JOLTIDA Journal of Learning and Teaching in Digital Age, 2023, **8**(1), 148-160
https://dergipark.org.tr/en/pub/joltida
ISSN: 2458-8350 (online)

Research Paper

Development and Validation of the Teachers' Digital Competence Scale (TDiCoS)

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ARTICLE INFO

Received: 15 November 2022
Revised: 5 December 2022
Accepted: 9 December 2022

Keywords:
Digital competence
Scale development
Teacher
Digital technologies

doi: 10.53850/joltida.1204358

ABSTRACT

The competences expected from teachers are described in several international reports. An investigation of teacher competences has a potential to analyze and delineate the current situation. Assessment of any construct necessitates utilization of appropriate scales with established validity and reliability. Currently available validated digital competence scales have examined digital competences of citizens, teachers, students, but most are based on only one digital competence framework. In this study a valid, reliable, and comprehensive scale entitled "Teachers' Digital Competence Scale" (TDiCoS) for teachers of different subjects has been obtained by relying on standards/policy reports from several countries. TDiCoS items measure teachers' self-assessment and report of their use of digital technologies in their classrooms. TDiCoS was validated on a sample of 288 in-service teachers. In the final form TDiCoS is unidimensional and composed of 19 items. The model fit criteria, factor loadings, internal validity, and reliability of TDiCoS were examined and found to be good. Hence, it can inform design of new policies and teacher professional development programs targeting digital competences.

INTRODUCTION

Classrooms in all levels are now hosting the generation Z and students who were born later. These students are often called "digital natives" (Prensky, 2001) and from birth they are immersed in ever developing, state of the art digital technologies and the opportunities they offer (Twenge, 2017). For anyone it is now possible to access information quickly and easily via the internet in the forms of digital books, educational videos, or animations/simulations, etc. from anywhere and anytime. As a result, expectations from educators have also undergone transformations. Teachers are no longer expected to be the authority persons who possess and transfer information to students, but to be a guide for them to make sense of the knowledge they have acquired, to realize what is essential and what is unimportant, and to use the information they have acquired for their benefit in their lives (Kuran, 2018, p. 113). For this reason, teachers and students must know how to use digital technology to understand and interpret the world in which they live (NETS-S, 2007; NETS-T, 2008). Learning a new skill or coming to terms with a different perspective is challenging and time-consuming. For teachers, adapting to an approach they are not accustomed to in their classrooms is indeed a complex and gradually developing process (Guskey, 2002; Van Driel, Beijaard, & Verloop, 2001).

Students need learning environments in which they can collaborate with their peers and develop critical thinking and creativity skills while using digital opportunities to acquire information/knowledge (Harari, 2018, p. 241). Accordingly, teachers should design learning environments where students can use digital technologies and these skills.

The construct "Digital Competence" has been a topic that has attracted much attention and has been frequently researched recently due to the COVID-19 pandemic experienced worldwide beginning early in 2020 (TEDMEM, 2021). The forcedly widespread use of online teaching environments and learning management systems during the pandemic has revealed the importance of teachers' ability to use digital tools (OECD, 2022). It is asserted that teachers with a high level of digital competence will assist their students in learning more efficiently and enjoy their schoolwork more in the digital environment (Caena & Redecker, 2019; Redecker, 2017). Ilomäki, Paavola, Lakkala, and Kantosalo (2016) underlined that the idea of digital competence incorporates elements from other disciplines and that it first emerged in education policy reports. Digital competence has dimensions of knowledge, skills, and attitude to use information and communication technologies (ICT) and digital media in a creative, critical, and efficient way for various purposes (work, participation, learning, socializing, etc.) (Ferrari, 2012, p. 3; Oberländer, Beinicke, & Bipp, 2020). Due to its characteristics, digital competence is difficult to define by a few words. The reason lies in its multidimensional, complex, and interconnected in nature (Calvani, Cartelli, Fini, & Ranieri, 2008). Therefore, it is said to be a "pluralist concept" (Janssen, Stoyanov, Ferrari, Punie, Pannekeet, & Sloep, 2013).

Digital competences are also defined in various policy reports created by national and international organizations (Carretero, Vuorikari, & Punie, 2017; Ferrari 2012; etc.). In these reports, the competences required by the new century were defined and the digital competences expected from the citizens were specified. Additionally, there exist particular definitions for educators (Redecker, 2017), citizens (Carretero et al., 2017), consumers (Brecko & Ferrari, 2016), entrepreneurs and virtual office workers (Bartolomé et al, 2018).

Digital competences for teachers in reports include profession-specific features (e.g., UNESCO, 2011; ISTE, 2000; ISTE, 2017; Redecker, 2017). When addressing the digital competence of teachers, various factors must be considered, including their social, cultural, educational, and ethical natures. Many scales have also been developed to measure teachers' digital competences (Alarcón, Jimenez, & Vicente-Yagüe, 2020; Gümüş & Kukul, 2022; Lucas, Bem-Haja, Siddiq, Moreira, & Redecker, 2021; Toker, Akgün, Cömert, & Edip, 2021). It is suggested that future research should determine the similarities and differences among the digital competence models, frameworks, and strategies (Sillat, Tammets, & Laanpere, 2021). Although the competences expected from teachers agree with the requirements of the age, they can still differ due to the cultural, social and economic characteristics of the country (He & Li, 2019; Ilomäki et al., 2016; Skantz-Åberg, Lantz-Andersson, Lundin, & Williams, 2022). Infrastructure, access to technology, and facilitation are all positively related to digital competence; however, individual factors appear more pivotal (Lucas et al., 2021). This situation can change the way teachers evaluate their desired and expected characteristics (Lucas et al., 2021).

By qualitatively analyzing digital competence indicators in various standards/policy reports in different countries the "Teachers' Digital Competence Scale" (TDiCoS) has been developed in this study. A strength of TDiCoS is that it is informed by teacher competence documents of different countries and incorporates their common aspects. Potentially, researchers and institutions/organizations can use TDiCoS to investigate/assess teachers' digital technology competences. On the other hand, teachers can use it for self-evaluation purposes as well.

Teachers' Digital Competences

The Organisation for Economic Co-operation and Development (OECD) conducts large scale surveys of teachers called The Teaching and Learning International Survey (TALIS). The most recent one was conducted in 2018 and revealed some striking results. For the purposes of the current study, it is noteworthy that in the 2018 TALIS survey (Schleicher, 2020, p. 21) teachers reported that they highly prioritized professional development in the use of information and communication technologies (ICT) for teaching. This can be attributed to the finding that the frequency of student use of ICT for projects or class work has been increasing continuously and has become very common.

The adaptation of digital technologies in classrooms recently has revealed the need for teachers to use them effectively and efficiently to enhance student learning (Redecker, 2017; Turkish Education Association, 2009, p. 176). In Turkey, the FATIH (Movement to Increase Opportunities and Improve Technology) project was launched in 2010 to increase technology use in the classroom and provide necessary technical equipment to all schools. However, providing the necessary technical infrastructure is insufficient for integrating technology into teaching as emphasized by the 2018 TALIS report. Teachers may experience various problems and difficulties regarding when and how to integrate new educational technologies into the learning-teaching environment (Niess, 2011, p. 299). It would be beneficial to examine the standards of the teaching profession to overcome these difficulties and learn what is expected from teachers.

Various international standards describe the digital competences expected from teachers. Although there is no digital competence framework in Turkey, they were included in the "General Competences of the Teaching Profession" (Ministry of National Education [MNE], 2006). In the updated 2017 version emphasizes that teachers should use digital technologies effectively in their classrooms (MNE, 2017). The "Turkish Qualifications Framework" was developed in accordance with the European Qualifications Framework and published in 2016. It brings together all learning paths and competence principles. "Digital Literacy Competence Framework" has been explained in the Digital Literacy Teacher's Guide created by the Ministry of National Education for current needs during the pandemic process (MNE, 2020). In this framework, competence areas consisting of sub-titles such as communication, cooperation, security, and problem-solving are defined in addition to basic technology usage skills.

The "Digital Competences for Educators (DigCompEdu) Framework" has defined the profession-specific digital competences that educators should capture the potential digital technologies offer to enhance and reform education in many European Member States. This framework also allows educators to develop and evaluate their digital competences (Redecker, 2017, p. 9). The first spark for the DigCompEdu framework was ignited by Ferrari (2012), who provided a comprehensive definition of digital competence by analyzing 15 different digital literacy and competence frameworks. The framework (titled DigComp 1.0), which received an update in 2013, consists of constructs in five competence areas (information, communication, content creation, security, and problem solving). In this framework, it suggests definitions of relevant competences, not of desired citizen behavior (Ferrari & Punie, 2013, p. 12). It has been updated due to the incorporation of new technologies and the use of distinct terminology. The digital competence framework for citizens called DigComp 2.0 has received new word updates to its previous version (Vuorikari, Punie, Carretero Gomez, Van den Brande, 2016). DigComp 2.1 (Carretero et al., 2017) defines eight proficiency levels for twenty-one proficiency indicators. Each of these levels contains descriptive information in considerable detail. The European Framework for Digital Competence of Educators (DigCompEdu) provides a holistic framework for teachers' digital competence (Redecker, 2017, p. 19):

1. Professional engagement (organizational communication, professional collaboration, reflective practices)
2. Digital resources (selecting, creating & modifying, managing-protecting-sharing)
3. Teaching and learning (teaching, guidance, collaborative learning, self-regulated learning)
4. Assessment (assessment strategies, analyzing evidence, feedback & planning)
5. Empowering Learners (differentiation & personalization, accessibility & inclusion, actively engaging learners
6. Facilitating learners' digital competence (information & media literacy, communication, content creation, responsible use, problem solving)

Assessment of Teachers' Digital Competences

There is a rising interest to improve and assess pre-service and in-service teachers' digital competences (Revuelta-Domínguez, Guerra-Antequera, González-Pérez, Pedrera-Rodríguez, & González-Fernández, 2022). Kluzer and Pujol Priego (2018, p. 35) defined four different approaches for assessing digital competences: self-assessment questions, knowledge-based tests, and performance-based evaluation, a mix of these methods. Self-assessment approach helps encourage respondents to think critically about their own levels of digital competence and to evaluate their own perceived strengths and weaknesses. The self-assessment of teachers' digital competences has been the subject of a significant number of studies (e.g., Scherer, Siddiq, & Tondeur, 2017; Tondeur, Aesaert, Pynoo, van Braak, Fraeyman, & Erstad, 2017). A knowledge-based test approach can more accurately describe a user's digital competence as it measures both factual and procedural knowledge. In the performance-based assessment approach, where users are asked to solve various problem situations that reflect the real situations they may encounter, a far more accurate evaluation of their digital competence is possible.

Cartelli (2010), who presented a digital competence assessment framework, suggested that cognitive, affective, and social-relational dimensions are related to each other in the evaluation process. In the cognitive dimension, technological, verbal-linguistic, and logical-mathematical features are measured. In the social dimension, characteristics such as the use of self-reflective skills and capacities, the ability to interact with others and be sensitive to their needs, and the ability to work in a group are highlighted.
DigCompEdu also suggests a multi-stage, six-level assessment model of digital competence proficiency: beginner (A1) and explorer (A2), integrator (B1) and expert (B2), and leader (C1) and Pioneer (C2) (Redecker, 2017, p. 31). Several studies have used the DigComp framework to develop scales. With teachers from various disciplines in Turkey (Gümüş & Kukul, 2022; Toker et al., 2021) and Spain (Alarcón et al., 2020). The digital competence level can be determined based on the overall score gained on this scale. Other scales were prepared to measure the importance that teachers attach to the status and development of their students' digital knowledge and skills rather than their own competences (Kim & Choi, 2018; Kuzminska, Mazorchuk, Morze, Pavlenko, & Prokhorov, 2018; Siddiq, Scherer, & Tondeur, 2016; Sillat et al., 2021). There are also scales for measuring the digital competences of higher education students as adult learners (e. g., Tzafilkou, Perifanou, & Economides, 2022). These scales are in the self-assessment category. Measurement tools using DigComp-related frameworks are usually multiple-choice format (Mattar, Ramos, & Lucas, 2022). This framework can be used for knowledge-based assessment and in the preparation and definition of authentic tasks for performance-based assessment (Alarcón, et al., 2020).

METHOD

Procedure

Scale development procedures have been the subject of various studies (Boateng, Neilands, Frongillo, Melgar-Quiñonez, & Young, 2018; Cohen & Swerdlik, 2009). The stages indicated by Cohen and Swerdlik (2009, p. 245) were followed throughout the TDiCoS's development. TDiCoS is aimed to measure teachers' self-assessment of using digital technologies for educational purposes.

Content Analysis for Item Generation

In the TDiCoS development process, we first determined the domain in accordance with the purpose of the scale. We explained what we mean by the expression of a teacher with digital technology competence. We defined it as follows: a teacher who uses digital technology in her/his classroom to ensure active student participation, use it to ensure professional development and cooperation with colleagues, and knows about moral and ethical use of digital technologies. Based on this definition, we benefited from the related English and Turkish standards and frameworks. To accomplish this, we searched the Google Academic database for the terms "digital yeter(li)lik " in Turkish and "digital competence" in English. The exclusion criteria were considered during this process, including 1) research articles and book chapters, and 2) documents written in languages other than English and Turkish. Then, we reached the following standards/policy reports: National Educational Technology Standards for Teachers (NETS-T, 2008), European Framework for the Digital Competence of Educators (Redecker, 2017), General Competences of the Teaching Profession MNE (2006), and UNESCO ICT Competency Framework for Teachers (UNESCO, 2018). A professional translation company translated these documents from English into Turkish. Then, we brought together these standards created for different countries and institutions in the MAXQDA 2018 qualitative analysis program and made content analysis of competence indicators. Because of the content analysis, we merged the common points of these frameworks and reached the following areas the digital technology competences of teachers: 1) learning-teaching process, 2) selecting and using digital resources, 3) assessment, 4) digital technologies, 5) professional learning, and 6) ethical use of resources. The descriptions of these six different areas are in Table 1.

Generating Scale Items and Expert Reviews for Revision

Fowler (1995, p. 103) and Clark and Watson (1995) defined the characteristics that items should have. Some of them are as follows: the items contain what people have experienced firsthand, the items consist of a single judgment, all the words chosen in the items mean the same thing for the respondents, the items are not complex, and so on. We ensure sure the scale's items aligned with these requirements. We collected statements that met similar competences and then developed new competence items in Turkish that could correspond to these statements. The size of the starting pool of items should be at least double that of the final scale (Kline, 1993, p. 162). We created a pool of 56 items from the competence statements we obtained. The results of the content analysis were collected from six distinct areas. The item pool created according to the proficiency areas because of the content analysis and the item numbers in the final scale is given in Table 1.

Table 1. TDiCoS scale's defined teacher competence areas and item-related explanations

Competence areas	Descriptions	Item number in the pool	Final scale item numbers
Learning-teaching process	Including technology in the lesson plan, using technology in a way that enables students to use their creativity and working collaboratively, ensuring active participation of students in the environment where technology is used, identifying learner characteristics using technologies and developing materials using technologies	1–2 (lesson plan)	17
		3–4 (developing materials)	8
		5–7 (enables students to use their creativity	2
		11 enables students to work collaboratively)	19
		12–14 (active participation)	15
		21–26 (identifying learner characteristics)	4
Selecting and using digital resources	This takes into account the students' knowledge level, subject area, and capabilities during the teaching-learning process.	8–10	1 14 16
Assessment	To enable students to evaluate their own knowledge, and their learning,	16–20	18 11 7
Digital technologies	Aware of the specific characteristics of technologies and employing compatible technologies	37–46	9 10
	Willingness to learn how to use various technologies and to engage in online groups for self-improvement	27–38 47–51	5 6 12
Ethical use of resources	Verifying information sources and educating students about copyright	52–56 15	3 13

To ensure content validity of the TDiCoS items, we received expert opinions from four people from the measuring, science, computer/instructional technology, and Turkish department. Experts (such as colleagues who have substantial experience and expertise with the construct in issue or related phenomena) might be asked to score the items' relevance to the construct or phenomenon being measured (DeVellis, 2017). We received their opinions in terms of the domain suitability of the items, clarity of the article, and compliance with the item writing rules. Finally, teachers' opinions were also sought to check the comprehensibility of the items on the TDiCoS. Finally, items were accepted, rejected, or modified based on the experts' views. By considering into account the feedback of several pre-service teachers who read the entire scale, we refined the accuracy, clarity, and parsimony of each item. After all the steps, we created a 20-item form. The last form of the scale has two items for each competence area of having technological knowledge and ethical use of resources, and three or more items for other competence areas.

We developed the TDiCoS as a Likert-type scale to measure teachers' digital competences. The scale we developed in this study was graded into 5 categories (Table 2). The teachers taking the scale will rate how often they make the statements in the items. Since our items contain some technological tools, equipment, or material information, the category of "Not Appropriate" has been added to the frequency statements. If the teachers did not know/experience the given item, they chose the NA category. In this way, we have distinguished between the teacher who does not know the technology in that article and the teacher who does but never uses it in her lessons.

Table 2. 5-point Likert scale response options

Point	How often does it use	Description of the category
[NA]	Not Appropriate	If you are not familiar with the substance.
(1)	Never	If you know and never use it.
(2)	Rarely	If you know it, but rarely apply it.
(3)	Sometimes	If you know and sometimes, apply it.
(4)	Generally	If you know and usually apply it.
(5)	Always	If you know and always apply it.

Sample Characteristics and Data Collection

DeVellis (2017) prefers a sample size as large as possible to ensure factor stability. Comrey and Lee (1992, p. 217) indicate the adequacy of a sample with the following scale: 50 —very weak; 100 — poor; 200 — fair; 300—good; 500 — very good; and 1000 or more—perfect. However, the sample size fulfills the recommendation that there be a minimum of 10 participants for each relevant item evaluated (Guadagnoli & Velicer, 1988). The final version of the TDiCoS, returned by the experts, consists of 20 items. For this reason, applying EFA to nearly 200 participants can be considered an appropriate value. However, if the results contain relatively few factors and the amount of variance explained by the factor is large, the investigator can be confident that the factors obtained represent a close match to the population factors, even at medium to small sample sizes (MacCallum, Widaman, Zhang, & Hong, 1999). Generally, CFA/SEM requires large samples (Kline, 2016, p. 15), A lower sample size is appropriate if there are substantial correlations and few, distinct components (Tabachnick & Fidell, 2013, p. 666). Moreover, a simple model can be analyzed with 100 and less (Kline, 2016, p. 16).

The TDiCoS was applied to the teachers working in different regions of Turkey with a 5-point Likert-type scale. The descriptive statistics of the study groups in which the scale was applied to exploratory factor analysis and confirmatory factor analyzes are given in Table 3.

Table 3. Demographics of the participants

Respondents Characteristics	Exploratory Factor Analysis Sample % (N)	Confirmatory Factor Analysis Sample % (N)
Gender		
Female	79.2% (95)	71.4% (120)
Male	20.8% (25)	28.6% (48)
Experience		
1–5 years	48.3% (58)	29.2% (49)
6–10 years	31.7% (38)	35.2% (59)
11–15 years	8.3% (10)	13.7% (23)
16–20 years	1.17% (14)	21.4% (36)
Area		
Science education	83.3% (100)	91.1% (153)
Physics	5% (6)	1.8% (3)
Chemistry	6.7% (8)	4.8% (8)
Biology	5% (6)	2.4% (4)
Total	100% (120)	100% (168)

Although this scale was designed to be applicable to all teachers, only teachers from different science fields completed it. The great majority of participants in both analyses are involved in science education. In Turkey, science education teachers teach science to students between the ages of 10–14. Physics, chemistry, and biology teachers work at the high school level. Most respondents were women. In both groups, those with less than 10 years of experience constituted the majority. The total number of participants invited to participate in TDiCoS voluntarily and anonymously is 357 teachers.

We assigned 162 responses randomly to the exploratory factor analysis (EFA) group. With advice from two experts, 42 participants' responses were excluded from the data list since they included at least one "Not Appropriate [NA]" item response. Thus, 120 of these participants constituted the EFA sample. For model-fit calculations, the sample was separated from the EFA sample (Schumacker & Lomax, 2010, p. 224). Similarly, we assigned the remaining 195 respondents to the confirmatory factor analysis (CFA) group randomly. Twenty-six respondents were dropped due to missing value items. Thus, 168 of them constituted the CFA sample.

Analysis of Data

We used exploratory and confirmatory factor analyzes to reveal the TDiCoS's validity (Hurley, Scandura, Schriesheim, Brannick, Seers, Vandenberg, & Williams, 1997). For the TDiCoS's reliability, we calculated the Cronbach's Alpha value.
Factor analysis is used in scales calculated based on the total for features that cannot be measured directly. This analysis is about constructing validity. The pattern of correlations (or covariances) between the observed measures is examined in factor analyses (DeCoster, 1998). Factor analysis consists of two main topics. While exploratory factor analysis helps us understand the structure to be measured, confirmatory factor analysis allows for testing the revealed structure (Costello & Osborne, 2005).

With the data we obtained for the validity analysis of the scale, we first performed exploratory factor analysis, then reliability analysis, and finally confirmatory factor analysis.

RESULTS

Exploratory Factor Analysis (EFA)

To ensure construct validity with the remaining 120 people, we conducted exploratory factor analysis using the SPSS 25 program with the principal components analysis method.

Evaluation of The Suitability of Data for Factor Analysis

We performed the KaiserMeyer-Olkin test and the Bartlett test for the suitability of the dataset for the study group for principal component analysis. Kaiser-Mayer-Olkin (KMO value) value of .930 indicates that the sample size is sufficient for factor analysis (it should be greater than .80). This value indicated that the sample size was perfect. This because according to the literature review, the KMO value is 0.60 moderate, 0.70 good, 0.80 very good, and 0.90 excellent (Bryman & Cramer, 1999). According to the KMO value obtained, it can be evaluated whether the data structure is sufficient for factor analysis.

It is determined by the "Bartlett Test of Sphericity" that the data come from a multivariate normal distribution. The p-value (p=0.000) obtained from the Bartlett test is less than the 0.05 significance level. This results in a clear rejection of the independence hypothesis, indicating that the matrix may be suitable for analysis (Dziuban & Shirkey, 1974). Since the Bartlett Test of Sphericity is less than .05, it shows that at least one significant factor can be formed from these items.

Determining The Number of Factors

In factor analysis, the lowest factor loadings of the items were .571. We did not do rotations because the load given to the different factor was higher than that for the other. Because "if the correlation patterns in the data are clear, different rotation methods tend to give similar results" (Tabachnick & Fidell, 2013, p. 690). Even though there was no rotation, we excluded the 16th item from the analysis because an item alone loaded a factor, and there could not be a factor from a single item in that factor. Finally, the TDiCoS consists of 19 items, and the eigenvalues and variance explanation percentages of the factors are presented in Table 4.

Table 4. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% Variance	Cumulative%	Total	%Variance	Cumulative %
1	10.198	53.675	53.675	10.198	53.675	53.675
2	1.736	9.135	62.811	1.736	9.135	62.811
3	.954	5.021	67.831			

After the 16th item was removed, the single factor structure (eigenvalue 10,198) explained 53.68% of the variance. Bryman and Cramer (1999) stated that factors with an eigenvalue of 1 or greater than 1 can be considered important factors. When the total explained variance is examined, two factors with an eigenvalue greater than 1 are seen in the scale. This scale is unidimensional because the first eigenvalue is much bigger than the second (Hambleton & Traub, 1973). The eigenvalue of the first factor is more than 3 times the nearest eigenvalue of the other. Simultaneously, when their contribution to the total variance is examined, the second factor's contribution is relatively low. Using Cattell's (1966) Scree test, researchers chose to retain one component. It was thought that testing and examining the Scree plot, another criterion used in determining the number of factors, would be effective in making the final decision (Tabachnick & Fidell, 2013, p. 697). Scree plot is presented in Figure 1.

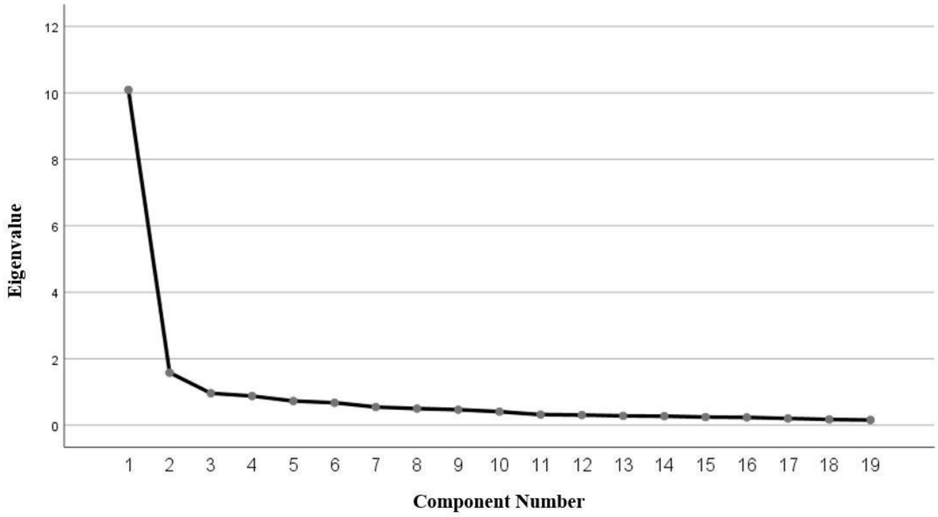

Figure 1. Scree plot

While interpreting the Scree plot, "it is necessary to pay attention to the places where the slope of the line formed by the combination of points changes" (Tabachnick & Fidell, 2013, p. 697). When the graph in Figure 1 is examined, it is seen that the slope of the line has changed since the second component. Therefore, according to the explained variance distributions and Scree plot data, it has been determined that this 19-item scale has a single factor structure.

Determination of Factor Variables

After determining the factor number of the scale and removing the 16th item, the factor loads of the scale were determined. The factor loads of 19 items in the TDiCoS are presented in Table 5. Since variables with factor loadings of .32 and higher were interpreted, those below this value are not included in the table (Tabachnick & Fidell, 2013, p. 702).

Table 5. Component matrix

Items	Component	
	1	2
Item 1	.765	
Item 2	.777	
Item 3	.657	
Item 4	.781	
Item 5	.786	
Item 6	.653	-.357
Item 7	.695	.363
Item 8	.593	
Item 9	.777	
Item 10	.790	
Item 11	.696	.364
Item 12	.776	
Item 13	.672	-.499
Item 14	.726	-.423
Item 15	.782	
Item 16	.822	
Item 17	.759	
Item 18	.684	.542
Item 19	.683	.452

When Table 5 is examined, it is seen that all items give a more significant load to the 1st factor. Considering the variance explanation value, it was determined that the scale had a single factor structure. However, some items' loads given to the second factor should not be ignored. The 6th, 7th, 11th, 13th, 14th, 18th, and 19th items are evaluated as explaining the variance very well in the first factor with factor loadings above .63 (Comrey & Lee, 1992, p. 243).

Reliability Measure of TDICoS

We chose the most widely used "internal consistency reliability" method, which can be easily detected by software, to determine the reliability of a scale. Internal consistency measures item homogeneity, or how well test items measure the same construct (Henson, 2001). The Cronbach Alpha coefficient was calculated to determine the reliability of the scale. The Cronbach's Alpha value of this 19-item TDiCoS was determined as .949. Alpha values were excellent when 0.93–0.94 (Taber, 2018). Therefore, it can be said that the TDiCoS, which consists of a single factor, is a reliable measurement tool.

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) offers a measurement based on the structural equation model (Fontaine, 2005). We performed confirmatory factor analysis to test whether the 19-item TDiCoS, which was determined as a single factor, was validated as a model. We used confirmatory factor analysis for the remaining 168 people using the Lisrel 8.80 program. To determine the model compatibility of the scale, we reached the standardized values in Figure 2.

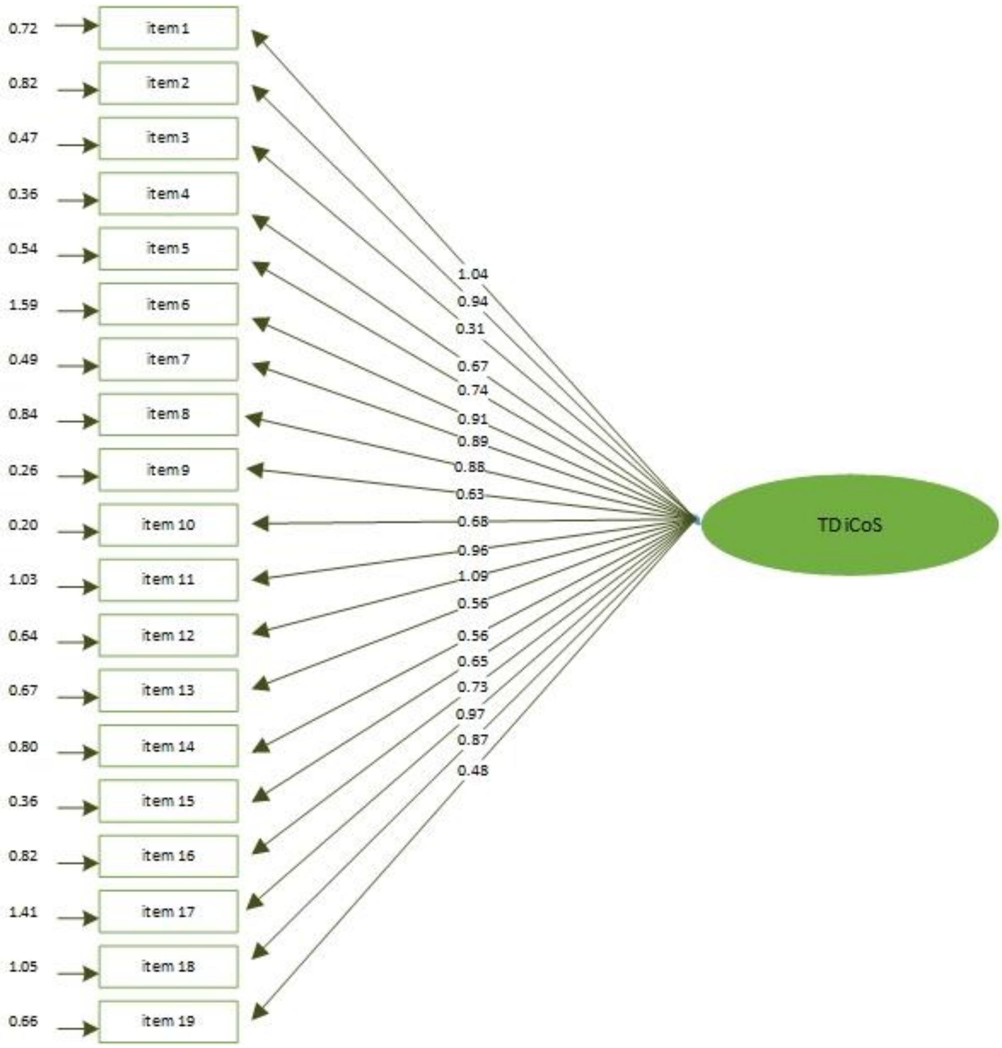

Figure 2. Path diagram

In the confirmatory factor analysis, a strong structure was obtained due to the single factor structure's variance explanation rate and the single factor's very high eigenvalue.

The standardized estimates of all items is shows that the value of the ratio of Chi square (χ^2) to degree of freedom (*df*) is 1.94, and at a significant level ($p<0.000$) and the root mean square error of approximation (RMSEA) value is .075. If the RMSEA values are less than .05, the model fit is good; a value of .08 shows that it is an acceptable limit (Schermelleh-Engel, Moosbrugger, & Muller, 2003). The RMSEA value found because of the analysis shows that the model fit is within the reference range of acceptable fit values.

The model's goodness of fit index (GFI) was found to be .74. The GFI value is not within the acceptable limit. Normed fit index (NFI) .95, non-normed fit index (NNFI) .97; comparative fit index (CFI) .98; incremental fit index (IFI) was found to be .98. These values show that the model fit is within the reference range of good fit values (Schermelleh-Engel, Moosbrugger, & Muller, 2003).

DISCUSSION

This study aims to develop a valid and reliable scale to determine teachers' digital competences. The exploratory factor analysis shows that TDiCoS consists of a single factor with 19 items. This unidimensional structure shows that the digital competence items on the scale are not significantly different from each other and that each one coexists and measures the same feature. The confirmatory factor analysis yielded that the fit indices obtained are at an acceptable level. The Cronbach Alpha reliability coefficient for TDiCoS is .949. These results show that in its final version TDiCoS is a scale that enables teachers to determine their digital competences. However, different factors have emerged in the scales that tried measuring teachers' digital competences in the literature. For example, TDiCoS has items that include the ability of teachers to collaborate using digital tools and use them with their students. In this regard, it has been determined that items prepared for similar characteristics on different scales constitute different factors. Although the factor names are different, they mean the same thing: "sharing and communicating" (Siddiq, et al., 2016), "social/cultural engagement" (Kim & Choi, 2018), and "professional engagement" (Toker, et al., 2021). The items measuring this feature on TDiCoS did unload a different factor. Similarly, there are competence items on the safe use of digital resources. It has been determined that these items are involved in different factors on various scales (Siddiq, et al., 2016; Toker et al., 2021; Yılmaz, Aktürk, & Çapuk, 2021). Additionally, there is an item on TDiCoS that includes teachers' digital material development competences. Similar items are also found in the Turkish adaptation scale of the DigCompEdu standards (Toker et al., 2021). These items are included in the factor called "professional engagement." The items in this factor relate to teachers' digital teaching skills and communication with colleagues and students.

Many types of measurement tools based on different theoretical frameworks can be found in the literature. This is partly because there is currently no agreed-upon method for measuring digital competence (Sillat et al., 2021). The multi-faced nature of this concept (Oberländer et al., 2020) can be shown as a reason for differentiating the frameworks created. Different countries' definitions and indicators of competences may diverge because of cultural differences in how this concept is perceived (He & Li, 2019; Ilomäki et al., 2016; Skantz-Åberg et al., 2022). For example, The DigComp 2.0 competence framework targets high-income and technologically-advanced European countries (Law, Woo, de la Torre, & Wong, 2018, p. 28). This framework's competence indicators are thus not transferable to a country with different demographics and socioeconomic conditions.

Furthermore, contrary to previous studies that suggested quite long (e.g., Alarcón et al., 2020; Gümüş & Kukul, 2022) instruments, the TDiCoS proposes a comprehensive model of unidimensional and 19 items, providing a practical and easy-to-use instrument for future research on teachers' digital competence. The person who will administer TDiCoS does not need any training. Instead, the scale will be administered individually. The original items in the TDiCoS were prepared in Turkish and included in the doctoral dissertation (Author, 2020) of the first author. It can be created in paper format or online via Google Forms. An English translation is presented in the appendix.

In its final form TDiCoS has content validity to identify teachers with digital technology competence. In this scale, respondents indicate how and how often they use digital technologies in instruction. Thus, those who administer the TDiCoS can determine the digital technology competences of the practitioners and teachers. TDiCoS assesses teachers' capacity to use digital technologies in the classroom environment. This situation will be beneficial for both practitioners and teachers. TDiCoS helps to highlight teachers' strengths and weaknesses across digital competences. Teachers can be aware of their digital literacy and can critically question and develop themselves (Roberts & Kruse, 2021). Using TDiCoS, practitioners can conduct needs assessments to design programs and create relevant materials for teacher education and professional development. Teachers are more likely to adopt a more constructivist technology pedagogy if they see examples of effective mastery, mentoring, and technology integration throughout their education and career (Rowston, Bower, & Woodcock, 2021). In this way, teacher education can be redesigned to equip educators with digital technology-related skills.

Limitations

One of the main limitations of this study is its sample size at the lower limit recommended for EFA and CFA. In this scale development process, the recommended number of respondents could not be reached due to time constraints and difficulty in accessing teachers. Therefore, further research on larger populations is recommended in the future. Another limitation of our study is that we investigated TDiCoS based on teachers' self-reports. These reports reflect teachers' perceptions of their digital competence. Therefore, it may not reflect the actual classroom environment. Qualitative data collection tools (such as observation, reflective journals, and video) can be used to learn more about teachers' practices in the classroom (Calvani, et al., 2008; Revuelta-Domínguez et al., 2022; Sillat et al., 2021). Most of the data were gathered using a web-based google form. This could mean teachers who are already engaged with digital technologies answer this scale. Although data were collected online and science teachers were not targeted specifically it has become the case that only science teachers participated. Also, the sample is mostly middle school science teachers, so the results cannot be generalized to teachers of other subjects. It is recommended that the validity and reliability measures of this scale be established with participation of teachers of other subjects.

Conclusion

This study established the internal and external validities of TDiCoS and its reliability. We report that teachers' digital competence is best represented by a single factor scale with congruent exploratory and confirmatory factor analysis. We consider TDiCoS as a construct that can identify teachers' use of ICT in future research on technology acceptance and integration. Here we show the suitability of the construct for teachers to self-evaluate their classroom practices and for teacher educators to examine the current situation.

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APPENDIX

Read each of the following statements and mark as X in the box next to the statement in the column that shows how often you do / do not do this statement in the learning-teaching environment or have no knowledge at all.	NA (Not Appropriate)	Never (1)	Rarely (2)	Sometimes (3)	Generally (4)	Always (5)
1. I choose digital technologies suitable for the subject.						
2. I use digital technologies to develop students' creative thinking skills.						
3. I inform students about the copyrights of digital materials.						
4. I create learning environments suitable for students' individual differences by using digital technologies.						
5. I learn to use new digital technologies that support students' learning.						
6. I join communities in social networks about innovative digital technology applications that support student learning.						
7. I enable students to evaluate their own learning processes using digital technologies (educational software, virtual classroom, etc.).						
8. I create learning materials with digital content for students.						
9. I design rich learning environments using digital technologies.						
10. I use different Digital technologies in a way to complement each other.						
11. I evaluate students' learning processes by using various digital technologies (e-portfolio, excel, etc.).						
12. I closely follow new digital technologies that support students' learning.						
13. While searching for a subject on the Internet, I evaluate the information I get from different sources according to the reliability of the source.						
14. I consider the relevant learning outcome when choosing digital technologies.						
15. I use digital technologies in a way that ensures active participation of students in the lesson.						
16. I consider students' individual differences when choosing digital technologies.						
17. I incorporate digital technologies into the lesson plan.						
18. I provide instant feedback to students during the lesson using various digital technologies (audio or video response, cloud applications, etc.).						
19. I use a digital technology to enhance student collaboration.						