools to create customized classroom activities and lessons. For instance, teachers used iMovie to create educational videos, and GarageBand to develop audio projects, giving them an undestarting on how they can implement these tools with their students, such as allowing students to reflect on their learning using video or voice recording. Collaborative exercises and group discussions were incorporated, allowing teachers to share insights, exchange ideas, and design learning activities using these tools. This collaborative approach fostered the development of Technological Pedagogical Knowledge (TPK), ensuring that teachers not only learned new technology tools but also gained practical experience in integrating them into their teaching practices to enhance student engagement and learning outcomes.
- Duration: Four PD sessions were conducted within a month, with each session spanning 6 h of intensive learning. After each session, teachers were encouraged to engage in reflective practice, contemplating their learning experiences and insights gained. They were tasked with preparing an instructional activity to be showcased during the subsequent session. Teachers used iPads and Apple tools to create and refine their lesson plans, integrating technology into their instructional designs. This reflective component is critical for the development of Pedagogical Content Knowledge (PCK), as it allowed teachers to apply their learning to real-world classroom scenarios.
- Support: In addition to the structured PD sessions, ongoing support mechanisms were established to provide teachers with continuous assistance and guidance throughout their journey. This support system included access to online resources that were shared and updated after each session, such as instructional videos, templates, and curated links. Moreover, a designated mentor who is an ICT coach in the school was available to offer personalized support, address individual concerns, and provide feedback on lesson plans and activities developed by teachers in between the PD sessions. This continuous support reinforced the development of Teacher Digital Competence in terms of both technical proficiency and the pedagogical use of technology in the classroom.

## 3.5 Data collection procedures

### 3.5.1 ICT competencies survey

Teachers completed the self-reported ICT competencies survey before and after participating in the PD program. This allowed for a comparative analysis to assess any statistically significant improvements in self-reported competencies.

### 3.5.2 Classroom observation

Classroom observations were conducted before and after the PD program to measure changes in technology integration practices. Each classroom was observed by a group of the academic leadership team in the school using the developed observation tool. Pre- and post-intervention observation data were compared to identify any statistically significant changes in teaching practices.

### 3.5.3 Reliability assessments

To ensure the reliability of the instruments used in this study, we employed two key reliability assessments: the Guttman Split-Half Coefficient and the Intraclass Correlation Coefficient (ICC). The Guttman Split-Half Coefficient was used to assess the internal consistency of the survey and observation tools. This method divides the items of the instrument into two halves and checks the correlation between them, helping to determine whether the items consistently measure the intended constructs [44]. Additionally, the Intraclass Correlation Coefficient (ICC) was used to evaluate inter-rater reliability for the classroom observations. This method assesses the consistency of ratings across different raters, ensuring that the evaluation process was stable and reliable across all observations [45].

To ensure consistency in the classroom observations, a detailed rating scheme was developed for each element of the observation tool. Each element was clearly defined, and specific criteria were provided to guide raters in applying consistent ratings. For example, the rating scale ranged from 1 to 5, where 1 indicated minimal technology integration and 5 indicated exemplary use of technology in teaching. The raters were trained to apply these criteria consistently across all observations, with detailed descriptions of what each rating level looked like in the classroom setting. This approach helped ensure that the observations were conducted in a systematic manner and that all raters evaluated teachers' technology integration in a consistent way.

## 4 Results and analysis

Statistical analysis was performed in IBM SPSS Statistics 27, including descriptive analysis and inferential statistics. Paired-samples t-test was used to evaluate the impact of technology-related professional development on technology integrated classroom practices and self-reported competencies; with significance level set at $\alpha = 0.05$. The paired-samples t-test is a statistical method used to compare the mean scores of two related datasets. This test is particularly useful when analyzing repeated measures from the same individuals taken at different times. It compares the means of two measurements within the same individual, making it suitable for scenarios where the data points are not independent [46].

### 4.1 Self-evaluated technology skills survey

The self-evaluated technology skills survey was used to assess teachers' self-reported competencies. Paired-samples t-test is used to analyze this data, which is used to compare the difference between the mean scores of two repeated measures [47]. In this study, the two repeated measures are the scores pre and post technology-related professional development sessions.

#### 4.1.1 Checking normality of observation scores

Prior to conducting the paired-samples t-test, the normality assumption should be met. For this test, the normality is checked for the difference between pre and post scores using skewness and kurtosis, reported in Table 2. Absolute values of skewness ranged between zero and 2.422, which are within normality ranges (− 2 to + 2), and absolute values of kurtosis ranged from 0.295 to 6.341, which are within normality ranges (− 7 to + 7) [48]. Although some skewness values were out of the normal ranges, the distribution of the variables are still considered approximately normal as the paired-samples t-test is considered "robust" in handling violations of normality to some extent.

#### 4.1.2 Survey scale reliability

The current study is a repeated measurement study, so the survey scale reliability and internal consistency was assessed by two methods: (1) test–retest reliability, and (2) intraclass correlation coefficient (ICC).

**4.1.2.1 Test–retest reliability** The test–retest reliability was performed by calculating split-half reliability coefficients, namely, Guttman split-half coefficient; and the results are reported in Table 3. Test–retest reliability indicates stability of a test over time [49].

From the reported results, Guttman split-half coefficient is 0.779, which exceeds the cutoff of 0.70, recommended by [50]. This implies that the survey was well-developed and that the standardized achievement tests were administered reasonably close together. Therefore, the scores are consistent between the first and second sessions.

In Table 3, the Guttman split-half coefficient of 0.779 indicates a strong level of internal consistency between the two halves of the survey, suggesting that the instrument produces stable and reliable results across time. This value shows that 77.9% of the variance in the test results is attributed to true variance (reflecting teachers' actual abilities), while 22.1% is attributed to error, which supports the validity of the instrument for measuring teacher competencies. The coefficient value exceeds the general threshold of 0.70, which is widely regarded as acceptable in educational measurement for ensuring the instrument is measuring the intended construct accurately [51]. Therefore, the instrument is reliable for assessing teachers' skills and their classroom integration of technology over time.

Additionally, Table 3 shows that the correlation between forms is 0.744, which indicates a strong positive correlation between the pre- and post-session survey forms, further confirming the reliability of the instrument. The Spearman-Brown coefficient values for both equal and unequal length forms are 0.853, indicating strong reliability when adjusting for the unequal lengths of the forms [52]. These values confirm that the survey can consistently measure teachers' abilities, even when considering different sections of the survey.

**Table 2** Descriptive summary of survey variable difference

| Survey score difference<br>I am able to… | M | SD | Sk | Ku |
|---|---|---|---|---|
| Teaching | | | | |
| Integrate technology into lesson plans and teaching strategies to enhance engagement and promote deep understanding | 0.92 | 0.584 | − 0.007 | 0.295 |
| Integrate technology into teaching to enhance understanding of subject concepts | 1.13 | 0.448 | 0.641 | 2.082 |
| Select appropriate digital applications for a specific learning setting | 0.92 | 0.504 | − 0.196 | 1.463 |
| Use technology to create differentiated tasks based on individual learning styles, needs, and interests (videos, animations, simulations, AR, etc.) | 1.00 | 0.417 | 0.000 | 4.032 |
| Provide personalized learning paths and adaptive resources to modify the curriculum successfully for diverse groups of students using technology (Exact Path, Achieve 3000, Level Up, 3asafeer, etc.) | 0.96 | 0.464 | − 0.179 | 2.500 |
| Adapt the learning environment to maximize technology use | 1.13 | 0.338 | 2.422 | 4.210 |
| Integrate technology routines into classroom procedures without compromising instructional time | 1.04 | 0.464 | 0.179 | 2.500 |
| Maintain control during technology transitions with a positive and encouraging attitude | 1.13 | 0.338 | 2.422 | 4.210 |
| Promote learners who are risk-takers in both conventional and technological aspects | 0.96 | 0.550 | − 0.037 | 0.825 |
| Attainment | | | | |
| Use technology tools to accurately evaluate knowledge, skills, and understanding of individual students | 1.08 | 0.408 | 0.716 | 3.673 |
| Assessment and progress | | | | |
| Integrate a variety of technology-based assessment methods that are valid, rigorous, and linked to curriculum standards | 1.00 | 0.417 | 0.000 | 4.032 |
| Use technology tools that enable real-time progress monitoring for students | 1.00 | 0.511 | 0.000 | 1.543 |
| Provide ongoing, comprehensive, and constructive feedback through various technology tools | 1.04 | 0.464 | 0.179 | 2.500 |
| Use digital means where students provide self and peer feedback | 1.04 | 0.464 | 0.179 | 2.500 |
| Act upon students' feedback to foster an environment of continuous improvement through technology | 0.92 | 0.408 | − 0.716 | 3.673 |
| Learning skills | | | | |
| Motivate students to improve their critical thinking, collaboration, creativity, and communication skills through technology | 1.00 | 0.511 | 0.000 | 1.543 |
| Guide students in using technology responsibly to reflect on their learning, evaluate their strengths and weaknesses, and set goals for improvement | 1.04 | 0.464 | 0.179 | 2.500 |
| Use technology tools to facilitate interdisciplinary connections and real-world applications | 1.00 | 0.511 | 0.000 | 1.543 |
| Offer students opportunities to express ideas in a creative and innovative way by means of technology | 1.13 | 0.338 | 2.422 | 4.210 |
| Support students in searching for information by means of technology | 1.13 | 0.338 | 2.422 | 4.210 |
| Support students in analyzing and interpreting data by means of technology | 1.04 | 0.464 | 0.179 | 2.500 |
| Support students to present information by means of technology | 1.00 | 0.659 | 0.000 | − 0.448 |
| Educate students to use technology in a conscious way (respecting ergonomics, intellectual property, avoiding plagiarism, etc.) | 1.00 | 0.511 | 0.000 | 1.543 |
| Behavior for learning | | | | |
| Develop self-disciplined learners through setting clear expectations and consistent routines while using technology | 0.96 | 0.550 | − 0.037 | 0.825 |
| Reinforce positive behavior through advanced digital platforms | 1.04 | 0.359 | 0.646 | 6.341 |
| Support students to communicate using technology in a safe, responsible, and effective way | 1.04 | 0.464 | 0.179 | 2.500 |
| Provide guidance on responsible and ethical use of technology | 1.13 | 0.338 | 2.422 | 4.210 |

**Table 3** Reliability Statistics for Survey Scale

| | | | |
|---|---|---|---|
| Cronbach's alpha | Part 1 | Value | 0.960 |
| | | N of items | 27[a] |
| | Part 2 | Value | 0.881 |
| | | N of items | 27[b] |
| | Total N of Items | | 54 |
| Correlation between forms | | | 0.744 |
| Spearman-brown coefficient | Equal length | | 0.853 |
| | Unequal length | | 0.853 |
| Guttman split-half coefficient | | | 0.779 |

a pre-session questions

b post-session questions

**4.1.2.2 Intraclass correlation coefficient (ICC)** The value of an ICC can range from 0 to 1, with 0 indicating no reliability among raters (i.e., repeated measurements) and 1 indicating perfect reliability among raters. A two-way mixed effects ICC model with absolute agreement relationship average measures was used for this analysis. This model is commonly employed in reliability studies to account for both person effects and measurement effects that may influence the results. Results are reported in

The single measures ICC of 0.195 indicates relatively low reliability when considering individual ratings, which is typical as the average measures ICC provides a more reliable estimate. The average measures ICC of 0.929 suggests excellent reliability, indicating strong consistency among raters in evaluating the teachers' technology integration. The 95% confidence interval of 0.881 to 0.964 further confirms this, suggesting that the reliability of the ratings ranges from good to excellent. The Spearman-Brown coefficient values of 0.853 for both equal and unequal lengths highlight the strong reliability of the survey, regardless of the length of the forms, and the significance value of < 0.001 indicates that these results are statistically significant, further confirming the robustness of the instrument.

Table 4. Based on results, the ICC of 0.93 indicates excellent reliability, which is well above the threshold of 0.75 commonly considered excellent in reliability studies [45]. The 95% confidence interval of (0.88, 0.96) suggests that the level of reliability can range from "good" to "excellent." This wide confidence interval indicates strong precision in the ICC estimate, further reinforcing the reliability of the raters' evaluations.

The single measures ICC of 0.195 indicates relatively low reliability when considering individual ratings, which is typical as the average measures ICC provides a more reliable estimate. The average measures ICC of 0.929 suggests excellent reliability, indicating strong consistency among raters in evaluating the teachers' technology integration. The 95% confidence interval of 0.881 to 0.964 further confirms this, suggesting that the reliability of the ratings ranges from good to excellent. The Spearman-Brown coefficient values of 0.853 for both equal and unequal lengths highlight the strong reliability of the survey, regardless of the length of the forms, and the significance value of < 0.001 indicates that these results are statistically significant, further confirming the robustness of the instrument.

#### 4.1.3 Impact of technology-related professional development sessions on teachers' self-reported competencies

**4.1.3.1 Teaching** The paired-samples t-test was run to determine if teaching improved with the technology-related professional development sessions. The results showed that the mean score pre-sessions were significantly less than

**Table 4** Intraclass correlation coefficient for survey scale

| | Intraclass correlation[b] | 95% CI | | F test with true value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower bound | Upper bound | Value | df1 | df2 | Sig |
| Single measures | 0.195[a] | 0.120 | 0.331 | 25.259 | 23 | 1219 | < 0.001 |
| Average measures | 0.929 | 0.881 | 0.964 | 25.259 | 23 | 1219 | < 0.001 |

Two-way random effects model where both people effects and measures effects are random

[a]The estimator is the same, whether the interaction effect is present or not

[b]Type A intraclass correlation coefficients using an absolute agreement definition

the mean score post-sessions for all teaching aspects listed in Table 5. Effect size (Cohen's d) for each component was computed to measure how large the difference is.

For all items, the effect size was large (Cohen's d > 0.8), indicating that the difference in scores between pre-sessions and post-sessions is efficiently different from zero, which is an indication that the sessions might have been really effective.

**4.1.3.2 Attainment** The paired-samples t-test was conducted to determine the effect of technology-related professional development sessions on teachers' ability to use technology tools to accurately evaluate knowledge, skills, and understanding of individual students (Table 6).

**4.1.3.3 Assessment and progress** Evaluation of technology-related professional development sessions on self-reported competencies related to teachers' assessment and progress using the paired-samples t-test yielded the results reported in Table 7.

**4.1.3.4 Learning skills** As shown in Table 8, the paired-samples t-test indicated that there were statistically significant differences between the mean score of pre-sessions of all learning skills and the mean score of post-sessions with large effect size values (Cohen's d > 0.8); suggesting strong effectiveness of the technology-related professional development sessions.

**4.1.3.5 Behavior for learning** As indicated in Table 9, the paired-samples t-test showed that there were statistically significant differences between the mean score of pre-sessions of all aspects of behavior of learning and the mean score of post-sessions. In addition, all effect size (Cohen's d) values exceeded 0.8, suggesting effective technology-related professional development sessions.

## 4.2 Classroom observation tool

In this section, the statistical analysis of the data obtained from the developed classroom observation tool, utilized to assess how teachers integrate technology into their classrooms, is presented.

## 4.3 Checking normality of observation scores

*Prior to conducting the paired-samples t-test,* the normality assumption should be met. For this test, the normality is checked for the difference between pre and post scores using skewness and kurtosis, reported in Table 10. Absolute values of skewness ranged between 0.298 and 1.511, which are within normality ranges (− 2 to + 2), and absolute values of kurtosis ranged from 0.539 to 1.963, which are within normality ranges (− 7 to + 7) [48].

### 4.3.1 Observation scale reliability

**4.3.1.1 Test–retest reliability** The results presented in Table 11 show the Guttman split-half coefficient for the observation scale, which is 0.795, exceeding the commonly accepted threshold of 0.70 for reliability in educational measurement [50]. This value suggests that the observation tool is well-developed and produces consistent results, with 79.5% of the variance attributed to true scores, reflecting teachers' actual abilities, and 20.5% attributed to error. This strong consistency indicates that the observation scale effectively differentiates between teachers' abilities, supporting its reliability in assessing technology integration in the classroom. Additionally, the high correlation between forms (0.899) and Spearman-Brown coefficient (0.947) further demonstrate the instrument's reliability across different forms and lengths, ensuring that the results are stable even when adjusting for unequal lengths of the forms. These findings confirm that the observation tool provides reliable measurements of teachers' performance, consistent with the general standards in educational assessments.

**4.3.1.2 Intraclass correlation coefficient (ICC)** Based on the results in Table 12, the Intraclass Correlation Coefficient (ICC) of 0.91 indicates excellent reliability [45], with a 95% confidence interval of (0.85, 0.96), suggesting that the level of reliability can range from "good" to "excellent." The high ICC value indicates a strong level of agreement among raters, confirming that the observation tool is highly reliable in measuring teachers' technology integration practices across

**Table 5** Paired-samples t-test for teaching in survey

| Survey: teaching<br>I am able to… | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Integrate technology into lesson plans and teaching strategies to enhance engagement and promote deep understanding | 3.33 | 0.761 | 4.25 | 0.532 | − 7.695 | < 0.001 | − 1.571 |
| I am able to integrate technology into teaching to enhance understanding of subject concepts | 3.21 | 0.779 | 4.33 | 0.482 | − 12.290 | < 0.001 | − 2.509 |
| I am able to select appropriate digital applications for a specific learning setting | 3.25 | 0.847 | 4.17 | 0.702 | − 8.917 | < 0.001 | − 1.820 |
| I am able to use technology to create differentiated tasks based on individual learning styles, needs, and interests (videos, animations, simulations, AR, etc.) | 3.13 | 0.797 | 4.13 | 0.537 | − 11.747 | < 0.001 | − 2.398 |
| I am able to provide personalized learning paths and adaptive resources to modify the curriculum successfully for diverse groups of students using technology (Exact Path, Achieve 3000, Level Up, 3asafeer, etc.) | 3.29 | 0.751 | 4.25 | 0.737 | − 10.112 | < 0.001 | − 2.064 |
| I am able to adapt the learning environment to maximize technology use | 2.96 | 0.624 | 4.08 | 0.504 | − 16.314 | < 0.001 | − 3.330 |
| I am able to integrate technology routines into classroom procedures without compromising instructional time | 3.13 | 0.797 | 4.17 | 0.637 | − 10.991 | < 0.001 | − 2.243 |
| I am able to maintain control during technology transitions with a positive and encouraging attitude | 2.83 | 0.868 | 3.96 | 0.751 | − 16.314 | < 0.001 | − 3.330 |
| I am able to promote learners who are risk-takers in both conventional and technological aspects | 2.96 | 0.859 | 3.92 | 0.654 | − 8.536 | < 0.001 | − 1.742 |

**Table 6** Paired-samples t test for attainment in survey

| Survey: attainment I am able to… | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Use technology tools to accurately evaluate knowledge, skills, and understanding of individual students | 2.92 | 0.830 | 4.00 | 0.659 | − 13.000 | < 0.001 | − 2.610 |

The results indicate a significant difference between the mean score pre-sessions ($M = 2.92$; $SD = 0.83$) and the mean score post-sessions ($M = 4.00$; $SD = 0.66$); [$t(23) = -13.00$, $p < 0.001$, $d = -2.61$]. The effect size is large (Cohen's $d > 0.8$) indicating that the sessions were very effective

**Table 7** Paired-samples t-test for assessment and progress in survey

| Survey: assessment and progress<br>I am able to… | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Integrate a variety of technology-based assessment methods that are valid, rigorous, and linked to curriculum standards | 2.79 | 0.658 | 3.79 | 0.658 | − 11.747 | < 0.001 | − 2.398 |
| Use technology tools that enable real-time progress monitoring for students | 2.88 | 0.850 | 3.88 | 0.741 | − 9.592 | < 0.001 | − 1.958 |
| Provide ongoing, comprehensive, and constructive feedback through various technology tools | 2.88 | 0.741 | 3.92 | 0.717 | − 10.991 | < 0.001 | − 2.243 |
| Use digital means where students provide self and peer feedback | 2.67 | 0.963 | 3.71 | 0.806 | − 10.991 | < 0.001 | − 2.243 |
| Act upon students' feedback to foster an environment of continuous improvement through technology | 2.88 | 0.741 | 3.79 | 0.658 | − 11.000 | < 0.001 | − 2.245 |

The effect size for all competencies is really large (Cohen's $d > 0.8$) indicating that the sessions might have been very effective

**Table 8** Paired-samples t-test for learning skills in survey

| Survey: learning skills<br>I am able to… | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Motivate students to improve their critical thinking, collaboration, creativity, and communication skills through technology | 3.00 | 0.722 | 4.00 | 0.511 | − 9.592 | < 0.001 | − 1.958 |
| Guide students in using technology responsibly to reflect on their learning, evaluate their strengths and weaknesses, and set goals for improvement | 3.00 | 0.780 | 4.04 | 0.550 | − 10.991 | < 0.001 | − 2.243 |
| Use technology tools to facilitate interdisciplinary connections and real-world applications | 3.08 | 0.881 | 4.08 | 0.717 | − 9.592 | < 0.001 | − 1.958 |
| Offer students' opportunities to express ideas in a creative and innovative way by means of technology | 3.13 | 0.741 | 4.25 | 0.608 | − 16.314 | < 0.001 | − 3.330 |
| Support students in searching for information by means of technology | 3.17 | 0.702 | 4.29 | 0.550 | − 16.314 | < 0.001 | − 3.330 |
| Support students in analyzing and interpreting data by means of technology | 2.83 | 0.761 | 3.88 | 0.612 | − 10.991 | < 0.001 | − 2.243 |
| Support students to present information by means of technology | 3.13 | 0.612 | 4.17 | 0.381 | − 10.991 | < 0.001 | − 2.243 |
| Educate students to use technology in a conscious way (respecting ergonomics, intellectual property, avoiding plagiarism, etc.) | 3.13 | 0.741 | 4.13 | 0.537 | − 9.952 | < 0.001 | − 1.958 |

**Table 9** Paired-samples t test for behavior for learning in survey

| Survey: behavior for learning<br>I am able to… | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Develop self-disciplined learners through setting clear expectations and consistent routines while using technology | 2.96 | 0.806 | 3.92 | 0.504 | − 8.536 | < 0.001 | − 1.742 |
| Reinforce positive behavior through advanced digital platforms | 3.00 | 0.590 | 4.04 | 0.464 | − 14.229 | < 0.001 | − 2.904 |
| Support students to communicate using technology in a safe, responsible, and effective way | 2.83 | 0.702 | 3.88 | 0.612 | − 10.991 | < 0.001 | − 2.243 |
| Provide guidance on responsible and ethical use of technology | 2.88 | 0.537 | 4.00 | 0.417 | − 16.314 | < 0.001 | − 3.330 |

**Table 10** Descriptive summary of observation variable difference

| Observation score difference | M | SD | Sk | Ku |
|---|---|---|---|---|
| Teaching | | | | |
| Technology integration in lesson planning | 1.17 | 0.637 | 0.958 | 2.375 |
| Teacher knowledge of technology pedagogy | 0.67 | 0.637 | 0.408 | − 0.539 |
| Teacher knowledge of students and how they learn using technology | 1.17 | 0.761 | − 0.298 | − 1.148 |
| Technology and the learning environment | 0.79 | 1.103 | 1.511 | 1.963 |
| Attainment | | | | |
| Acquiring and applying knowledge, skills, and understanding with the aid of technology | 0.71 | 0.464 | − 0.979 | − 1.145 |
| Assessment and progress | | | | |
| Technology-enhanced assessment | 0.63 | 0.970 | 1.488 | 1.239 |
| Feedback through technology | 0.67 | 0.868 | 1.176 | 0.718 |
| Learning skills | | | | |
| Technology-enhanced interactions, collaboration, and questioning | 0.54 | 0.588 | 0.525 | − 0.586 |
| Technology-facilitated engagement, responsibility, and reflection | 0.67 | 0.761 | 0.669 | − 0.896 |
| Technology-facilitated connections | 0.79 | 0.884 | 0.443 | − 1.615 |
| Technology-enhanced innovation, enterprise, enquiry, critical thinking | 0.96 | 0.999 | 0.660 | − 0.654 |
| Behavior for learning | | | | |
| Digital positive behavior reinforcement | 0.88 | 0.992 | 0.561 | − 1.180 |
| Practicing digital citizenship | 0.63 | 0.824 | 0.834 | − 0.975 |

**Table 11** Reliability statistics for observation scale

| | | | |
|---|---|---|---|
| Cronbach's Alpha | Part 1 | Value | 0.629 |
| | | N of items | 13[a] |
| | Part 2 | Value | 0.961 |
| | | N of items | 13[b] |
| | Total N of items | | 26 |
| Correlation between forms | | | 0.899 |
| Spearman-brown coefficient | Equal length | | 0.947 |
| | Unequal length | | 0.947 |
| Guttman split-half coefficient | | | 0.795 |

[a]pre-session questions

[b]post-session questions

**Table 12** Intraclass correlation coefficient for observation scale

| | Intraclass correlation[b] | 95% CI | | F test with true value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower bound | Upper bound | Value | df1 | df2 | Sig |
| Single measures | 0.280[a] | 0.176 | 0.447 | 16.269 | 23 | 575 | < 0.001 |
| Average measures | 0.910 | 0.847 | 0.955 | 16.269 | 23 | 575 | < 0.001 |

Two-way random effects model where both people effects and measures effects are random

[a]The estimator is the same, whether the interaction effect is present or not

[b]Type A intraclass correlation coefficients using an absolute agreement definition

different evaluators. The confidence interval further supports this by showing that the reliability estimate remains consistently high across different raters and contexts, with minimal variation.

In Table 12, the single measures ICC of 0.280 shows relatively low reliability when considering individual ratings, which is expected because the average measures ICC provides a more reliable estimate when pooling ratings across multiple raters. The average measures ICC of 0.910 reflects the reliability of the average ratings across all raters, confirming that the evaluation of teachers' performance is highly consistent. The F-test for the ICC values with a significance value of < 0.001 indicates that these results are statistically significant, further supporting the consistency of the ratings. The values also show that the measurement tool is reliable in both the random effects model, where both person effects and measurement effects are considered, ensuring that the tool is robust under different conditions.

#### 4.3.2 Impact of technology-related professional development sessions on how teachers integrate technology into their classrooms

**4.3.2.1 Teaching** The paired-samples t-test was run to determine if teaching improved with the technology-related professional development sessions. The results showed that the mean score pre-sessions were significantly less than the mean score post-sessions for the four components listed in Table 13. Effect size (Cohen's d) for each component was computed to measure how large the difference is.

For the first three items, the effect size was large (Cohen's d > 0.8), while it was moderate for the fourth item, indicating that the difference in scores between pre-sessions and post-sessions is noticeably different from zero, which is an indication that the sessions might have been impactful.

**4.3.2.2 Attainment** The paired-samples t-test was conducted to determine the effect of technology-related professional development sessions on teachers' attainment in classwork, and the results are reported in Table 14.

**4.3.2.3 Assessment and progress** Two aspects of assessment and progress were tested by paired-samples t-test, and the results are reported in Table 15.

**4.3.2.4 Learning skills** As indicated in Table 16, the paired-samples t-test indicated that there were statistically significant differences between the mean score of pre-sessions of the four learning skills and the mean score of post-sessions with large effect size values (Cohen's d > 0.8).

**4.3.2.5 Behavior for learning** As indicated in Table 17, the paired-samples t-test indicated that there were statistically significant differences between the mean score of pre-sessions of the two aspects of behavior of learning and the mean score of post-sessions.

### 4.4 Summary

As indicated in Table 18, effect size (Cohen's d) absolute values ranged between 1.57 and 3.33, which are all large. In teaching, the largest effect was on teachers' ability to "adapting the learning environment to maximize technology use" (d = – 3.33) and "maintaining control during technology transitions with a positive and encouraging attitude" (d = – 3.33). With regard to assessment and progress, the largest effect was on "acting upon students' feedback to foster an environment of continuous improvement through technology" (d = – 2.25). The largest effect on learning skills lies in "offering students opportunities to express ideas in a creative and innovative way by means of technology" (d = – 3.33) and "support students in searching for information by means of technology" (d = – 3.33). With respect to behavior in learning, the largest effect was on "providing guidance on responsible and ethical use of technology" (d = – 3.33).

On the other hand, the analysis of classroom observation tool dataset revealed smaller effect sizes compared to the self-reported survey (Table 19) **Error! Reference source not found.**. For classroom observation, effect size absolute values range from 0.72 to 1.83. The largest effect was on technology integration in lesson planning (d = – 1.83) in teaching competencies. In terms of assessment and progress, the largest effect was on feedback through technology (d = – 0.77).

**Table 13** Paired-samples t test for teaching in observation

| Observation: teaching | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Technology integration in lesson planning | 2.54 | 1.021 | 3.71 | 0.859 | – 8.972 | < 0.001 | – 1.831 |
| Teacher knowledge of technology pedagogy | 2.67 | .565 | 3.33 | 0.868 | – 5.127 | < 0.001 | – 1.047 |
| Teacher knowledge of students and how they learn using technology | 2.00 | .722 | 3.17 | 0.868 | – 7.507 | < 0.001 | – 1.532 |
| Technology and the learning environment | 2.33 | 1.007 | 3.13 | 1.116 | – 3.518 | .002 | – .718 |

**Table 14** Paired-samples t-test for attainment in observation

| Observation: attainment | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Acquiring and applying knowledge, skills, and understanding with the aid of technology | 2.33 | 0.868 | 3.04 | 0.859 | − 7.474 | < 0.001 | − 1.526 |

The effect size is large (Cohen's d > 0.8) indicating that the sessions were very effective

**Table 15** Paired-samples t test for assessment and progress in observation

| Observation: assessment and progress | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Technology-enhanced assessment | 2.54 | 0.509 | 3.17 | 0.702 | – 3.158 | 0.004 | – 0.645 |
| Feedback through technology | 2.33 | 0.702 | 3.00 | 1.063 | – 3.762 | 0.001 | – 0.768 |

The effect size is moderate (0.2 < Cohen's d < 0.8) indicating that the sessions might have been effective

**Table 16** Paired-samples t test for learning skills in observation

| Observation: learning skills | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Technology-enhanced interactions, collaboration, and questioning | 2.79 | 0.415 | 3.33 | 0.816 | – 4.511 | < 0.001 | – 0.921 |
| Technology-facilitated engagement, responsibility, and reflection | 2.08 | 0.408 | 2.75 | 0.737 | – 4.290 | < 0.001 | – 0.876 |
| Technology-facilitated connections | 2.50 | 0.590 | 3.29 | 0.690 | – 4.389 | < 0.001 | – 0.896 |
| Technology-enhanced innovation, enterprise, enquiry, critical thinking | 2.04 | 0.955 | 3.00 | 0.834 | – 4.699 | < 0.001 | – 0.959 |

**Table 17** Paired-samples t-test for behavior for learning in observation

| Observation: behavior for learning | Pre | | Post | | Test | | Effect size |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t | Sig | Cohen's d |
| Digital positive behavior reinforcement | 2.54 | 0.509 | 3.42 | 0.776 | – 4.322 | < 0.001 | – 0.882 |
| Practicing digital citizenship | 2.46 | 0.658 | 3.08 | 0.776 | – 3.715 | 0.001 | – 0.758 |

For learning skills, the largest effect was on technology-Enhanced Innovation, enterprise, enquiry, critical thinking (d = – 0.959). Finally, for behavior for learning, the largest effect was on digital positive behavior reinforcement (d = – 0.88).

While the statistical analysis indicates significant improvements in all dimensions, a comparison of self-reported and observed values reveals some interesting patterns, as shown in Fig. 2. Teachers tended to report higher levels of technology integration in their own teaching practices compared to what was observed in the classroom. This discrepancy could be explained by social desirability bias, where teachers may overstate their use of technology in the survey to present themselves in a favorable light. Furthermore, some teachers might have perceived their use of technology as more comprehensive than what was observable in the classroom.

Further qualitative analysis of the classroom observations revealed that teachers who demonstrated high levels of engagement with technology in the survey were also observed using technology to support differentiated learning strategies and enhance student collaboration. However, in cases where the self-reported ratings were high, yet classroom observations did not align, it appeared that external factors such as technical issues or lack of professional development on specific tools influenced the actual implementation of technology. These factors may have limited teachers' ability to fully integrate technology into their lessons, even though they perceived themselves as effective in doing so. Further investigation into these contextual factors could provide deeper insight into the reasons behind these differences and help design more targeted professional development programs.

## 5 Discussion

The purpose of this study was to design and evaluate the impact of technology-related professional development sessions on teachers self-reported technology competencies and their use of technology inside the classroom. Based on the analysis conducted, it can be concluded that the technology-related professional development program was significantly effective in enhancing teachers self-reported technology competencies and their use of technology inside the classroom. However, as the study involved a small, homogenous sample within a specific context, caution should be exercised in generalizing these findings to a broader population or different educational settings.

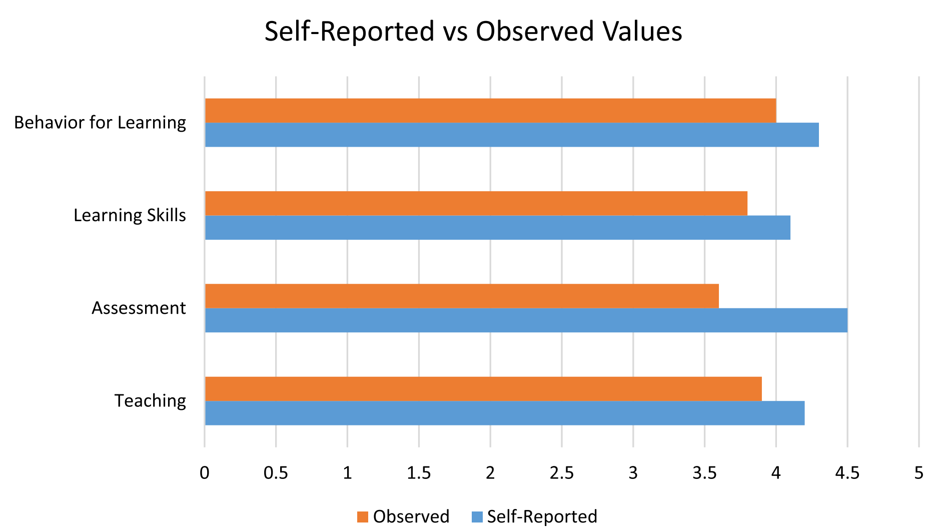
**Table 18** Effect size and mean difference summary for survey items

| Survey | | Cohen's d | Effect size | MDiff |
|---|---|---|---|---|
| Teaching | | | | |
| 1 | Integrate technology into lesson plans and teaching strategies to enhance engagement and promote deep understanding | − 1.571 | Large | − 0.917 |
| 2 | Integrate technology into teaching to enhance understanding of subject concepts | − 2.509 | Large | − 1.125 |
| 3.a | Select appropriate digital applications for a specific learning setting | − 1.820 | Large | − 0.917 |
| 3.b | Use technology to create differentiated tasks based on individual learning styles, needs, and interests (videos, animations, simulations, AR, etc.) | − 2.398 | Large | − 1.000 |
| 3.c | Provide personalized learning paths and adaptive resources to modify the curriculum successfully for diverse groups of students using technology (Exact Path, Achieve 3000, Level Up, 3asafeer, etc.) | − 2.064 | Large | − 0.958 |
| 4.a | Adapt the learning environment to maximize technology use | − 3.330 | Large | − 1.125 |
| 4.b | Integrate technology routines into classroom procedures without compromising instructional time | − 2.243 | Large | − 1.042 |
| 4.c | Maintain control during technology transitions with a positive and encouraging attitude | − 3.330 | Large | − 1.125 |
| 4.d | Promote learners who are risk-takers in both conventional and technological aspects | − 1.742 | Large | − 0.958 |
| Attainment | | | | |
| 1 | Use technology tools to accurately evaluate knowledge, skills, and understanding of individual students | − 2.654 | Large | − 1.083 |
| Assessment and Progress | | | | |
| 1.a | Integrate a variety of technology-based assessment methods that are valid, rigorous, and linked to curriculum standards | − 2.398 | Large | − 1.000 |
| 1.b | Use technology tools that enable real-time progress monitoring for students | − 1.958 | Large | − 1.000 |
| 2.a | Provide ongoing, comprehensive, and constructive feedback through various technology tools | − 2.243 | Large | − 1.042 |
| 2.b | Use digital means where students provide self and peer feedback | − 2.243 | Large | − 1.042 |
| 2.c | Act upon students' feedback to foster an environment of continuous improvement through technology | − 2.245 | Large | − 0.917 |
| Learning skills | | | | |
| 1 | Motivate students to improve their critical thinking, collaboration, creativity, and communication skills through technology | − 1.958 | Large | − 1.000 |
| 2 | Guide students in using technology responsibly to reflect on their learning, evaluate their strengths and weaknesses, and set goals for improvement | − 2.243 | Large | − 1.042 |
| 3 | Use technology tools to facilitate interdisciplinary connections and real-world applications | − 1.958 | Large | − 1.000 |
| 4.a | Offer students opportunities to express ideas in a creative and innovative way by means of technology | − 3.330 | Large | − 1.125 |
| 4.b | Support students in searching for information by means of technology | − 3.330 | Large | − 1.125 |
| 4.c | Support students in analyzing and interpreting data by means of technology | − 2.243 | Large | − 1.042 |
| 4.d | Support students to present information by means of technology | − 2.243 | Large | − 1.042 |
| 4.e | Educate students to use technology in a conscious way (respecting ergonomics, intellectual property, avoiding plagiarism, etc.) | − 1.958 | Large | − 1.000 |
| Behavior for learning | | | | |
| 1 | Develop self-disciplined learners through setting clear expectations and consistent routines while using technology | − 1.742 | Large | − 0.958 |
| 2.a | Reinforce positive behavior through advanced digital platforms | − 2.904 | Large | − 1.042 |
| 2.b | Support students to communicate using technology in a safe, responsible, and effective way | − 2.243 | Large | − 1.042 |
| 2.c | Provide guidance on responsible and ethical use of technology | − 3.330 | Large | − 1.125 |

**Table 19** Effect size and mean difference summary for classroom observation items

| Item | | Cohen's d | Effect size | MDiff |
|---|---|---|---|---|
| Teaching | | | | |
| 1 | Technology integration in lesson planning | – 1.831 | Large | – 1.167 |
| 2 | Teacher knowledge of technology pedagogy | – 1.047 | Large | – 0.667 |
| 3 | Teacher knowledge of students and how they learn using technology | – 1.532 | Large | – 1.167 |
| 4 | Technology and the learning environment | – 0.718 | Moderate | – 0.792 |
| Attainment | | | | |
| 1 | Acquiring and applying knowledge, skills, and understanding with the aid of technology | – 1.526 | Large | – 0.708 |
| Assessment and progress | | | | |
| 1 | Technology-enhanced assessment | – 0.645 | Moderate | – 0.625 |
| 2 | Feedback through technology | – 0.768 | Moderate | – 0.667 |
| Learning skills | | | | |
| 1 | Technology-enhanced interactions, collaboration, and questioning | – 0.921 | Large | – 0.542 |
| 2 | Technology-facilitated engagement, responsibility, and reflection | – 0.876 | Large | – 0.667 |
| 3 | Technology-facilitated connections | – 0.896 | Large | – 0.792 |
| 4 | Technology-enhanced innovation, enterprise, enquiry, critical thinking | – 0.959 | Large | – 0.958 |
| Behavior for learning | | | | |
| 1 | Digital positive behavior reinforcement | – 0.882 | Large | – 0.875 |
| 2 | Practicing digital citizenship | – 0.758 | Moderate | – 0.625 |

**Fig. 2** Comparison of self-reported and observed values for technology integration across four key dimensions




The research addressed four primary questions. In this section, we discuss the findings in regards to these questions and the results of the hypothesis testing.

*How effectively does the developed ICT competencies survey, which is based on the UAE school inspection framework, measure teachers' ICT competencies?*

The developed survey instrument included dimensions extracted from the UAE's schools inspection framework [26], such as teaching, attainment, assessment and progress, learning skills, and behavior for learning.

The high Guttman Split-Half Coefficient (0.779) supports the internal consistency and reliability of the developed self-rating technology skills survey. This finding indicates that the survey items are well-aligned and measure the intended constructs consistently. Internal consistency is crucial for ensuring that the survey reliably assesses teachers' self-reported technology competencies across different dimensions, such as teaching, assessment, and learning skills [53]. The high coefficient value implies that the survey is a robust tool for evaluating teachers' technology skills, which is essential for accurate assessment and subsequent PD planning.

*How effectively does the developed classroom observation tool, which is based on the UAE school inspection framework, assess the utilization and impact of technology in teaching practices?*

As with the survey, the classroom observation tool incorporated criteria dimensions extracted from the UAE's schools inspection framework [26], such as lesson planning, teacher, and learning environments.

The observation tool demonstrated high inter-rater reliability, with an Intraclass Correlation Coefficient (ICC) of 0.93. This result indicates strong agreement among different raters using the tool, confirming its reliability for assessing classroom practices. High inter-rater reliability is critical for ensuring that the observations are consistent and objective, regardless of who conducts them [54]. This consistency enhances the credibility of the findings related to teachers' use of technology in the classroom. The reliability of the observation tool means it can be confidently used to evaluate the impact of PD programs on classroom practices.

*What are the essential elements and strategies that contribute to the effectiveness of technology-related professional development programs for teachers?*

The PD program included essential elements aligning with best practices identified in the literature such as content alignment with teachers' subject areas, active learning through hands-on activities, collaborative learning opportunities, and sustained duration. These strategies contributed to significant improvements in teachers' self-reported competencies and classroom practices, as supported by H3 and H4 (see Table 20).

Active learning and collaboration have been shown to be effective in previous studies, as they engage teachers in meaningful ways and allow them to apply new knowledge directly to their teaching contexts [31, 32]. The sustained duration of the PD sessions ensured that teachers had ample time to absorb and implement new strategies, which likely contributed to the observed improvements.

*What is the overall impact of technology-related professional development on teachers' technology-integrated classroom practices and self-reported ICT competencies?*

The PD sessions resulted in statistically significant improvements in teachers' self-reported ICT competencies and their classroom practices across all measured domains. The mean scores for all aspects of teaching, assessment and progress, learning skills, and behavior for learning significantly increased post-intervention, indicating a positive impact of the PD program on teachers' technology integration in classroom practices.

The results of the paired-samples t-tests demonstrated statistically significant improvements in both observed classroom practices and self-reported ICT competencies. The significant t-values ($p < 0.05$) across all measured domains indicate that the PD program effectively enhanced teachers' abilities to integrate technology into their teaching.

For self-reported competencies (H3), the significant improvements indicate that teachers felt more confident in their technology skills after the PD sessions. This confidence likely translates into more frequent and effective use of technology in the classroom, enhancing the overall learning environment. The results also support the idea that targeted PD can significantly improve teachers' self-efficacy and willingness to integrate technology into their teaching practices [55–57].

For classroom practices (H4), the observed improvements suggest that teachers became more proficient in using technology to support student learning. This includes better lesson planning, more effective use of technology tools, and improved classroom management with technology. These changes align with the Technology Acceptance Model (TAM), which highlights the importance of perceived ease of use and usefulness in technology adoption [23].

The significant improvements observed in this study align with existing literature on the effectiveness of well-designed PD programs. The increase in teachers' competencies in integrating technology into their teaching practices suggests that the PD sessions were successful in enhancing their skills and confidence. These findings are consistent with previous studies that emphasize the importance of active learning, collaborative activities, and sustained duration in PD programs [31, 32].

Moreover, the study's results corroborate the Technology Acceptance Model (TAM), which posits that perceived ease of use and usefulness significantly influence technology adoption [23, 58]. The PD sessions likely enhanced these perceptions among teachers, contributing to the observed improvements. The incorporation of subject-specific examples and practical applications in the PD sessions may have further facilitated this positive outcome. Table 20 summarizes the results of the hypothesis testing.

### 5.1 Implications

This study makes significant theoretical contributions by reinforcing existing models and frameworks in educational technology. The observed improvements in teachers' self-reported competencies and classroom practices support the Technology Acceptance Model (TAM), emphasizing the importance of perceived ease of use and usefulness in the

**Table 20** Summary of hypothesis testing results

| Hypothesis | Value | Result |
|---|---|---|
| H1: The developed survey instrument will demonstrate high internal consistency, indicating reliability | Guttman split-half coefficient = 0.779 | Supported: High internal consistency and reliability demonstrated |
| H2: The developed observation tool will demonstrate high inter-rater reliability, indicating consistency in scoring among observers | Intraclass correlation coefficient (ICC) = 0.91 | Supported: High internal consistency and reliability demonstrated |
| H3: Teachers will report a statistically significant improvement in their self-reported ICT competencies after participating in technology-related professional development | t-values significant at $p < 0.05$ | Supported: Significant improvements in self-reported ICT competencies |
| H4: There will be a statistically significant difference in observed classroom practices before and after technology-related professional development, indicating a positive change | t-values significant at $p < 0.05$ | Supported: Significant improvements in observed classroom practices |

adoption of technology [23]. Additionally, the findings validate the Technological Pedagogical Content Knowledge (TPACK) framework, demonstrating that PD programs that integrate technological, pedagogical, and content knowledge can effectively enhance teachers' skills [18].

Moreover, the practical implications of this study are profound for educational settings. The results emphasize the importance of designing PD programs that incorporate active learning, collaboration, and sustained duration. Schools and educational institutions should align PD programs with teachers' subject areas and provide practical, hands-on experiences that teachers can directly apply in their classrooms [59]. The validated technology skills survey and classroom observation tool developed in this study offer valuable resources for assessing teachers' competencies and classroom practices. These tools can help identify specific areas where teachers need further support and monitor the progress of technology integration over time. Furthermore, providing ongoing support and resources, such as instructional videos, templates, and access to mentors, can help sustain the impact of PD programs. Continuous support ensures that teachers have the necessary guidance to effectively integrate new strategies into their teaching practices. At the policy level, educational policymakers should prioritize the allocation of resources for comprehensive and continuous PD programs, as investment in high-quality PD can lead to significant improvements in teachers' technology integration skills and enhance student learning outcomes [60].

However, the findings should be interpreted within the context of this study's specific sample size and setting. While the results are promising, further research with larger, more diverse samples and in different educational contexts is necessary to determine the broader applicability and effectiveness of these PD programs.

## 6 Limitations and future research directions

Despite the promising results, this study has several limitations that must be acknowledged. The small sample size and the homogeneity of the participant group, limited to teachers from a single private school in the UAE, may restrict the generalizability of the findings. Research indicates that small, homogeneous samples can limit the applicability of study results to broader populations [61]. Furthermore, the reliance on self-reported data introduces the potential for response bias, where participants may unintentionally over- or under-report their use of technology, which could affect the accuracy of the reported improvements [62]. The Hawthorne Effect could also have influenced the results, as teachers might have altered their behavior or teaching practices due to their awareness of being part of the study. This phenomenon, where individuals modify their behavior because they are being observed, is well-documented in educational research [63]. Additionally, factors such as teachers' prior experience with technology, school resources, and institutional support may have played a role in shaping the outcomes.

This study opens several avenues for future research. Longitudinal studies tracking the long-term impact of PD programs on teachers' competencies and classroom practices would provide valuable insights into the sustainability of the improvements observed in this study. Additionally, replicating this study with a larger and more diverse sample, including teachers from different educational settings and regions, would enhance the generalizability of the findings. Understanding how PD programs impact teachers with varying levels of initial technology proficiency and experience is crucial. Further research should explore the specific elements of PD programs that most significantly contribute to improved outcomes. Identifying these elements can help refine and optimize PD initiatives to maximize their effectiveness. Investigating the impact of improved teacher competencies on student outcomes would provide a more comprehensive understanding of the benefits of PD programs. Future studies could examine how changes in teachers' technology integration practices influence student engagement, learning, and achievement. Finally, research should explore PD programs tailored to specific technologies or platforms, examining how these focused interventions impact teachers' skills and classroom practices. Understanding the nuances of different technologies can help develop more targeted and effective PD programs.

## 7 Conclusion

In conclusion, the technology-related professional development sessions implemented in this study resulted in significant improvements in teachers' self-reported technology competencies and their integration of technology in classroom practices. These findings underscore the importance of well-designed PD programs in enhancing teachers' skills and confidence in using technology, ultimately contributing to better educational outcomes. This study provides several important contributions to the field of educational technology and professional development.

First, the study validates the self-rating technology skills survey and classroom observation tool developed for this research. These tools have proven to be reliable measures for assessing teachers' competencies and classroom practices. Their robust design ensures they can be effectively used to evaluate the impact of PD programs, thereby aiding in the continuous improvement of teacher training initiatives.

Second, the study demonstrates the effectiveness of a well-structured PD program in significantly improving teachers' technology integration skills. The PD sessions, which incorporated active learning, collaboration, and sustained support, led to notable enhancements in teachers' abilities to integrate technology into their teaching practices. This improvement not only boosts their confidence but also positively impacts their students' learning experiences.

By addressing both theoretical and practical aspects, this study lays a comprehensive foundation for ongoing efforts to enhance technology integration in teaching and learning. It emphasizes the critical role of continuous, well-designed professional development in preparing educators to navigate and leverage the dynamic landscape of educational technology, thereby fostering an enriched and effective learning environment for students.

**Author contributions** Y.S., N.S. and M.H. designed the study. M.H. recruited participants and administered the surveys. N.S and M.H. participated in the classroom observations. N.S and O.A. analysed the data. Y.S and M.H. wrote the paper with input from all authors.

**Funding** No funding was received for conducting this study.

**Data availability** The dataset generated during the current study, including questionnaire responses, is available from the corresponding author on reasonable request.

## Declarations

**Ethics approval and consent to participate** Ethics approval was obtained from the Research Ethics Committee of the British University in Dubai. All methods were carried out in full compliance with the standards set by the ethics committee, relevant guidelines, and the inspection framework standards.

**Consent for publication** Informed consent was obtained from all individual participants and the participating school included in the study. Data collection was conducted anonymously, ensuring the privacy and confidentiality of all participants.

**Competing interests** The authors declare no competing interests.



## References

1. Raja M, Priya GG. Conceptual origins, technological advancements, and impacts of using virtual reality technology in education. Webology. 2021. https://doi.org/10.14704/WEB/V18I2/WEB18311.
2. Singh MN. Inroad of digital technology in education: age of digital classroom, higher education for the. Future. 2021;8:20–30. https://doi.org/10.1177/2347631120980272.
3. Anwar AS, Mardisentosa B, Williams A. The role of technology in education. IAIC Trans Sustain Digit Innov (ITSDI). 2021. https://doi.org/10.34306/itsdi.v3i1.524.
4. Tsegay SM. ICT for post-2015 education: an analysis of access and inclusion in sub-Saharan Africa. Int J Res Stud Educ Technol. 2016;5:1–14.
5. Mallmann EM, Jacques JS. Dialogical relations between public educational policies and technological-pedagogical fluency in teacher training. Revista De Educ Distancia (RED). 2017. https://doi.org/10.6018/red/54/9.
6. Msafiri MM, Kangwa D, Cai L. A systematic literature review of ICT integration in secondary education: what works, what does not, and what next? Discov Educ. 2023;2:1–17. https://doi.org/10.1007/s44217-023-00070-x.
7. Yadav RP. Teachers' knowledge and practice of using ICT tools in high school science teaching and learning. Educ Q. 2023;4:59–74. https://doi.org/10.3126/jeqtu.v4i1.57246.

8. Nkundabakura P, Nsengimana T, Uwamariya E, Nyirahabimana P, Nkurunziza JB, Mukamwambali C, Dushimimana JC, Batamuliza J, Byukusenge C, Iyamuremye A. Effectiveness of the continuous professional development training on upper primary mathematics and science and elementary technology teachers' Pedagogical Content Knowledge in Rwanda. Discov Educ. 2024;3:1–13. https://doi.org/10.1007/s44217-024-00091-0.
9. Malakul S, Sangkawetai C. Evaluating computer science teaching competence: teachers' self-efficacy and professional development. Discov Educ. 2024;3:1–18. https://doi.org/10.1007/s44217-024-00363-9.
10. Thurm D, Barzel B. Effects of a professional development program for teaching mathematics with technology on teachers' beliefs, self-efficacy and practices. ZDM Mathematics Education. 2020;52:1411–22. https://doi.org/10.1007/s11858-020-01158-6.
11. Alnujaidi S. Adoption of mobile assisted language learning (MALL) in Saudi Arabian EFL classrooms. J Lang Teach Res. 2021. https://doi.org/10.17507/jltr.1202.13.
12. Elatawneh HAA, Sidek S, Mosali NA. Factors affecting academics professional development of higher education institutions. Int J Sustain Constr Engin Technol. 2022;13:350–61.
13. Siyam N, Hussain M. Academic staff's attitudes towards a curriculum mapping tool. Tech Trend. 2021. https://doi.org/10.1007/s11528-021-00650-4.
14. Parker CE, Stylinski CD, Bonney CR, Schillaci R, McAuliffe C. Examining the quality of technology implementation in STEM classrooms: demonstration of an evaluative framework. J Res Technol Educ. 2015;47:105–21. https://doi.org/10.1080/15391523.2015.999640.
15. King SO. Evidence-based course design for active learning: evaluation of a blended learning approach to enable academic faculty development. Int Dialog Educ J. 2015. https://doi.org/10.53308/ide.v2i3.179.
16. McSpadden EL. An educational paradigm in the midst of shifting: students' and professors' attitudes toward classroom technology. J Teach Learn Technol. 2018;7:59–69. https://doi.org/10.14434/jotlt.v7i1.23368.
17. Istenič Starčič A, Lebeničnik M. Investigation of university students' perceptions of their eductors as role models and designers of digitalized curricula. Human Technol. 2020. https://doi.org/10.17011/ht/urn.202002242163.
18. Mishra P, Koehler MJ. Technological pedagogical content knowledge: a framework for teacher knowledge. Teach Coll Rec. 2006;108:1017–54.
19. Setiawan I. Exploring a teacher educator's experiences in modeling TPACK to create English language multimedia in technology courses. Makassar: Universitas Negeri Makassar; 2018.
20. Li Y. Research on TPACK competence of RCI trainers 2019 3rd international conference on education, management science and economics (ICEMSE 2019). Cambridge: Atlantis Press; 2019. p. 526–30.
21. Sanders DA, Mukhari SS. Lecturers' perceptions of the influence of AI on a blended learning approach in a South African higher education institution. Discov Educ. 2024;3:1–18. https://doi.org/10.1007/s44217-024-00235-2.
22. Salleh SM, Musa J, Jaidin JH, Shahrill M. Development of TVET teachers' beliefs about technology enriched instruction through professional development workshops: application of the technology acceptance model, journal of technical. Educ Train. 2021;13:25–33.
23. Siyam N. Factors impacting special education teachers' acceptance and actual use of technology. Educ Inf Technol. 2019;24:2035–57. https://doi.org/10.1007/s10639-018-09859-y.
24. Ertmer PA. Addressing first-and second-order barriers to change: strategies for technology integration. Educ Tech Res Dev. 1999;47:47–61.
25. Kopcha TJ. Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. Comput Educ. 2012;59:1109–21. https://doi.org/10.1016/j.compedu.2012.05.014.
26. Knowledge and Human Development Authority, UAE School Inspection Framework 2015–16, KHDA. 2015. https://www.khda.gov.ae/en/publications/article?id=10204. Accessed 8 Jul 2020.
27. National Agenda. 2021. https://uaecabinet.ae/en/national-agenda. Accessed 24 May 2024.
28. Momdjian L, Manegre M, Gutiérrez-Colón M. Assessing and bridging the digital competence gap: a comparative study of lebanese student teachers and in-service teachers using the DigCompEdu framework. Discov Educ. 2024;3:1–23. https://doi.org/10.1007/s44217-024-00308-2.
29. Osborne JF, Borko H, Fishman E, Gomez Zaccarelli F, Berson E, Busch KC, Reigh E, Tseng A. Impacts of a practice-based professional development program on elementary teachers' facilitation of and student engagement with scientific argumentation. Am Educ Res J. 2019;56:1067–112. https://doi.org/10.3102/0002831218812059.
30. Korsager M, Reitan B, Dahl MG, Skår AR, Frøyland M. The art of designing a professional development programme for teachers. Prof Dev Educ. 2022. https://doi.org/10.1080/19415257.2022.2038234.
31. Darling-Hammond L, Hyler ME, Gardner M. Effective teacher professional development. Washington, D.C: ERIC; 2017.
32. Kennedy MM. How does professional development improve teaching? Rev Educ Res. 2016;86:945–80. https://doi.org/10.3102/0034654315626800.
33. Bhatt SP. Self-directed professional development: EFL teachers' understanding. Int J Lang Literar Stud. 2021;3:196–208.
34. Ohanyelu N C. Evaluation of the effectiveness of teachers professional development (tpd) on reciprocal teaching strategies. Actual problems in the system of education: general secondary education institution—Pre-University Training—Higher Education Institution, (2021). https://jrnl.nau.edu.ua/index.php/APSE/article/view/15816. Accessed 16 May 2024.
35. Martinez F, Taut S, Schaaf K. Classroom observation for evaluating and improving teaching: an international perspective. Stud Educ Eval. 2016;49:15–29. https://doi.org/10.1016/j.stueduc.2016.03.002.
36. Li Y, Dawley L. Technology Integration Panel (TIP): a classroom observation tool to measure the capacity of using technology to support student-centered learning in the K12 classroom. In: Annual meeting of the international society for technology in education: Philadelphia. 2019.
37. Siyam NYM. The impact of using information and communication technology in the attitudes and achievement of grade three students in mathematics and science. Dubai: The British University; 2017.
38. Yang J, Pan H, Zhou W, Huang R. Evaluation of smart classroom from the perspective of infusing technology into pedagogy. Smart Learn Environ. 2018;5:20. https://doi.org/10.1186/s40561-018-0070-1.
39. Tondeur J, Aesaert K, Pynoo B, Van Braak J, Fraeyman N, Erstad O. Developing a validated instrument to measure preservice teachers' ICT competencies: meeting the demands of the 21st century. Br J Edu Technol. 2017;48:462–72.

40. Lubuva EE, Ndibalema P, Mbwambo E. Assessment of tutors' level of ICT competencies in teaching in teacher education in Tanzania. J Learn Dev. 2022;9:436–54. https://doi.org/10.56059/jl4d.v9i3.705.
41. Miller CJ, Smith SN, Pugatch M. Experimental and quasi-experimental designs in implementation research. Psychiatry Res. 2020;283: 112452.
42. Stratton SJ. Quasi-experimental design (pre-test and post-test studies) in prehospital and disaster research. Prehosp Disaster Med. 2019;34:573–4. https://doi.org/10.1017/S1049023X19005053.
43. Sedgwick P. Convenience sampling. BMJ. 2013. https://doi.org/10.1136/bmj.f6304.
44. Callender JC, Osburn HG. ERIC—EJ218762—an empirical comparison of coefficient alpha, guttman's lambda-2, and MSPLIT maximized split-half reliability estimates. New York: JSTOR; 1979.
45. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med. 2016;15:155–63. https://doi.org/10.1016/j.jcm.2016.02.012.
46. Rahardja D. A review of the multiple-sample tests for the continuous-data type. J Mod Appl Stat Method. 2017;16:127–36. https://doi.org/10.22237/jmasm/1493597220.
47. Abu-Bader SH. Advanced and multivariate statistical methods for social science research. Oxford: Oxford University Press; 2010.
48. Hair J. Multivariate data analysis, faculty publications. 2009. https://digitalcommons.kennesaw.edu/facpubs/2925.
49. Kennedy I. Sample size determination in test-retest and Cronbach alpha reliability estimates, British Journal of. Contemp Educ. 2022;2:17–29.
50. Pohpam W. Modern educational measurement; practical guidelines for educational leaders. Los Angeles: Allyn and Bacon; 2000.
51. DeVellis RF, Thorpe CT. Scale development: theory and applications. Los Angeles: SAGE Publications; 2021.
52. Bobbitt Z. The spearman-brown formula: definition & example. Statology. 2021. https://www.statology.org/spearman-brown-formula/. Accessed 11 Jan 2025.
53. Ergül DY, Taşar MF. Development and validation of the teachers' digital competence scale (TDiCoS). JOLTIDA. 2023;8:148–60. https://doi.org/10.53850/joltida.1204358.
54. Svendsen MJ, Hendriksen PF, Schmidt KG, Stochkendahl MJ, Rasmussen CN, Holtermann A. Inter-rater reliability of ergonomic work demands for childcare workers using the observation instrument TRACK. Int J Environ Res Public Health. 2020;17:1607. https://doi.org/10.3390/ijerph17051607.
55. Backfisch I, Lachner A, Hische C, Loose F, Scheiter K. Professional knowledge or motivation? Investigating the role of teachers' expertise on the quality of technology-enhanced lesson plans. Learn Instr. 2020;66: 101300. https://doi.org/10.1016/j.learninstruc.2019.101300.
56. Corry M, Stella J. Teacher self-efficacy in online education: a review of the literature. Res Learn Technol. 2018. https://doi.org/10.25304/rlt.v26.2047.
57. Gomez FC, Trespalacios J, Hsu YC, Yang D. Exploring teachers' technology integration self-efficacy through the 2017 ISTE standards. TechTrend. 2017;66(2022):159–71. https://doi.org/10.1007/s11528-021-00639-z.
58. Siyam N, Hussain M, Alqaryouti O. Factors impacting teachers' acceptance and use of Bring Your Own Device (BYOD) in the classroom. SN Soc Sci. 2022;2:8. https://doi.org/10.1007/s43545-021-00307-2.
59. Zhang W. The role of technology-based education and teacher professional development in English as a foreign language classes. Front Psychol. 2022;13: 910315.
60. Lindfors M, Pettersson F, Olofsson AD. Conditions for professional digital competence: the teacher educators' view. Educ Inq. 2021;12:390–409. https://doi.org/10.1080/20004508.2021.1890936.
61. McConnell MM, Monteiro S, Bryson GL. Sample size calculations for educational interventions: principles and methods. Can J Anesth. 2019;66:864–73.
62. Li J, Copur-Gencturk Y. Perceptions versus performance: assessing teacher learning in asynchronous online professional development. Educ Inf Technol. 2024. https://doi.org/10.1007/s10639-024-13020-3.
63. Amos C. Teaching as inquiry and the Hawthorne effect. Set. 2013. https://doi.org/10.18296/set.0339.


**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.