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Research Article

Psychometric properties of information and communication technology competencies scale: Latent profile analysis

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ABSTRACT

Rapid expansion of information and communication technologies (ICT) underscores importance of ICT competency for success in modern society. In education, ICT facilitates knowledge acquisition, innovative teaching methods, and development of digital literacy skills. By measuring ICT competencies, teacher training programs can better equip educators for technology integration, leading to more effective teaching and learning processes. It is crucial for educational policies to emphasize integration of ICT and ensure teachers are prepared to utilize it effectively. The study aims to determine psychometric properties of "information and communication technology competency scale (ICTCS)" for pre-service teachers (PSTs) in the Russian setting and identify distinct proficiency levels among them. This study employed a mixed-methods approach to adapt a scale measuring PSTs' ICT competencies. The research involved two different samples for exploratory factor analysis (EFA) (n=160) and confirmatory factor analysis (CFA) (n=326). To establish language validity, a translation, and cross-cultural adaptation process was followed. Data analysis included EFA, CFA, reliability estimation, and latent profile analysis, with satisfactory results obtained for scale's psychometric properties. The study concludes that ICTCS, with two factors (ICTC-PU and ICTC-ID), is a valid and reliable measure of teachers' attitudes and skills regarding ICT use. Four-class latent profile model reveals distinct competence levels, informing targeted professional development programs. Educational institutions and policymakers should prioritize these programs and use the scale for teacher evaluations. Future research should explore the efficacy of these programs, expand the sample size, incorporate objective measures, and employ longitudinal designs to better understand the impact on student outcomes.

Keywords: adaptation of ICTCS, latent profile analysis, pre-service teachers' ICT competence

INTRODUCTION

Information and communication technologies (ICT) are expanding quickly nowadays and are ingrained in every aspect of our life. Competency in using ICT tools is therefore essential for people and society to succeed and be competitive in the modern world. These abilities include the capacity for knowledge and skill acquisition, assessment, analysis, and successful usage (Zheltukhina et al., 2017). Digital skills and technology literacy are also part of ICT competency. Since having these skills is now unavoidably necessary to assess the opportunities we come across in business, education, and social life, the significance of ICT competence can be demonstrated as the key to both individual and social success (Vasyura et al., 2020).

ICT is a concept that refers to the processes of accessing, processing, storing, and sharing information and communication with digital tools and technologies (Chen et al., 2017; Gulavani & Joshi, 2012). Also, ICT includes technological tools such as computers, software, networks, and the Internet. These tools and technologies are used to meet, accelerate, and optimize the information and communication needs of individuals and institutions (Braslauskienė et al., 2017). These technologies play an important role in every aspect of our lives by providing effective and efficient solutions in various fields from education to health, from business to communication (Chen et al., 2017). The definition of ICT is constantly updated and expanded over time with technological developments and innovations.

The importance of the use of ICT in education is that it facilitates the formation of ICT competencies by providing access to any amount of information at any time (Chen et al., 2017; Peeraer & van Petegem, 2012; Wang et al., 2021). It also allows the use of innovative teaching methods and creating a more interactive and attractive learning environment (Jedrinović et al., 2019; Siddiqui et al., 2021; Stavroulia et al., 2019). The use of ICT in education can help students develop digital literacy skills, and these skills are becoming more and more important in today's society (Chen et al., 2017; Churchill, 2020; Gómez-Trigueros et al., 2019).

There are several advantages to the use of ICT in the educational setting. These advantages include making learning more interesting and interactive for students (Adam & Ray, 2020; Braslauskienė et al., 2017); provide more effective learning opportunities to students with special needs (Istenic Starcic & Bagon, 2014; Mallidis-Malessas et al., 2022); enabling more efficient completion of homework and group work (Agasisti et al., 2020; Melander Bowden & Svahn, 2020); being a versatile tool for teachers with its ability to be used in different courses (Baez Zarabanda, 2019); helping teachers identify and address the specific needs of their students and improve teachers' professional competencies by using various ICT tools in the classroom (Braslauskienė et al., 2017; Ocampo-Botello et al., 2019). Overall, the use of ICT in education can lead to more effective and efficient teaching and learning processes and better prepare students for the digital world they will encounter in their future careers (Braslauskienė et al., 2017).

The use of ICT in education is becoming more and more important and teacher education institutions need to train teacher candidates who have the necessary competencies to integrate technology in teaching and learning processes (Pozas & Letzel, 2021; Tondeur et al., 2016). This means ensuring that teachers have the knowledge, skills, and attitudes necessary to support and develop the use of ICT in education. Developing teachers' ICT competency can make technology integration more effective and harmonious in classroom environments and enrich students' learning experiences (Alkan & Emmioglu Sarikaya, 2018; Tran et al., 2020). It is important for teacher education institutions to equip prospective teachers for technology integration (Chen et al., 2017; Peeraer & van Petegem, 2012; Tondeur et al., 2016). In this way, teachers can make the most of the potential benefits of ICT in education and prepare students for their future careers and lives by equipping them with contemporary skills.

The widespread use and effective application of ICT in education will contribute to the success of future generations in the digital world and will ensure that societies remain competitive in the ever-changing and developing world (Arushanyan et al., 2015; Zhang et al., 2022). Therefore, emphasizing the importance of ICT integration in education policies and providing investment and support in this regard is critical for both individuals and societies to be successful in the digital age. Considering the facts of informatization of society, the need to develop information culture and computer literacy, the future university should focus on the formation of ICT competences of schoolteachers. Appropriate integration of ICT into the education and learning process is important (Chen et al., 2017). The research (Pozas & Letzel, 2021) emphasizes the duty of institutes of teacher education in disseminating information on how to utilize ICT successfully. Teacher preparation programs should support pre-service teachers' (PSTs) ICT skills, beliefs, and self-efficacy. Braslauskienė et al. (2017) suggest that prospective teacher education programs should include training on the use of ICT in teaching to better prepare future teachers for the digital world they will encounter in their careers.

In the context of information society and development of knowledge culture, it is important for future teachers to acquire ICT competencies (Abbasova et al., 2021; Matviyevskaya et al., 2019). Appropriate integration of ICT in the education and learning process can lead to more effective teaching and learning processes. By providing training in the use of ICT by teacher trainee programs, it is important to better prepare teachers to succeed in the digital world (Vilppola et al., 2022).

Measuring ICT competencies for teacher candidates helps them to integrate technology effectively and efficiently in their education processes (Pozas & Letzel, 2021; Tran et al., 2020). Measuring ICT competencies allows to evaluate PSTs' knowledge, skills, and attitudes about technology use, and thus helps to identify and improve the deficiencies of education programs in this area (Huda et al., 2018).

In the literature, there are some scales (Aesaert et al., 2014; Alkan & Emmioglu Sarikaya, 2018; Uzun, 2019) can be used to measure PSTs' ICT proficiency. The importance of measuring PSTs' ICT competencies helps them to develop their knowledge and skills related to technology use and to successfully integrate technology in their education processes. The scales available in the literature can be used for this purpose and contribute to the development of teacher education programs. Accurate measurement of PSTs' ICT competencies enables them to provide more effective teaching to their students in the digital age.

In this context, the aim of the study is to determine the psychometric properties of "information and communication technology competency scale (ICTCS)" to measure the ICT competencies of PSTs in the Russian setting. In addition, this study aims to reveal hidden profiles that may differ according to the proficiency levels of PSTs.

METHODOLOGY

In the present research, which is focused on the adaptation of a scale, a mixed-methods research approach was employed to provide a comprehensive understanding of the findings. This approach integrated both qualitative and quantitative methods in examining the validity and reliability of the scale. Specifically, the language validity process of the scale was addressed through qualitative methods, ensuring a rigorous examination of the linguistic and cultural appropriateness. On the other hand, the psychometric properties of the scale, including its reliability and construct validity, were assessed using quantitative methods, providing statistically robust measurements to confirm the scale's effectiveness in the intended context.

Sample

It was studied with two different samples. The first sample is the group in which EFA analyses were made and consists of 160 participants. Of the participants, 94 were female and 66 were male. The age range is 17-34, with a mean (M) age of 19.8 and a standard deviation (SD) of 2.08. The second group is the group in which CFA analyses were performed. There are 326 people in total, 183 of whom are women and 143 are men. The age range of the participants was 17-34, with a mean of 19.8 and an SD of 1.84.

Scale

"ICTCS of PSTs" was employed in the study. It was first created by Tondeur et al. (2017). The study made use of the revised version of Alkan and Emmioglu Sarikaya (2018). The "ICT competencies to support pupils for ICT use" and "ICT competencies for instructional design" scales each include two components. It was discovered that the scale has strong psychometric characteristics. ICT capabilities for instructional design and ICT competencies to help students in using ICT were found to have respective Cronbach's alpha (α) values of .91 and .82. **Figure 1** shows the scree plot for ICTCS.

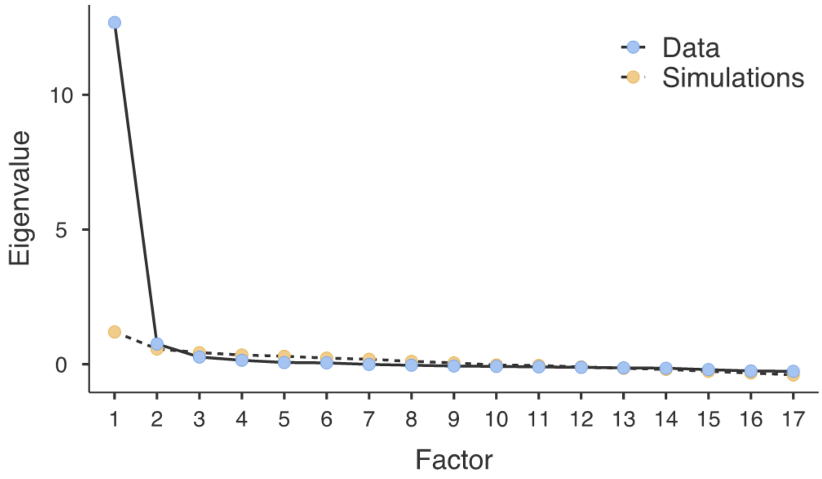

Figure 1. Scree plot for ICTCS (Source: Authors)

Process

To establish language validity, this study adhered to the guidelines proposed by Beaton et al. (2000) and Wild et al. (2005) for the translation and cross-cultural adaptation of measurement instruments. The process commenced with a team of linguists (group A) proficient in both English and Russian, who translated the scale from English to Russian. Upon comparing their individual translations, a consensus was reached on the most accurate rendition. Subsequently, a separate group of linguists (group B) conducted a back-translation, converting the Russian version back to English. This allowed for a comparison of the original and back-translated versions to ensure equivalence in meaning and intent. Following this, a panel of experts (group C), each holding a PhD. in ICT and pedagogy, scrutinized the translated scale, assessing the accuracy of the expressions and technical terms employed. As a penultimate step, the translated scale was pilot tested on a sample of 15 individuals, who were not part of the main study but possessed similar characteristics to the target population. This process served to gauge the clarity and comprehensibility of the items. Once the required revisions were taken care of, the scale underwent its final evaluation, clearing the path for its use in the main study. The scale was finalized and uploaded to the Google questionnaire and applied to the students of the pedagogy faculty.

Data Analyses

Data analysis for this study was conducted in four distinct phases, in alignment with the research objectives: exploratory factor analysis (EFA), confirmatory factor analysis (CFA), reliability estimation, and latent profile analysis. In the first phase, EFA was performed to explore the underlying factor structure of the scale. Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were utilized to evaluate the appropriateness of the sample for factor analysis (Williams et al., 2010). The parallel analysis method, corroborated by a scree plot, was employed to ascertain the optimal number of factors. A minimum factor loading criterion of .50 was established. Due to the interrelated nature of the factor structures, the principal axis factoring extraction method and Promax rotation technique were implemented (Yong & Pearce, 2013). Following the EFA, CFA was conducted to validate the factor structure identified in the previous phase (Brown, 2015; Harrington, 2009; Kline, 2016). CFA results demonstrated that the fit indices for the scale's factor structure were within acceptable levels. Evaluations based on factor loadings, factor covariances, and model fit indices provided invaluable insights into the scale's structural properties. Model indices included comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). Acceptable values were defined as above .90 for CFI and TLI, and below 0.08 for RMSEA and SRMR (Hu & Bentler, 1999; Kline, 2016). In the third phase, the reliability of the scales was assessed by calculating Cronbach's α and McDonald's omega (ω) coefficients. Subsequently, latent profile analysis (Bauer, 2022) was executed based on the factor structures derived from the CFA, with the aim of identifying distinct profiles within the participant group. Jamovi software was employed for all statistical analyses throughout the study.

Table 1. EFA factor loading for ICTCS

Items	1	2	Uniqueness
SS loadings	7.41	6.18	
Percentage of variance	43.6	36.4	
Cumulative percentage	43.6	79.9	
6	.986		.111
7	.934		.108
9	.919		.156
8	.909		.110
5	.882		.117
4	.759		.136
10	.667		.207
1	.625		.229
3	.601		.225
16		.987	.135
14		.967	.163
15		.805	.239
13		.804	.335
19		.682	.212
17		.677	.240
2		.598	.351
18		.564	.335

FINDINGS

Exploratory Factor Analysis

First, a model was created without any rotation. Bartlett's test of sphericity and KMO sample adequacy measure were used to evaluate the suitability of the first model (EFA-initial). According to the results of Bartlett's test of sphericity, χ^2 (Chi-square) value is 4,294 and the degrees of freedom (df) are 171. The p-value of this test is <.001, indicating that the data are suitable for factor analysis. In addition, KMO sample adequacy measure results also indicate that there is sufficient sample size for analysis. The overall KMO value is 0.955, indicating an excellent sample adequacy level. Two factors were calculated according to the results of the parallel analysis, but since all the items were collected in one factor, it was decided to rotate.

Since the items are related to each other, the second model was created by applying the Promax rotation process. Bartlett's test of sphericity and KMO sample adequacy measure were used to evaluate the suitability of the second model (EFA-final). According to the results of Bartlett's test of sphericity, χ^2 value is 3,841 and df is 136. The p-value of this test is <.001, indicating that the data are suitable for factor analysis.

In addition, KMO sample adequacy measure results also indicate that there is sufficient sample size for analysis. The overall KMO value is 0.951, indicating an excellent sample adequacy level. Items 11 and 12 with factor loadings below .50 were omitted. KMO values on a per-item basis also support the relevance of the analysis; all values are above .90 and are suitable for factor analysis. These results show that the second model (EFA-final) is suitable for factor analysis.

Table 1 shows the relationship of the items to the two factors. When we examine **Table 1**, we can interpret the relationship of the items with each factor as follows:

The first factor contains most of the items and generally high factor loadings are observed with 1, 3, 4, 5, 6, 7, 8, 9, and 10. This factor indicates that these items have a common background and perhaps relate to a topic or component. Most factor loadings are 0.6 and above, indicating that these items are strongly related to this factor. This factor was named "competencies to support pupils for ICT use (ICTC-PU)" in the original scale.

The second factor has high factor loadings with 2, 13, 14, 15, 16, 17, 18, and 19 items. This factor indicates that these items also have a common background and perhaps relate to another topic or component. Most of the factor loadings are .50 and above, indicating that these items are strongly related to this factor. This factor was named "competencies for instructional design (ICTC-ID)" in the original scale.

Table 2. Model fit indices for ICTCS

Fit indices	Criteria	First model	Second model
χ^2/df	<5	923/118=7.82	295/104=2.83
CFI	>90	.8910	.9740
TLI	>.90	.8740	.9660
SRMR	<.08	.0378	.0249
RMSEA	<.08	.1450	.0751

Table 3. CFA estimate & Z-values for ICTCS

Factor	Indicator	Estimate	SE	Z-value	p-value
ICTC-PU	1	.867	.0468	18.5	<.001
	3	.869	.0474	18.3	<.001
	4	.875	.0470	18.6	<.001
	5	.935	.0454	20.6	<.001
	6	.951	.0429	22.2	<.001
	7	.968	.0423	22.9	<.001
	8	.960	.0434	22.1	<.001
	9	.946	.0417	22.7	<.001
	10	.831	.0448	18.5	<.001
ICTC-ID	2	.849	.0481	17.6	<.001
	13	.876	.0508	17.3	<.001
	14	.881	.0476	18.5	<.001
	15	.845	.0465	18.2	<.001
	16	.881	.0464	19.0	<.001
	17	.901	.0431	20.9	<.001
	18	.910	.0479	19.0	<.001
	19	.959	.0446	21.5	<.001

The factor loadings in the second model (EFA-final) reveals two different groups of items associated with two different factors. Each factor indicates that the items have a common structure and represent a particular subject or component. These factors can be considered to represent two main components or dimensions of the area being measured.

In the second model, two factors explain 79.90% of the total variance. While factor 1 represents 43.60% of the total variance, factor 2 contributes 36.40%. This shows that both factors together have a significant impact on teachers' attitudes and skills regarding the use of ICT. The model reveals two factors that encompass teachers' ability to provide guidance and support to students on ICT and their ability to integrate and guide ICT in teaching processes. These two factors provide valuable information that can help teachers understand key aspects of their use of ICT and how they are successful at it.

Confirmatory Factor Analysis

According to **Table 2**, the fit indices of the last model are better than the first model. Notably, RMSEA value decreased from .145 to .0751 and CFI and TLI values increased from .891 and .874 to .974 and .966, respectively. SRMR value decreased from and .378 to .0249, indicating a good fit of the model. This comparison shows that the final model better explains teachers' attitudes and skills regarding the use of ICT and more accurately represents the relationships in this area.

According to **Table 3**, two factors and their associated indicators are examined. Estimates, standard errors, Z values and p values are given for each indicator of factor 1 and factor 2. Estimates of the indicators in factor 1 range from .831 to .968, with p-values <.001 for all indicators. Estimates of the indicators in factor 2 range from .845 to .959 and again all indicators have p-values <.001. It can be said that the relationship between factors and indicators is strong and significant, since the predictive values, standard errors, and Z-values of the indicators are high in both factors. This indicates that it is appropriate to use these factors and indicators in the analysis.

Reliability Analyses

Cronbach's α and McDonald's ω reliability coefficients for the two factors and the overall scale were examined.

Table 4. Cronbach's α & McDonald's ω coefficients for ICTCS

Factors	Cronbach's α	McDonald's ω
Factor 1	.979	.973
Factor 2	.957	.957
Overall scale	.980	.978

Table 5. Model & class comparation based on indices

Model	Class	LogLik	AIC	AWE	BIC	CAIC	CLC	KIC	SABIC	ICL	Entropy
1	1	-874	1,756	1,804	1,771	1,775	1,750	1,763	1,758	-1,771	1.000
1	2	-749	1,512	1,599	1,539	1,546	1,500	1,522	1,517	-1,568	.852
1	3	-670	1,360	1,484	1,398	1,408	1,342	1,373	1,366	-1,434	.897
1	4	-595	1,215	1,377	1,264	1,277	1,191	1,231	1,223	-1,290	.938
1	5	-579	1,190	1,389	1,250	1,266	1,160	1,209	1,200	-1,281	.938
3	1	-644	1,298	1,359	1,317	1,322	1,290	1,306	1,301	-1,317	1.000
3	2	-637	1,290	1,388	1,320	1,328	1,276	1,301	1,295	-1,323	.984
3	3	-618	1,258	1,395	1,300	1,311	1,238	1,272	1,265	-1,379	.815
3	4	-601	1,231	1,405	1,284	1,298	1,205	1,248	1,239	-1,321	.912
3	5	-601	1,237	1,449	1,301	1,318	1,204	1,257	1,247	-1,405	.841

According to **Table 4**, Cronbach's α value for factor 1 is .979 and McDonald's ω value is .973. Cronbach's α value for factor 2 is .957 and the McDonald's ω value is .957. Cronbach's α value for the overall scale is .980 and McDonald's ω value is .978. Generally, Cronbach's α and McDonald's ω values above .70 are considered reliable. As a result, both Cronbach's α and McDonald's ω values for factor 1, factor 2 and the overall scale are high, indicating that these factors and the overall scale are reliable and valid in terms of internal consistency.

Latent Profile Analysis

Based on the latent profile analysis comparison model data provided, it is essential to select the model and class that yield the best-fit indices and the most meaningful interpretation (**Table 5**).

In determining the optimal model and class, one should consider various information criteria such as AIC, AWE, BIC, CAIC, CLC, KIC, SABIC, and ICL, as well as entropy values. Lower values for information criteria (AIC, AWE, BIC, CAIC, CLC, KIC, SABIC, and ICL) indicate a better model fit, while higher entropy values (closer to 1) suggest better classification accuracy and less uncertainty in-class assignment. Upon examining the provided data, model 1 with four classes seems to be the most appropriate choice. This decision is based on several factors:

1. The AIC, BIC, and SABIC values are lower for model 1 with four classes compared to other models and class numbers.
2. The entropy value for model 1 with four classes is relatively high (0.938), indicating good classification accuracy.
3. An increase in the number of classes (e.g., moving from four to five classes) in model 1 does not lead to a substantial improvement in the model fit indices. The decrease in AIC, BIC, and SABIC values is minimal, and the entropy value remains the same.

Considering these factors, model 1 with four classes would be the most suitable choice for this dataset, as it provides the best balance between model fit, classification accuracy, and model parsimony.

The descriptive statistics (**Table 6**) provided are related to the four profiles obtained from the latent profile analysis. These profiles represent different levels of ICTC-PU and ICTC-ID scores and are interpreted based on the mean, SD, skewness, and kurtosis for the two variables across the four profiles. Profile 1 (n=34, 10.43%) is characterized by the lowest ICTC-PU and ICTC-ID scores, with slightly left-skewed and somewhat platykurtic distributions for ICTC-PU, and mild left-skewed and near-normal distributions for ICTC-ID. This profile is named "low competency". Profile 2 (n=157, 48.16%) displays moderate ICTC-PU and ICTC-ID scores. The ICTC-PU variable exhibits a near-normal distribution, while ICTC-ID variable has a slightly left-skewed and leptokurtic distribution. The second profile is named "moderate competence". Profile 3 (n=81, 24.85%) is marked by high ICTC-PU and ICTC-ID scores. ICTC-PU distribution is right-skewed and highly leptokurtic, whereas ICTC-ID distribution is somewhat left-skewed and highly leptokurtic.

Table 6. Descriptive statistics based on profile

Factor	Profile	n	Mean	SD	Skewness	SE	Kurtosis	SE
ICTC-PU	1	34	1.77	0.487	-0.7152	0.403	-1.1356	0.788
	2	157	3.04	0.283	0.0382	0.194	1.813	0.385
	3	81	3.97	0.236	1.1894	0.267	4.7719	0.529
	4	54	4.9	0.196	-1.6736	0.325	1.3359	0.639
ICTC-ID	1	34	1.93	0.55	-0.4537	0.403	0.053	0.788
	2	157	2.93	0.333	-0.8498	0.194	1.9028	0.385
	3	81	3.74	0.448	-1.3807	0.267	4.121	0.529
	4	54	4.82	0.294	-1.6145	0.325	1.6467	0.639

Note. SE: Standard error

The third profile is named “high competence.” Profile 4 (n=54, 16.56%) features the highest ICTC-PU and ICTC-ID scores, with substantially left-skewed and leptokurtic distributions for both variables. The third profile is named “very high competence.” The percentages indicate that almost half of the participants (48.16%) belong to profile 2, which is characterized by moderate ICTC-PU and ICTC-ID scores. Profile 1, with the lowest ICTC-PU and ICTC-ID scores, represents 10.43% of the sample, while profile 3 and profile 4 account for 24.85% and 16.56% of the participants, respectively. The four profiles represent a range of ICTC-PU and ICTC-ID scores, from the lowest in profile 1 to the highest in profile 4. The distribution shapes vary across profiles, with some being near-normal, and others displaying varying degrees of skewness and kurtosis.

DISCUSSION

The aim of this study is to validate an ICTCS for PSTs, which effectively measures their attitudes and skills regarding the use of ICT in educational settings. Furthermore, the study seeks to identify distinct profiles of PSTs with varying levels of ICT competence to facilitate targeted interventions and professional development programs. The results of the exploratory and CFA demonstrate the suitability of ICTCS in assessing teachers’ attitudes and skills regarding ICT usage. In EFA, the steps outlined by Thompson (2004) and Williams et al. (2010) were followed. For the evaluation of CFA, preferred model indices in the literature were employed. These indices encompassed CFI, TLI, RMSEA, and SRMR. Acceptable values were defined as above 0.9 for CFI and TLI, and below 0.08 for RMSEA and SRMR (Hu & Bentler, 1999; Jackson et al., 2009; Kline, 2016).

Two factors emerged from the analysis, with the first factor covering items related to competencies in supporting pupils’ ICT use (ICTC-PU) and the second factor comprising items associated with competencies for instructional design (ICTC-ID). These two factors jointly account for 79.90% of the total variance, emphasizing their substantial influence on teachers’ ICT-related attitudes and skills. This two-factor structure is consistent with the original scale (Alkan & Emmioglu Sarikaya, 2018) utilized. Cronbach’s α and McDonald’s ω values above 0.7 are generally considered reliable (Aliaga-Tovar et al., 2018; Hair et al., 2010; Schumacker & Lomax, 2004). Consequently, high Cronbach’s α and McDonald’s ω values for factor 1, factor 2, and overall scale indicate the reliability and validity of these factors and the overall scale in terms of internal consistency.

The latent profile analysis (Bauer, 2022; Thurm, 2018) indicates that a four-class model best fits the dataset, striking an optimal balance between model fit, classification accuracy, and model parsimony. In the chosen four-class model, the descriptive statistics disclose distinct profiles of teachers with varying ICT competence levels in both ICTC-PU and ICTC-ID dimensions. This classification facilitates a deeper understanding and differentiation of teachers’ ICT-related attitudes and skills, ultimately enabling targeted interventions and professional development programs to address specific needs and areas for enhancement. Nearly half of the group is at the moderate level. Pedagogical knowledge, ICT-related courses in PST education, and perceived ICT competence significantly predicted the integration of ICT into teaching practice (Aslan & Zhu, 2017). Some studies report that pre-service ICT and usage of digital tools competency level is satisfactory (García-Martín & García-Sánchez, 2017; Huda et al., 2018; McGarr & McDonagh, 2021; Tondeur et al., 2018) and medium-low level (Guillén-Gámez et al., 2019; Gunduz, 2020). Universities take measures to increase PSTs’ competence in integrating ICT into their teaching practices by eliminating external barriers to ICT, decreasing differences between universities in ICT competence, planning ICT-related courses according to the curricula of different subject teaching programs, emphasizing practice to gain ICT skills, and placing greater emphasis on ICT issues in pedagogical courses (Aslan & Zhu, 2017).

In conclusion, ICTCS, consisting of two factors (ICTC-PU and ICTC-ID), offers a valid and reliable measure of teachers' attitudes and skills regarding ICT usage. The four-class latent profile model provides valuable insights into the diverse levels of ICT competence among teachers, which can be utilized to inform tailored support and development initiatives aimed at augmenting the integration of ICT in teaching and learning processes.

CONCLUSIONS

In summary, the findings of EFA and CFA indicate that ICTCS is suitable for measuring teachers' attitudes and skills regarding the use of ICT. The results reveal two factors, with the first factor encompassing items related to competencies to support pupils for ICT use (ICTC-PU) and the second factor consisting of items related to competencies for instructional design (ICTC-ID). Together, these two factors explain 79.90% of the total variance, highlighting their significant impact on teachers' ICT-related attitudes and skills. The reliability analyses further support the validity and reliability of the scale. Both factors and the overall scale exhibit high Cronbach's α and McDonald's ω values, demonstrating strong internal consistency. The latent profile analysis suggests that a four-class model is the most suitable for this dataset, providing the best balance between model fit, classification accuracy, and model parsimony. In the selected four-class model, the descriptive statistics reveal distinct profiles of teachers with varying levels of ICT competence in both ICTC-PU and ICTC-ID dimensions. This classification allows for a better understanding and differentiation of teachers' ICT-related attitudes and skills, ultimately enabling targeted interventions and professional development programs to address specific needs and areas for improvement.

In conclusion, ICTCS, comprising two factors (ICTC-PU and ICTC-ID), provides a valid and reliable measure of teachers' attitudes and skills concerning ICT use. The four-class latent profile model offers valuable insights into the different levels of ICT competence among teachers, which can be used to inform tailored support and development initiatives aimed at enhancing the integration of ICT in teaching and learning processes.

Based on the findings, it is suggested that educational institutions and policymakers prioritize the development of professional development programs that address the specific requirements and enhancement areas identified in the ICT competence profiles of teachers. This would facilitate a more efficient incorporation of ICT into the teaching and learning processes. ICTCS devised in this study is a reliable and valid instrument for evaluating the ICT-related attitudes and abilities of teachers. Educational administrators and policymakers should consider incorporating this scale into routine teacher evaluations to track progress and identify areas requiring improvement. Future research should investigate the efficacy of targeted professional development programs in enhancing instructors' ICT competencies and their impact on the learning outcomes of students. This would provide valuable insight into the most effective strategies for integrating ICT into education. The findings of the study are founded on a specific sample of instructors, which may limit their generalizability. Future research should strive to replicate the study with a larger and more diverse sample of instructors from diverse educational contexts and geographic regions in order to further validate and expand the applicability of ICTCS. Self-reported measures of teachers' ICT-related attitudes and abilities may be susceptible to social desirability bias. Future research should consider incorporating objective measures of ICT proficiency, such as performance-based assessments, to provide a more thorough comprehension of teachers' ICT proficiency. The study's cross-sectional design hinders the ability to establish causal relationships between instructors' ICT competence and their influence on students' learning outcomes. Future studies should employ longitudinal research designs to examine the evolution of teachers' ICT competencies and their potential impact on students' academic performance and digital literacy.

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

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