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Preparing teachers to integrate technology in education according to SQD model: scale development and validation

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Abstract

Technology and pedagogy integration is a skill that teachers must possess in order to successfully implement technology in the classroom. In order to evaluate the technology integration training that instructors received, a scale was created in this study within the parameters of the SQD model. We recruited a total of 492 teachers from elementary, middle, and high schools. The scale developed in this study consists of 5 factors (constructs) and 40 items namely "Reflection (Ref)", "Role Model (Rol)", "Collaboration (Col)", "Instructional Design (ID)", and "Authentic Experiences (AutE)". There is evidence that the constructed scale has explained 72.358 percent of the total variation. The Cronbach's alpha internal consistency reliability rating for the total scale was calculated to be 0.97. As a consequence of the analyses conducted, we found that the scale is a valid and reliable measurement instrument that can be used to assess the technology integration training of teachers. We can note that the scale has the potential to make major contributions to the existing literature.

Keywords Teacher professional development · Pedagogical issues · Teaching/learning strategies · Improving classroom teaching

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1 Introduction

Future educators must be able to integrate technology and pedagogy into learning settings due to the fast evolution of technology. (Ahmed & Opoku, 2022; Cansoy, 2018; Luo et al., 2022; Vlachopoulos & Makri, 2021; Yánez Corrales & Moreano Barragan, 2021). Consequently, teacher training institutes have changed their programs, and academics have established frameworks and models for the effective use of technology in educational settings (Carretero et al., 2017: International Society for Technology in Education [ISTE], 2017; Mishra & Koehler, 2006; Organisation for Economic Co-operation and Development [OECD], 2018; United Nations Educational, Scientific and Cultural Organization [UNESCO] 2018). The TPACK framework established by Mishra and Koehler (2006) is the most extensively utilized of these models. This framework and other frameworks have been studied in a variety of circumstances and with a variety of variables (Benoliel & Berkovich, 2021; Gomez et al., 2022; Graham et al., 2009; Gümüş & Kukul, 2022; Koh et al., 2014; Raman et al., 2019). In their study, Tondeur et al. (2012) conducted a qualitative analysis of research evaluating the integration of technology into the educational setting and modeled the training that pre-service teachers should undergo (Synthesis of Qualitative Evidence Model). Consequently, a model based on models of technology integration has arisen for the technology integration training that future in-service teachers should get. It is required to examine this model in the following stage.

Tondeur et al. (2016) created a measuring instrument based on the SQD model in response to this need. It was the first instrument to evaluate the training preservice teachers got to incorporate technology into learning contexts (Tondeur et al., 2016). However, unlike the concept, the produced measuring instrument comprised of objects gathered under a single dimension. In other words, a measuring instrument that aims to quantify the six fundamental methods in the model with a single construct was established. This condition makes it impossible to analyze which method is used successfully or not in the technology integration training obtained by teachers. From this perspective, it has been concluded that a measuring tool based on the SQD model that can evaluate alternative strategies in the model in multiple dimensions is required. In this sense, the main premise of this present study is to build a measurement instrument that can assess the technology integration training acquired by teachers. In line with this, the purpose of this study is to construct a measurement instrument that can assess the training of teachers in technology integration.

2 Literature Review

2.1 Technology in Education

The fast growth of technology has had an impact on the competencies that people must possess. The talents identified as 21st-century skills are shaped by technology (ISTE, 2016). Individuals must be digitally literate in the twenty-first century, according to Settle and Perkovic (2010), to stay up with the digital world. Not only are students expected to use technology for this, but also to produce utilizing technology (ISTE, 2016). In order to equip individuals with these competencies, the responsibilities of educators have likewise evolved (Tondeur et al., 2016; ISTE, 2016).

As proposed by Prensky (2001), teachers, who are referred to as the teachers of the future, are digital natives. These are persons that utilize technology often and are ahead of the curve in terms of incorporating technology into educational contexts (Kabakçı-Yurdakul, 2018). However, the regular use of technology by these individuals is not sufficient evidence that they utilize technology appropriately and successfully in educational settings. Mishra and Koehler (2006) assert that in order for instructors to incorporate technology into their educational contexts, they must possess both pedagogical and technological competence. Consequently, educational scholars have performed studies assessing the technical, pedagogical, and subject knowledge of teachers and pre-service teachers in various circumstances.

According to Yildiz Durak (2021), the aspect that most influence instructors' confidence in integrating technology is their TPACK level. Further, the teacher effectiveness of instructors with greater TPACK levels, their assessment of technology's usefulness, and therefore, their intention to utilize technology, all rise (Joo et al., 2018). Teachers' high levels of TPACK and successful integration of technology into their lessons have a positive effect on student achievement (Akturk & Ozturk, 2019; Lashari et al., 2022).

2.2 Measuring Technology Integration

Integration of technology is crucial for instructors to use technology properly. Based on the previous research, it can be noted that a hardware infrastructure must be established in order for technology integration to be implemented and for instructors to take use of technological potential (Kafyulilo, 2014). In addition, it is essential to provide in-service training that enables instructors to utilize technology appropriately and efficiently and to assess technology integration abilities in order to maximize the use of technology in education (Elmaadaway & Abouelenein, 2022; Sedoyeka, 2012). In this context, it is evident that many measures have been devised to assess instructors' technological integration (Njiku et al., 2019; Vannatta & Banister, 2009).

An examination of previous research has revealed that the factors linked to instructors' use of technology for technology integration, technological self-efficacy, attitudes towards technology, communication, access, and students' use of technology were explored. For instance, Niederhauser and Perkmen (2008) created an interpersonal technology integration scale and analyzed the cognitive factors that instructors need to possess in order to incorporate technology into education. Consequently, a structure composed of self-efficacy, result expectancies, and interest constructs was uncovered (Niederhauser & Perkmen, 2008). In another research, Vannatta and Banister (2009) examined the characteristics of attitudes and behaviors towards the use of technology in the classroom environment and the usage of technology in a scale designed to quantify teachers' technology integration. Access to technology assistance, communication, and the usage of technology by students are further aspects of the investigation. In a separate research, Browne (2009) created a scale based on national educational technology standards to evaluate teachers' technology integration attitudes and abilities. Çakıroğlu et al. (2015), on the other hand, worked on the fundamental indicators of technology integration by revealing a five-dimensional structure including technology literacy, teaching with technology, Professional development, ethics and policies, organization and method in the scale developed for teachers' technology integration. In addition, Artun and Günüç (2016) demonstrated a two-dimensional structure comprising technology utilization and technology usage aspects in the scale designed to measure the opinions of teachers's about the technology integration abilities of their course instructors. Hsu (2017) created a measure to assess the evolution of teachers' technology integration skills. This scale indicated a six-factor structure including planning, building, communication, teaching, development, and difficulties. In the scale research, it is evident that technology integration scales for instructors have been created. Simultaneously, Ifinedo et al. (2020) did a separate study focusing on the factors influencing teachers' technology integration. Examined in this study's scale were teachers' characteristics, teachers' perceived technological knowledge, teachers' perceived knowledge to integrate technology, information, and communication technologies pedagogical practices, teachers' perceived impact of teaching with technology on students, teachers' content knowledge, and technology integration sub-dimensions (Ifinedo et al., 2020). In this framework, the TPACK framework was utilized to explain how technology may be utilized more effectively and harmoniously for technology integration. Consequently, it may be stated that the issue of technology integration also encompasses the scales produced in TPACK frameworks. As a result, the issue of technology integration includes the scales created in TPACK frameworks.

Examining the various scales produced within the scope of TPACK, for instance, Fidan et al. (2020) investigated teachers' self-assessments of technological competency and technology integration. This study indicated a four-dimensional structure incorporating e-mail, the World Wide Web, integrated apps, and technology-based instruction. Erdoğmuş et al. (2020) created a technological formation scale to assess technological knowledge and technological pedagogical expertise. In this study, the TPACK framework was examined, the significance of technology in teacher education was emphasized, and the elements of content production, interactive object creation, problem-solving, and creativity were explored. In a separate research, Wang (2022) devised a scale to assess instructors' level of technology integration in order to foster 21st-century learning. Within the context of the TPACK model, Castro Sierra and Gutiérrez Santiuste (2021) designed a structure to test the technological expertise of university mathematics professors. Examining the research, it is feasible to conclude that several days of collecting tools addressing identical aims in various dimensions and different frameworks for the integration of technology by instructors have contributed to the literature.

2.3 SQD Model

In terms of teachers' efficient and effective use of technology, the ability of instructors to integrate technology into the educational environment in light of evolving technology plays a crucial role (Brun & Hinostroza, 2014; OECD, 2010; Pappa et al., 2023; Tømte et al., 2015; Trevisan & De Rossi, 2023; Xu & Stefaniak, 2023). Therefore, instructors not only need to understand or utilize technology but also need to know how to mix technology with pedagogical topic knowledge (Koehler & Mishra, 2009). The previous literature has indicated that these procedures are complicated by highlighting the need for various strategic considerations in the technology integration processes of instructors (Mouza et al., 2014; Polly et al., 2010). The SQD model is created as a tool for teachers to integrate technological knowledge into the classroom environment, to disclose the essential knowledge and abilities, and the amount of assistance and training they get for integration (Tondeur et al., 2012). Tondeur et al. (2012) created the SQD model by addressing these strategies and discussing technology integration under 12 topics. In the model, these themes have been mentioned as "Systematic and Systemic Change Efforts" and "Aligning Theory and Practice" at the outermost level, while "Technology Planning and Leadership", "Training Staff", "Access to Resources" and "Cooperation within and beyond Institutions" appear at a lower level. One level below this level, there are six strategies in total: "Role Models", "Reflection", "Instructional Design", "Collaboration", "Authentic Experiences" and "Feedback". Tondeur et al. (2012) intended to prepare instructors for the use of technology within the context of these phases. Figure 1 displays all of the model's themes.

Exemplary teaching approaches and practices are being observed by instructors (Ellis et al., 2020). In the stage of reflection, the advantages and problems that

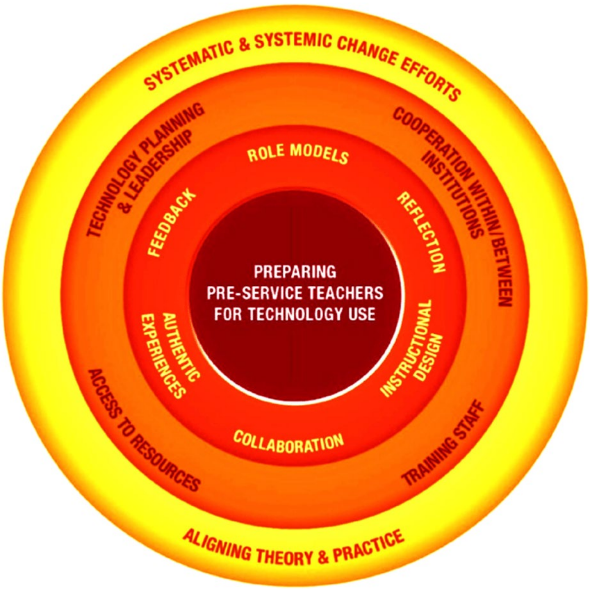

Fig. 1 SQD model to prepare pre-service teachers for technology use (Tondeur et al., 2012)

technology reflects on education (Gudmundsdottir & Hatlevik, 2018). Creating instructional resources and ensuring their incorporation throughout the instructional design phase (Agyei & Voogt, 2016). Boosting instructors' confidence in integration through group work is a construct of the collaboration stage (Koh & Chai, 2016). At the authentic experiences stage, teachers' technological experiences are integrated into the educational environment (Kimmons et al., 2015). In the final phase, feedback, it is determined whether instructors' digital abilities and digital integration skills are sufficient (Tondeur et al., 2012). In addition, Tondeur et al. (2012), who examined 19 qualitative research within the context of this model, constructed a single-factor, 22-item scale using pre-service teachers' gathered data.

3 Method

3.1 Research Model

The descriptive survey approach was used to design this study, which attempts to create the SQD scale. The data-gathering instrument follows the scale development procedures of Devellis (2014). First, the structure to be measured was identified, followed by the creation of an item pool and the determination of the measuring procedure. The item pool was assessed by field experts, and the final item pool was determined based on their comments. Then, the scale items were administered to the teachers and analyzed alongside the acquired data. The scale has been finalized.

3.2 Sampling

In this present study, we recruited a total of 492 teachers working in primary, secondary, and high schools. Further, 20 teacher respondents were included in the test–retest reliability procedure to determine the temporal stability level of the developed scale. Table 1 displays the demographic data on the characteristics of the participants.

When the seniority of the teachers participating in the study is analyzed, it is seen that 97 teachers have a seniority of 25 years or more. All teachers before 25 years are graduates of education faculties or have pedagogical formation certificate from education faculties. Teachers with 25 or more years of seniority can be either faculty graduates or graduates of teacher training institutions that were active in Turkey at that time. No matter what type of school they graduated from, no one can teach who has not received teacher training. In addition, teachers on duty have to attend different in-service courses organized by the Ministry of National Education.

3.3 Procedures

The scale development process began with literature research and the creation of an item pool. The item pool was developed in three phases. In the initial phase, the SQD Model proposed by Tondeur et al. (2012) was investigated in depth. The

Table 1 The demographic profile of respondents

Gender	Teaching Experience	Educational Background		Total
		Undergraduate	Graduate	
Male	0–5 years	15	3	18
	5–10 years	22	7	29
	10–15 years	38	7	45
	15–20 years	21	19	40
	20–25 years	43	21	64
	25 years and above	73	9	82
	Total	212	66	278
Female	0–5 years	31	3	34
	5–10 years	43	5	48
	10–15 years	34	6	40
	15–20 years	22	10	32
	20–25 years	27	6	33
	25 years and above	24	3	27
	Total	181	33	214

definitions of Role models, Reflection, Instructional Design, Collaboration, Authentic Experiments, and Feedback in the literature (Barton & Haydn, 2006; Brush et al., 2003; Jang, 2008; Lunenberg et al., 2007; Tearle & Golder, 2008; Thompson et al., 2003) were examined, and each of the prominent characteristics in these definitions was expressed as a scale item. In addition, the items from the SQD Scale unidimensional validity and reliability research done by Tondeur et al. (2016) were examined and added to the item pool.

In the second stage, the researchers examined the item pool created in the first stage for content validity and added new items by writing new items for the parts deemed necessary based on the definitions in the literature (Agyei & Voogt, 2016; Ellis et al., 2020; Gudmundsdottir & Hatlevik, 2018; Kimmons et al., 2015; Koh & Chai, 2016; Tondeur et al., 2012). Each researcher worked independently to compose draft items, and then they met to review each draft. The items on which an agreement was established were finalized and added to the item pool as a consequence of this evaluation. Thus, a pool of items containing a total of 52 items was obtained, with 7 to 10 items for each construct.

In the last phase, the researchers analyzed each item and drafted a scale from their findings. The SQD scale item pool acquired at the conclusion of the investigations was evaluated by four field experts with a Ph.D. in educational technology and extensive expertise in the field of technology integration in terms of both content validity and the applicability of each question to the relevant factor. In keeping with the ideas submitted, the draft item pool was reexamined by the researchers. Some items were rewritten, some items were somewhat updated, some items were eliminated, and some new ones were introduced. Consequently, the scale trial form was acquired. In the pilot version of the scale, there were 9 items pertaining to Role models, 10 items pertaining to Reflection, 9 items pertaining to Instructional

Design, 9 items pertaining to Collaboration, 8 items pertaining to Authentic Experiences, and 7 items pertaining to Feedback, for a total of 52 items. Afterward, the items were reviewed with the assistance of a Turkish language specialist for ambiguous phrasing and mistakes in expression, and the required arrangements were made.

To determine the degree of instructors stated in the items, five graded choices were provided. These selections were categorized and rated as "(1) never," "(2) seldom," "(3) occasionally," "(4) frequently," and "(5) always." The trial form was reviewed by five teachers, who were questioned about how they saw each item and whether they had problems comprehending it. Items that were not understood or were interpreted differently were re-examined, and the trial form was finalized.

3.4 Data analysis

To test the construct validity of the scale, KMO and Bartlett's analyses were done on the data gathered using the SQD Scale trial form, and it was studied whether factor analysis could be applied to the resulting data set. A sufficient KMO value indicates that the data set is appropriate for factor analysis (Russell, 2002). The data were then subjected to exploratory and confirmatory factor analyses; the factorization of the scale was established using principal construct analysis; and factor loadings were analyzed utilizing the Varimax orthogonal rotation approach. As a result of the Principal Component Analysis, items with factor loadings below 0.40 and items with a difference of at least 0.100 between their loadings on two factors, i.e. items whose loadings are dispersed on both factors, should be removed (Brush et al., 2003). In fact, factor loadings of items on the scale above 0.30 and accounting for at least 40% of the total variance are deemed adequate in terms of behavioral sciences (Büyükoztürk, 2002; Eroğlu, 2008; Kline, 1994; Scherer et al., 1988). However, loadings of 0.50 or more are regarded to be fairly satisfactory (Büyüköztürk, 2002) . The factor loadings are the most important criterion for evaluating the findings of factor analysis (Balcı, 2009; Gorsuch, 1983; Eroğlu, 2008). High factor loadings are viewed as a sign that the variable may be categorized under the factor in question (Büyükoztürk, 2002). Çokluk et al. (2010) indicate that it is vital to determine the common factor variance, which is the variation induced by the factors on each variable as a consequence of factor analysis.

On the data gathered from 492 instructors for exploratory factor analysis, confirmatory factor analysis was conducted. Confirmatory factor analysis is predicated on the testing of hypotheses concerning the links between observable and unobserved variables (items and factors) (Pohlmann, 2004). In other words, confirmatory factor analysis is a structural equation model concerned with the measurement models of the links between latent variables and observable measures. Each factor is described in terms of the association between the observable variables (items) (Raykov & Marcoulides, 2006; Yılmaz & Çelik, 2009) . In confirmatory factor analysis, the maximum likelihood approach was applied. In structural equation modeling, it is often suggested to provide several fit values (Thompson, 2000). In this investigation, therefore, five fit values were provided. In this context, the observed values of the scale model derived from confirmatory factor analysis show an acceptable fit (Kline, 2005).

We validated the scale's validity as a consequence of the factor analysis by examining the item discrimination power of the remaining items in the scale with the independent sample t-test and the item-total correlations using Pearson's r-test. The correlation between the score received from each item and the score gained from the factor to which the item belongs is used as a criterion for determining the degree of each scale item serving the general goal of the factor (Balcı, 2009). Corrected correlations are an additional metric that may be used to assess an item's ability to achieve its intended function. Correlation values greater than 0.20 indicate that an item can significantly fulfill the aim of the connected construct (Tavşancıl, 2010). These coefficients are the validity coefficients of each item and represent the consistency of the scale as a whole; in other words, the extent to which the scale serves its primary goal (Carmines & Zeller, 1982) . It is widely believed that discrimination is one of the most essential factors in assessing the validity of a scale (Büyüköztürk, 2002). Observing the differentiation between the lower 27% and upper 27% groups after the raw scores collected from an item are ordered in decreasing order is another method for testing the discrimination of a scale.

Internal consistency coefficients and stability tests were conducted in order to establish the reliability of the scale. Internal consistency was determined using Cronbach's alpha reliability coefficient, the correlation value between the two halves, the Sperman-Brown method, and the Guttmann split-half reliability formula. A reliability coefficient of 0.70 or above is recognized as a sign of the scale's reliability (Büyüköztürk, 2002; Gorsuch, 1983). The stability level of the scale was determined by calculating the correlation between the results of two five-week-old applications. As is common knowledge, a trustworthy measuring instrument should be able to produce consistent measurements (Balcı, 2009). In addition, the stability, consistency, and sensitivity of the scale are connected to its reliability. These results, which are computed as the stability coefficient, are therefore regarded as evidence of whether or not the scale's reliability is good (Hovardaoğlu, 2000). The reliability coefficient, which quantifies consistency, reaches 1.00 and declines as it approaches 0.00. (Gorsuch, 1983). As is often known, a correlation coefficient with a value between 0.00 and 0.30 is low, 0.30 to 0.70 is medium, and 0.70 to 1.00 is high (Büyüköztürk, 2002).

4 Findings

4.1 Findings on the Scale Construct Validation Process

Within the scope of the SQD Scale's validity, construct validity, item-total correlations, corrected correlations, and item discrimination were analyzed, and the results are presented below.

4.1.1 Construct Validity

Exploratory Factor Analysis (EFA) Results First, the Kaiser-Meyer-Oklin (KMO) and Bartlett tests were used to the data to assess the construct validity of the SQD, with the following results: KMO = 0.974; Bartlett test value χ 2 = 24,887,821; sd = 1326 (p = 0.000). We found that construct analysis could be done on a 52-item scale within the context of these values.

The first stage was doing a principal construct analysis to assess whether the scale has a single structure. The Varimax vertical rotation approach was then used in accordance with the primary constructs. After deleting a total of 12 items with an item load of less than 0.40 and whose load was distributed across multiple factors from the scale, factor analysis was done again with a total of 40 items. As a consequence of these processes, the remaining 40 items on the scale were classified into five categories. With its final state, the scale's KMO value is 0.968 and its Bartlett value is 2. = 19,366,172; sd = 780; p 0.001 was calculated. When the Varimax vertical rotation approach is used, the factor loads of the remaining 40 items on the scale range between 0.514 and 0.819. On the other side, it was discovered that the scale's items and constructs explained 72,358% of the overall variation. In the subsequent stage, the contents of the items comprising the factors were analyzed, and the factors themselves were identified. The resultant constructs mostly correspond with the sub-dimensions chosen when the item pool was created. In this context, 10 items were collected: 8 under the factor "Role Model", 8 under the factor "Collaboration", 9 under the construct "Instructional Design", 5 under the factor "Authentic Experience" and lastly under the element "Reflection". On the other hand, the "Feedback" dimension in the SQD model was not observed in the study. In addition, the items under the "Feedback" dimension were not distributed under other dimensions. This is also evident in the scree plot graph test based on the eigenvalues (Fig. 2).

Figure 2 shows that the first five constructs are declining at a faster rate. The contribution of these five constructs is significant. Other constructs' contributions to variations have become horizontal, that is, they are near to each other (Büyüköztürk, 2002). Table 2 summarizes the findings on the item loadings of the remaining 40 items in the scale according to the factors, as well as the quantities of the factors in explaining the eigenvalue and variance.

As shown in Table 2, the "Reflection" factor of the scale consists of 10 items, with factor loads ranging from 0.74 to 0.80. In the general scale, the eigenvalue of this factor is 8,543. 21.358% of the variation is accounted for by the contribution. Eight constructs comprise the "Role Model" factor. The item factor loads range from 0.58 and 0.80. The factor had an overall eigenvalue of 6,547. The percentage contribution to the overall variation is 16.367%. Eight constructs make up the "Collaboration" factor. Between 0.572 and 0.819, the factor loads of the items fall. Overall, the factor had an eigenvalue of 6,108. The contribution to the overall variance is equal to 15.269%. Nine constructs make up the "Instructional Design" factor. The factor loads of the items range from 0.51 to 0.71. The factor has a total eigenvalue

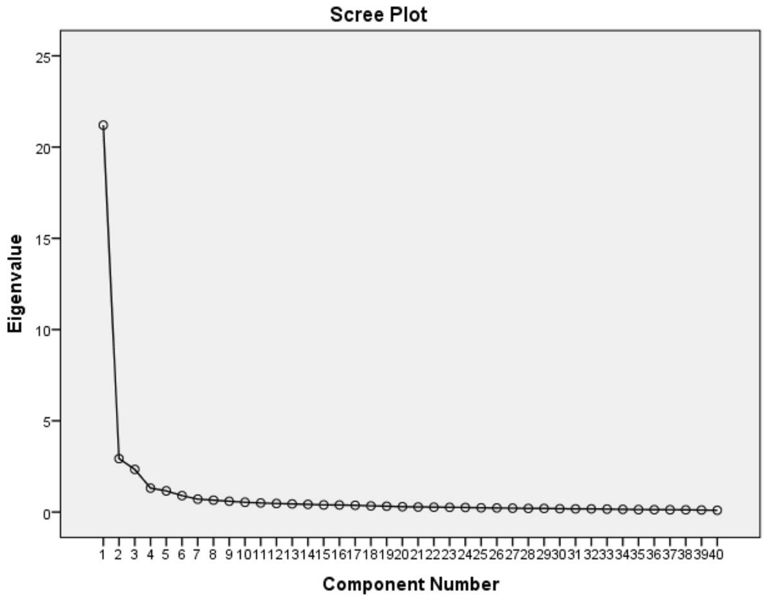

Fig. 2 Eigenvalue Scree-Plot Graph Test

of 4,387. The percentage contribution to the overall variation is 10,968%. There are five constructs comprising the "Authentic Experiences" factor. The factor loads of the goods range from 0.597% to 0.728%. Overall, the factor's eigenvalue is 3,359. 8.396% of the variation is attributable to the contribution.

Confirmatory Factor Analysis (CFA) Results On the data acquired for exploratory factor analysis from 492 instructors, confirmatory factor analysis was conducted. A 5-factor structure is generated as a consequence of exploratory factor analysis. Table 3 displays the estimated values for each item obtained by the confirmatory factor analysis.

According to Table 3, three of the predicted values fall below 0.70. However, these values were considered acceptable. The predictive values of the items were found to range between 0.662% and 0.914% in this context. Table 4 provides a summary of information on confirmatory factor analysis.

On the basis of the scores in Table 4, it can be concluded that the observed compliance values demonstrate an acceptable level of quality (Kline, 2005; Şimşek, 2007). In other words, the developed model indicates that the data support the factors. Figure 3 depicts the factorial model of the scale and the factor-item relationship values.

Figure 3 shows the findings of the confirmatory factor analysis provides standardized correlation values. These values indicate how to fit the items with their respective constructs. Accordingly, the Collaboration (Col) factor is between 0.75 and 0.90, the Reflection (Ref) construct is between 0.82 and 0.91, the Role factor is

Table 2 Exploratory Factor Analysis (EFA) results

Constructs	Indicator	Item Statements	Com. Fac	F1	F2	F3	F4	F5
Reflection	I43	I was asked my thoughts about the application of technology in educational settings were taken into consideration	,721	,753				
	I44	I had the opportunity talk on the advantages and disadvantages of employing technology in educational settings	,722	,740				
	I45	I had the opportunity to voice my complaints and opinions regarding the technologically facilitated presentations	,760	,752				
	I46	I had the opportunity to share my disagreements with my professors and classmates over the usage of technology in education	,778	,755				
	I47	I was asked my thoughts about the online learning settings provided by our school	,764	,768				
	I48	I had the opportunity to reflect on my views about the use of technology in education	,836	,804				
	I49	We spoke about the difficulties of incorporating technology into teaching	,749	,762				
	I50	During the teaching practice, we had the opportunity to discuss our experiences using technology in the classroom	,793	,798				
	I51	We were able to have a productive conversation on how we generally feel about using technology in the classroom	,782	,788				
	I52	I had the opportunity to voice my opinion about classroom technology	,775	,775				

Table 2 (continued)

Constructs	Indicator	Item Statements	Com. Fac	F1	F2	F3	F4	F5
Role Model	I1	In the classes I took, technology was employed well	,736		,754			
	I2	In the classes I took, I've observed the application of instructional technology	,782		,799			
	I3	The instructors of the courses I've completed have served as excellent technological role models for me	,807		,790			
	I4	I observed the employment of many instructional technology in the courses I studied	,818		,806			
	I5	I had instructors who served as examples for my use of technology in the classroom	,733		,730			
	I6	I had an instructor whose use of educational technology I wished to imitate	,764		,757			
	I7	I observed good practices of how technology may be integrated into the teaching practice procedure	,649		,647			
	I8	The usage of technology by my colleagues who gave presentations in the lectures served as a model	,575		,584			

Table 2 (continued)

Constructs	Indicator	Item Statements	Com. Fac	F1	F2	F3	F4	F5
Collaboration	I10	I was able to collaborate with my peers on the use of technology in education	,565			,572		
	I11	Using various technologies made it simpler for me to collaborate with my peers	,735			,722		
	I12	In the context of the use of technology in education, it was really beneficial for me to share my worries and experiences with my peers	,733			,732		
	I13	Group work for the use of technology in education is a simple and enjoyable approach to collect and exchange knowledge and experiences	,645			,751		
	I14	During my studies on the use of technology in education, I benefited much from group work	,772			,819		
	I15	By communicating with my group members, I received valuable expertise in the use of technology in teaching	,796			,807		
	I16	During group work, I realized that in order to assess others in the context of the use of technology in education, I must first analyze myself	,647			,754		
	I18	The fact that I have colleagues in my group that are skilled with technology has been quite beneficial to me	,651			,684		

Table 2 (continued)

Constructs	Indicator	Item Statements	Com. Fac	F1	F2	F3	F4	F5
Instructional Design	I19	In the classes I took, I saw that relevant technology were picked to complement the instructional approaches	,706				,562	
	I20	In the classes I took, I've had the impression that careful planning preceded them	,692				,680	
	I21	I realized that the instructional materials utilized in the courses I completed were created as a construct of the lesson plan	,719				,717	
	I22	In the classes I took, we got the opportunity to create and present our own instructional designs	,665				,633	
	I23	In the classes I took, I was able to observe my peers' instructional designs and instructional materials	,625				,559	
	I24	In the classes I took, I was told at the beginning of the course about the subject that would be delivered and the educational technology that would be used to provide it	,615				,519	
	I25	I have obtained enough training in preparing classes that correctly integrate technology	,681				,526	
	I26	I learned how to integrate technology into classroom instruction	,658				,521	
	I27	I obtained the training necessary to design instructional materials using technology	,648				,514	
Authentic Experiences	I37	In school experience classes, I gained real-world exposure to the use of technology in teaching	,718					,597
	I38	I had the opportunity to teach utilizing technology in a real school setting for a semester in the teaching practice course	,794					,678
	I39	Different courses I've attended, and my school experience courses have provided me with ample expertise instructing utilizing a variety of technology	,823					,728
	I40	I had the opportunity to experience several educational applications of technology	,762					,627
	I41	The teaching experience course enabled me to strengthen the utilization of technology in education	,752					,610
Eigenvalue				8,543	6,547	6,108	4,387	3,359
Explained variance				21,358	16,367	15,269	10,968	8,396

Table 3 Standardized regression weights

Item No		Estimate	Item No		Estimate
i52	←	,846	i12	←	,797
i51	←	,860	i13	←	,761
i50	←	,876	i14	←	,866
i49	←	,858	i15	←	,897
i48	←	,914	i16	←	,749
i47	←	,861	i18	←	,769
i46	←	,862	i27	←	,809
i45	←	,845	i26	←	,810
i44	←	,819	i25	←	,823
i43	←	,823	i24	←	,750
i1	←	,836	i23	←	,675
i2	←	,866	i22	←	,709
i3	←	,891	i21	←	,725
i4	←	,902	i20	←	,733
i5	←	,813	i19	←	,822
i6	←	,827	i37	←	,802
i7	←	,760	i38	←	,870
i8	←	,678	i39	←	,871
i10	←	,662	i40	←	,849

Table 4 Goodness-of-fit indices of Confirmatory Factor Analysis (CFA)

Index of Compliance	Construct Performance of the SQD Model	Acceptable Range	Fit Situations
Normed Chi-Square (CMIN/df)	2,938	CMIN/DF < 3	Acceptable
Root Mean Square Error of Approximation (RMSEA)	0,063	RMSEA < 0.08	Acceptable
Standardized Room Mean Square Residual (SRMR)	0,0517	SRMR < 0.06	Acceptable
Comparative Fit Index (CFI)	0,927	CFI > 0.9	Acceptable
Incremental Fit Index (IFI)	,927	IFI > 0.8	Acceptable
Normed Fit Index (NFI)	0,894	NFI > 0.8	Acceptable

between 0.68 and 0.90, the Authentic Experience (AutE) factor is between 0.80 and 0.87, and the Instructional Design (ID) factor varied from 0.68 to 0.82. Furthermore, covariance plots were constructed between the error terms of the items I5-I6, I20-I21, I22-I23, I26-I27, I10-I11, I11-I12, I45-46, and I51-I52. As a consequence, it was determined that the standardized values of the model's constructs were between 0.59 and 0.81 and that the items adequately represented these constructs.

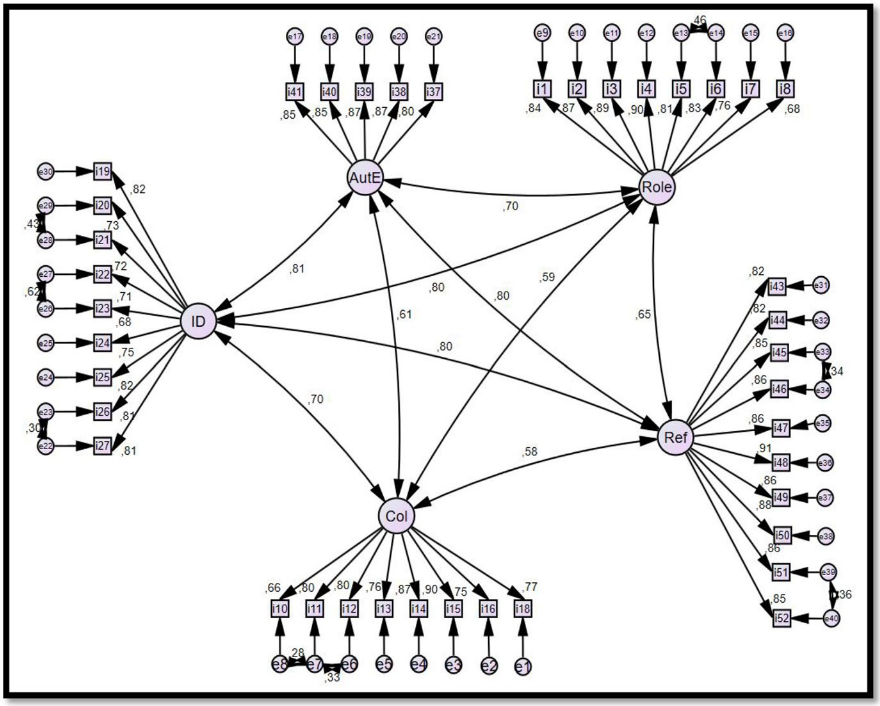

Fig. 3 Confirmatory Factor Analysis (CFA) diagram showing five related constructs

Item-Factor totals and corrected correlations In this part, the item-total correlation and corrected item correlation methods were employed to calculate the correlations between the scores acquired from each item and the scores obtained from the constructs, and the amount of each item's contribution to the overall purpose was assessed.

Table 4 displays the item-factor correlation values computed for each item, whereas Table 5 displays the corrected correlation values.

According to Table 5, item test correlation coefficients varied from 0.848 to 0.912 for the first construct, 0.744 to 0.898 for the second factor, 0.736 to 0.887 for the third factor, 0.758 to 0.828 for the fourth factor, and 0.846 to 0.900 for the final factor. Generally, each item has a substantial and positive correlation with the factor ($p<0.001$). Consequently, each item serves both the construct it is in and the overall purpose of the scale. Table 6 displays the outcomes of the corrected correlation analysis for item-factor scores.

According to Table 6, the corrected item-factor correlation coefficients for each item on the scale were between 0.81 and 0.89 for the first factor, 0.67 and 0.86 for the second factor, and 0.65 and 0.85 for the third construct. The range for the fourth construct is between 0.69 and 0.78, while the range for the final factor is between 0.76 and 0.84. It may be claimed that these results confirm the results presented

Table 5 Item-factor scores correlation analysis

F1 Reflection (Ref)		F2 Role Model (Role)		F3 Collaboration (Col)		F4 Instructional Design (ID)		F5 Authentic Experiences (AutE)	
I	r	I	r	I	r	I	r	I	r
I43	0,849**	I1	0,845**	I10	0,736**	I19	0,828**	I37	0,846**
I44	0,848**	I2	0,872**	I11	0,851**	I20	0,789**	I38	0,898**
I45	0,873**	I3	0,882**	I12	0,851**	I21	0,802**	I39	0,900**
I46	0,885**	I4	0,898**	I13	0,789**	I22	0,792**	I40	0,877**
I47	0,866**	I5	0,862**	I14	0,864**	I23	0,758**	I41	0,876**
I48	0,912**	I6	0,874**	I15	0,887**	I24	0,784**		
I49	0,863**	I7	0,811**	I16	0,783**	I25	0,823**		
I50	0,887**	I8	0,744**	I18	0,795**	I26	0,819**		
I51	0,880**					I27	0,816**		
I52	0,873**								

$N = 492$; ** $= p <, 001$

Table 6 Corrected item-factor scores correlation analysis

F1 Reflection (Ref)		F2 Role Model (Role)		F3 Collaboration (Col)		F4 Instructional Design (ID)		F5 Authentic Experiences (AutE)	
I	r	I	r	I	r	I	r	I	r
I43	0,81	I1	0,80	I10	0,65	I19	0,78	I37	0,76
I44	0,81	I2	0,83	I11	0,80	I20	0,73	I38	0,84
I45	0,84	I3	0,84	I12	0,80	I21	0,74	I39	0,84
I46	0,86	I4	0,86	I13	0,72	I22	0,73	I40	0,80
I47	0,83	I5	0,81	I14	0,82	I23	0,69	I41	0,80
I48	0,89	I6	0,83	I15	0,85	I24	0,72		
I49	0,83	I7	0,75	I16	0,71	I25	0,77		
I50	0,86	I8	0,67	I18	0,73	I26	0,77		
I51	0,85					I27	0,76		
I52	0,84								

$N = 492$s

previously, and hence, each item serves both the factor in which it resides and the overall purpose of the scale.

Item discrimination In this part, we assessed the discriminating power of the scale's items. First, the data acquired from each item were sorted from largest to smallest for this reason. Then, the lower and higher groups of 196 individuals, each comprising

27% of the lower and top groups, were identified. Using the t-test for independent groups, test values were produced based on the total scores for each group. Table 7 displays the t-values and significance levels associated with the item discrimination levels.

In Table 7, the test results of the t-test for 40 items on the scale and the overall score vary between 14,552 and 36,35. The t value for the whole scale was calculated to be 61,064 The level of each observed distinction is statistically significant ($p < 0.001$). Consequently, both the scale as a whole and each item have a high degree of discrimination.

4.1.2 Findings on the Reliability of the Scale

4.1.2.1. Internal Consistency Using Cronbach's Alpha reliability coefficient, two equal halves, and the correlation value between the Sperman-Brown formula and Guttmann's split-half reliability formula, the reliability analysis of the scale according to the factors and as a whole was computed. Table 8 provides a summary of the results of the reliability study for the entire scale and for each construct.

As shown in Table 8, the Spearman-Brown reliability coefficient of the scale, which has 40 items and five constructs, is 0.894; the Guttmann's Split-Half value is 0.893; and the Cronbach's Alpha reliability coefficient is 0.977. Cronbach's Alpha scores vary from 0.927 and 0.966. Accordingly, both individual elements and the scale as a whole are capable of producing consistent measurements.

Table 7 Item discrimination values

F1 Reflection (Ref)		F2 Role Model (Role)		F3 Collaboration (Col)		F4 Instructional Design (ID)		F5 Authentic Experiences (AutE)	
I	t	I	t	I	t	I	t	I	t
I43	26,624	I1	22,738	I10	20,669	I19	36,035	I37	26,323
I44	25,070	I2	22,663	I11	24,403	I20	22,103	I38	30,197
I45	28,663	I3	24,971	I12	23,493	I21	21,691	I39	25,354
I46	31,275	I4	25,957	I13	14,552	I22	23,961	I40	29,317
I47	25,698	I5	26,914	I14	19,408	I23	20,181	I41	30,450
I48	30,169	I6	26,599	I15	23,907	I24	24,665		
I49	24,513	I7	28,103	I16	14,603	I25	29,178		
I50	25,772	I8	19,813	I18	21,193	I26	30,481		
I51	25,823					I27	27,379		
I52	27,869							FT	61,064
F1	34,457	F2	29,025	F3	43,962	F4	38,104	F5	34,926

*df: 264; $p <$, 001

Table 8 Reliability estimates

Constructs	The number of the items	Spearman-Brown reliability coefficient	Guttmann's split-half reliability coefficient	Cronbach's Alpha Reliability Coefficient
Reflection (Ref)	10	0,940	0,940	0,966
Role Model (Rol)	8	0,907	0,907	0,966
Collaboration (Col)	8	0,896	0,895	0,930
Instructional Design (ID)	9	0,890	0,881	0,931
Authentic Experiences (AutE)	5	0,909	0,872	0,927
Total	40	0,894	0,893	0,977

4.1.2.2. Temporal Stability Utilizing the test–retest approach, the stability of the scale was assessed. The final, 40-item version of the measure was administered to 20 instructors who reapplied. The association between the scores attained at the conclusion of both applications was considered in terms of both individual variables and the entire scale. Table 9 summarizes the findings.

According to Table 9, the test–retest approach yields correlation coefficients ranging from 0.579 to 0.774 for each element composing the scale, and each relationship is significant and positive. The overall correlation is 0.605, and each association is regarded as significant and positive. Consequently, it can be stated that the scale is capable of producing consistent measurements.

5 Discussion and Conclusion

This study has sought to develop an instrument to measure the technology integration training of teachers. Following Devellis' scale creation procedures, we constructed a scale within the context of the SQD model to evaluate the technology integration training received by teachers. The developed scale consists of 40 items and

Table 9 Test–retest reliability analysis

F1 Reflection (Ref)	F2 Role Model (Rol)	F3 Collaboration (Col)	F4 Instructional Design (ID)	F5 Authentic Experi-ences (AutE)
r	r	r	r	r
,655	,598**	,588**	,579	,774

N = 20; *p* < , 001. r = ,605

five factors: "Reflection", "Role Model", "Collaboration", "Instructional Design", and "Authentic Experience." Analyses of the scale's validity were conducted using factor analyses and item discrimination tests. Analyzing the factor loadings of each item under the factors, the eigenvalues of the factors, and the overall variance ratios explained by the factors, we have concluded that the scale has construct validity. After exploratory factor analysis indicated a five-factor structure, confirmatory factor analysis was performed to validate the structure, and the model was validated by assessing the reliability of the data based on the results from this study.

Calculations of item-total correlations and corrected correlations were performed to establish the amount to which the items on the scale measured the factor and the characteristics to be measured, and we found that the items served their intended purpose. In contrast, the disparities between the top 27% and lower 27% groups were studied, and it was established that the items had a high level of item discrimination. We determined the internal consistency coefficients of the scale by using Spearman Brown, Guttman split-half, and Cronbach Alpha values. On the basis of these, the scale could make consistent measurements. In addition, the level of temporal stability was assessed using the test–retest technique within the scope of the factors and items in the scale, and we concluded that the scale could provide consistent measurements.

As a consequence of the factor analyses, a six-factor structure was predicted to emerge according to the SQD model (Tondeur et al., 2012), but in this study, a five-factor structure was found except for the feedback construct. When the feedback factor is studied with the other elements, it is possible to state that feedback is a construct of the constructs. Accordingly, it is argued that being a role model also offers feedback since offering feedback needs being a competent role model educator. Consequently, it is reasonable to assert that delivering feedback is one of the most important aspects of being a role model (Ellis & Loughland, 2017; Martínez Agudo, 2016). Alternatively, when the reflection construct is evaluated in conjunction with input on whether the subject-related inferences are true or not (Brandt, 2008; Sabuncuoğlu, 2016). Consequently, we might conclude that reflection involves feedback. When evaluating the collaboration element and the feedback construct, we argued that they are connected and that collaborative work involves feedback (Daniel et al., 2013; Jang et al., 2022). Similarly, it is observed that the feedback element affects the performance of joint work (Asterhan et al., 2014; Guasch et al., 2013; Wigglesworth & Storch, 2012; Zumbach et al., 2006). In contrast, when the Authentic experience construct and the feedback factor is addressed, feedback is essential for meaningful learning, while Authentic experiences are necessary for appropriate feedback (Copland, 2010; Ellis & Loughland, 2017; Lee, 2014; McLachlan & Tippett, 2023). The Authentic experience aspect, therefore, includes the feedback factor. Finally, when instructional design and feedback aspects are evaluated, it can be claimed that every phase of instructional design contains feedback (Çakır & Karataş, 2012; Eren & Ergulec, 2020; Janesarvatan & Van Rosmalen, 2023). In other words, feedback is included in the instructional design element since it is utilized during the instructional design process. In this approach, an SQD model modification can be offered. Figure 4 depicts the suggested modification to the model.

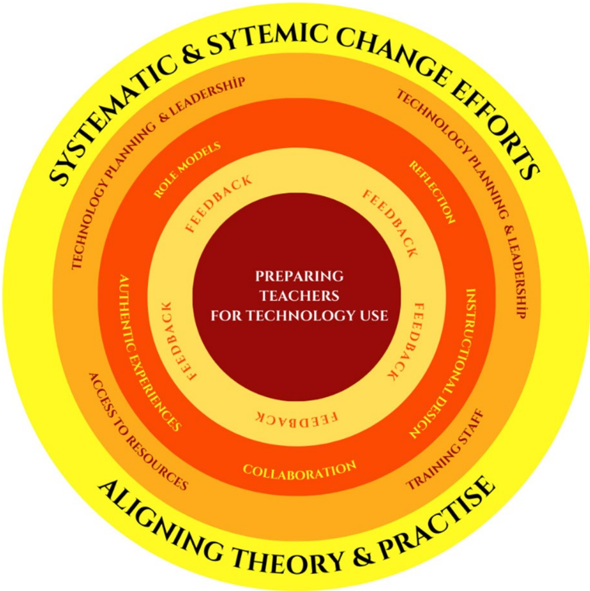

Fig. 4 SQD model to prepare in-service teachers for technology use

Analysis of Fig. 4 reveals that a new ring has been created as a result of the Feedback construct being covered by other factors. In contrast to the SQD paradigm, Feedback is regarded as a new ring within the elements of Role Models, Reflection, Instructional Design, Collaboration, and Authentic Experiences. Consequently, this model can serve as a substitute for the SQD model.

Taking into account the study's variables, the role model factor can be described as the advice of pre-service teachers' mentors about the use of technology and the observation of the use of technology in the educational environment by pre-service teachers (Christensen & Knezek, 2017; Instefjord & Munthe, 2017). Another element, reflection, might be described as students transferring their experiences and opinions toward the importance of technology in education (Kimmons et al., 2015). In contrast, the instructional design aspect implies that teachers use technology to create the process and resources (Howard et al., 2021). The collaboration factor may be stated as the capability of students to use, share, and evaluate technology collectively in technology-based education (Howard et al., 2021). Finally, the Authentic experience construct may be described as the establishment of possibilities for instructors to utilize technology in education and to experience the activities they will perform here (Valtonen et al., 2015). In this framework, it can be said that a valid and reliable scale for evaluating the technology integration training obtained by teachers was constructed using the SQD model's themes.

6 Limitations and Recommendations for Future Research

The developed scale can be used to determine whether teachers can successfully integrate technology into their future classrooms. The use of the scale in different periods during teacher training is important in order to take the necessary precautions for successful technology integration.

The scale can be used in different modeling studies with different variables (Knezek et al., 2023). Thus, the professional development of teacher candidates can be handled from a wider perspective and necessary interventions can be made where necessary.

Despite the difficulties encountered with EFA and CFA, both analyses were performed on the present sample. This is a limitation of the study.

Appendix: SQD scale items

	Constructs and scale items	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
Item	Reflection					
I43	I was asked my thoughts about the application of technology in educational settings were taken into consideration	(1)	(2)	(3)	(4)	(5)
I44	I had the opportunity talk on the advantages and disadvantages of employing technology in educational settings	(1)	(2)	(3)	(4)	(5)
I45	I had the opportunity to voice my complaints and opinions regarding the technologically facilitated presentations	(1)	(2)	(3)	(4)	(5)
I46	I had the opportunity to share my disagreements with my professors and classmates over the usage of technology in education	(1)	(2)	(3)	(4)	(5)
I47	I was asked my thoughts about the online learning settings provided by our school	(1)	(2)	(3)	(4)	(5)
I48	I had the opportunity to reflect on my views about the use of technology in education	(1)	(2)	(3)	(4)	(5)
I49	We spoke about the difficulties of incorporating technology into teaching	(1)	(2)	(3)	(4)	(5)
I50	During the teaching practice, we had the opportunity to discuss our experiences using technology in the classroom	(1)	(2)	(3)	(4)	(5)

	Constructs and scale items	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I51	We were able to have a productive conversation on how we generally feel about using technology in the classroom	(1)	(2)	(3)	(4)	(5)
I52	I had the opportunity to voice my opinion about classroom technology	(1)	(2)	(3)	(4)	(5)
	Role Models					
I1	In the classes I took, technology was employed well	(1)	(2)	(3)	(4)	(5)
I2	In the classes I took, I've observed the application of instructional technology	(1)	(2)	(3)	(4)	(5)
I3	The instructors of the courses I've completed have served as excellent technological role models for me	(1)	(2)	(3)	(4)	(5)
I4	I observed the employment of many instructional technology in the courses I studied	(1)	(2)	(3)	(4)	(5)
I5	I had instructors who served as examples for my use of technology in the classroom	(1)	(2)	(3)	(4)	(5)
I6	I had an instructor whose use of educational technology I wished to imitate	(1)	(2)	(3)	(4)	(5)
I7	I observed good practices of how technology may be integrated into the teaching practice procedure	(1)	(2)	(3)	(4)	(5)
I8	The usage of technology by my colleagues who gave presentations in the lectures served as a model	(1)	(2)	(3)	(4)	(5)
	Collaboration					
I10	I was able to collaborate with my peers on the use of technology in education	(1)	(2)	(3)	(4)	(5)
I11	Using various technologies made it simpler for me to collaborate with my peers	(1)	(2)	(3)	(4)	(5)
I12	In the context of the use of technology in education, it was really beneficial for me to share my worries and experiences with my peers	(1)	(2)	(3)	(4)	(5)

	Constructs and scale items	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I13	Group work for the use of technology in education is a simple and enjoyable approach to collect and exchange knowledge and experiences	(1)	(2)	(3)	(4)	(5)
I14	During my studies on the use of technology in education, I benefited much from group work	(1)	(2)	(3)	(4)	(5)
I15	By communicating with my group members, I received valuable expertise in the use of technology in teaching	(1)	(2)	(3)	(4)	(5)
I16	During group work, I realized that in order to assess others in the context of the use of technology in education, I must first analyze myself	(1)	(2)	(3)	(4)	(5)
I18	The fact that I have colleagues in my group that are skilled with technology has been quite beneficial to me	(1)	(2)	(3)	(4)	(5)
	Instructional Design					
I19	In the classes I took, I saw that relevant technology were picked to complement the instructional approaches	(1)	(2)	(3)	(4)	(5)
I20	In the classes I took, I've had the impression that careful planning preceded them	(1)	(2)	(3)	(4)	(5)
I21	I realized that the instructional materials utilized in the courses I completed were created as a construct of the lesson plan	(1)	(2)	(3)	(4)	(5)
I22	In the classes I took, we got the opportunity to create and present our own instructional designs	(1)	(2)	(3)	(4)	(5)
I23	In the classes I took, I was able to observe my peers' instructional designs and instructional materials	(1)	(2)	(3)	(4)	(5)
I24	In the classes I took, I was told at the beginning of the course about the subject that would be delivered and the educational technology that would be used to provide it	(1)	(2)	(3)	(4)	(5)
I25	I have obtained enough training in preparing classes that correctly integrate technology	(1)	(2)	(3)	(4)	(5)
I26	I learned how to integrate technology into classroom instruction	(1)	(2)	(3)	(4)	(5)

	Constructs and scale items	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I27	I obtained the training necessary to design instructional materials using technology	(1)	(2)	(3)	(4)	(5)
	Authentic Experiences					
I37	In school experience classes, I gained real-world exposure to the use of technology in teaching	(1)	(2)	(3)	(4)	(5)
I38	I had the opportunity to teach utilizing technology in a real school setting for a semester in the teaching practice course	(1)	(2)	(3)	(4)	(5)
I39	Different courses I've attended, and my school experience courses have provided me with ample expertise instructing utilizing a variety of technology	(1)	(2)	(3)	(4)	(5)
I40	I had the opportunity to experience several educational applications of technology	(1)	(2)	(3)	(4)	(5)
I41	The teaching experience course enabled me to strengthen the utilization of technology in education	(1)	(2)	(3)	(4)	(5)

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Data availability The data that support the findings of this study are not openly available due to [reasons of sensitivity e.g., human data] and are available from the corresponding author upon reasonable request.

Declarations

Ethics approval The authors declare that the work is written with due consideration of ethical standards. The study was conducted in accordance with the ethical principles approved by the provincial directorate of national education (21.04.2021–13,686).

Informed Consent All the participants have given their written informed consent.

Consent for Publication All the participants have given their consent for the publication of the research results.

Conflict of interest The authors declare that they have no competing interests.

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