

Development of the Digital Transformation Scale: Assessment of Measurement Invariance

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Abstract

The primary aim of this study is to develop a valid and reliable measurement tool that assesses teachers' perceptions of digital transformation. A total of 828 teachers working in public schools in 2 provinces located in the eastern and southern regions of Turkey participated in the study. The construct validity of the scale was tested using exploratory and confirmatory factor analyses (EFA and CFA). According to the EFA results, the scale has a single-factor structure that explains 67.73% of the total variance. The CFA results indicated acceptable fit indices for the single-factor Digital Transformation Scale (DTS). Criterion validity was evaluated using the 21st Century Technology Literacy Skills Scale (TLSS) and the Resistance to Change Scale (RCS), and it was found that the DTS has a positive relationship with the TCTS and a negative relationship with the RCS. Reliability assessments were conducted by calculating the Cronbach's alpha internal consistency coefficient, test-retest method, and composite reliability values across three different samples, all of which exceeded threshold values. The test-retest analysis confirmed the stability of the scale, while the composite reliability analysis supported its reliability. Item analysis was performed using the "top and bottom 27% rule" and corrected item-total correlations, with both analyses yielding positive results. Additionally, measurement invariance for gender and age variables was established, and the values indicated that measurement invariance was achieved. It was confirmed that the scale provides reliable comparisons between gender and age groups. All these findings support the Digital Transformation Scale as a valid and reliable measurement tool.

Keywords

digital transformation, teacher, measurement invariance, scale development

Introduction

As a result of technological advancements, digital transformation has become a fundamental aspect of daily life. Digital transformation is progressing every day, and significant steps are being taken in many sectors to understand, interpret, and implement this change (Yildiz, 2022).

Educational institutions have also been profoundly impacted by this transformation, and the widespread use of digital technologies has become inevitable (Smirani & Boulahia, 2022). Digital devices such as computers, interactive whiteboards, tablets, smartphones, augmented reality, robots, virtual reality, and 3D printing are being systematically and extensively used in educational processes and teacher training (Luo et al., 2021). Moreover, software and smart devices have increasingly permeated in classrooms, with

significant investments being made in the development of digital services such as learning management systems, educational platforms, and synchronous/asynchronous communication tools (Smirani & Boulahia, 2022). In Turkey, efforts have been made to implement digital transformation in education through technology policies. With the introduction of the Movement to Enhance Opportunities and Improve Technology

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Data Availability Statement Included at the end of the article



(FATİH) Project in 2010, interactive whiteboards, tablets, and computers began to be used in classrooms. The Education Information Network (EBA), initially developed for providing digital educational materials through the FATİH Project, became a remote education platform after the Covid-19 pandemic, and education delivery shifted to this platform. Additionally, e-book and e-content platforms were created (Aydin & Atasoy, 2023; Ceylan et al., 2024; Tekin & Polat, 2014). These developments place a significant demand on teachers to integrate technologies into learning environments and enhance their technological skills. They are also expected to enrich educational processes, improve students' learning experiences, and guide them in acquiring digital competencies (Iivari et al., 2020; Koral Gümüsoğlu & Akay, 2017; Smirani & Boulahia, 2022; Yildiz Durak, 2019; Yureva et al., 2020). In other words, teachers are expected to lead the digital transformation process. Teachers' adaptation to this transformation process is crucial for both themselves and their students (Yildiz, 2022). There is a need for a reliable and valid measurement tool that can assess teachers' approaches and competencies toward digital transformation. When examining the relevant literature, scales aimed at assessing the overall level of digital transformation at the organizational level (Agostino & Costantini, 2022; Kontić & Vidicki, 2018; Lin et al., 2024) are well-documented. At the individual level, scales related to digital transformation focus on businesses (Lin et al., 2024; Nadeem et al., 2018; Sağlam, 2021). Pettersson et al. (2024) developed a scale focused on digitalization, digitization, and digital transformation in the context of sociocultural change in schools and education. In Turkey, adaptation studies have been conducted to determine the level of digital transformation in businesses (Sağlam, 2021).

Despite the existence of scales measuring teachers' digital competencies (Ghomi & Redecker, 2019; Yilmaz Ergül & Taşar, 2023), digital literacy (Erkam Sulak, 2019; Küslü, 2022), self-assessment of technology competencies (Christensen & Knezek, 2017), and technology integration (Alpaslan et al., 2021; Horzum et al., 2014; Su et al., 2017; A. Y. Wang, 2022), no scale assessing perceptions of digital transformation appears to exist. In this context, the aim of the study is to develop a Digital Transformation Scale (DTS) that assesses teachers' perceptions of digital transformation and to conduct validity and reliability studies. The Unified Theory of Acceptance and Use of Technology (UTAUT), developed by Venkatesh et al. (2003), was used in the scale development process to explain and predict technology acceptance and use.

Unified Theory of Acceptance and Use of Technology (UTAUT)

In the literature, many theories and models explain and predict the use of technology by individuals (Teo & Noyes, 2014). The UTAUT model, proposed by Venkatesh et al. (2003), provides a comprehensive framework for understanding technology acceptance and usage. This model synthesizes eight established theories: the Theory of Reasoned Action, Technology Acceptance Model, Motivational Model, Theory of Planned Behavior, Combined Technology Acceptance Model, Computer Usage Model, Innovation Diffusion Theory, and Social Cognitive Theory. UTAUT was designed to integrate the strengths of these models, focusing on four key components: performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003). Performance expectancy refers to the belief that using technology will enhance an individual's job performance and is regarded as the strongest predictor of behavioral intention. Effort expectancy is the perceived ease of using technology. Social influence pertains to the extent to which individuals perceive that significant others encourage the use of a particular technology. Facilitating conditions involve the availability of resources and support for using the technology (Teo & Noyes, 2014; Venkatesh et al., 2003). The model's ability to consider a wide range of variables to explain technology use is regarded as one of its most distinguishing features (Yildiz Durak, 2019), and it is widely used (Bajunaied et al., 2023). A review of the literature shows that this model has been employed to guide organizations in their digital transformations and has proven successful in identifying variables influencing digital transformation (Hewavitharana et al., 2021; Jayawardena et al., 2023; Tolkun & Tekin, 2022). For this reason, the UTAUT model was used as the foundation for generating the items in this study's scale.

Digital Transformation in Education

Digital transformation refers to the process of enhancing an entity by implementing substantial changes to its features through the integration of information, communication, and connectivity technologies (Vial, 2021). In the context of educational institutions, digital transformation involves the integration of technological innovations into educational processes and the role these innovations play in improving the quality of education (AL-Ali & Marks, 2022; Mahlow & Hediger, 2019). Digital transformation, with its multidimensional structure, is a combination of both technological and non-technological antecedents (Jayawardena et al., 2023). Therefore, before

implementing digital transformation in an institution, the key components that require attention must be assessed (Hewavitharana et al., 2021). The Unified Theory of Acceptance and Use of Technology is utilized to manage institutions' digital transformation processes. When examining the impact of the model's key determinants on digital transformation:

Performance Expectancy: Teachers are more likely to adopt digital technologies when they believe that using these technologies will be beneficial to the educational process and will increase success and productivity (Nikolopoulou et al., 2021). Moreover, the perception that technology use will facilitate work processes such as lesson planning and material creation positively influences the use of digital technologies (Ismail et al., 2022). In this case, the use of technology will help boost teachers' confidence and enhance the quality of teaching, eventually becoming a daily routine (Omar et al., 2019). The expectation that digital technologies will positively affect the performance of both students and teachers is considered to support the success of digital transformation.

Effort Expectancy: Teachers who believe that using technology in the educational process will not require much effort, difficulty, or complexity—that is, that it is easy—are expected to adopt digital technologies more quickly (Nikolopoulou et al., 2021; Omar et al., 2019). Effort expectancy predicts the adoption of digital technologies across all age groups (Magsamen-Conrad et al., 2015). The successful realization of digital transformation in education, and the adoption of technology in education is believed to be closely related to the perceived ease of use of digital technologies for both teachers and students.

Social Influence: Positive feedback from teachers' social networks significantly influences their adoption and usage of digital technologies (J. Kim & Lee, 2022). Teachers who perceive that significant individuals, such as stakeholders, school leaders, and colleagues, influence their use of mobile technology, are more likely to adopt such technologies for educational purposes (Nikolopoulou et al., 2021; Sun et al., 2014; C. S. Wang et al., 2017). The support of school administrators, teachers, students, and other stakeholders for the use of digital technologies can increase the participation of teachers and students in the digital transformation process.

Facilitating Conditions: The successful use of digital technologies in educational institutions requires internet access, hardware, software, technical support, and necessary infrastructure (Ambarwati et al., 2020; Neslin & Shankar, 2009). Moreover, access to necessary resources, the ability to acquire information, skills training, available materials, and administrative support are facilitating factors that affect the use of digital technologies in education (Nikolopoulou et al., 2021; Teo, 2010). Therefore, providing technological support for teachers

and students, along with training aimed at adapting to new technologies, is believed to facilitate the digital transformation process.

Gender and Age in Digital Transformation: Measurement Invariance

In the social and behavioral sciences, self-report surveys are frequently used to assess various aspects of human behavior. These surveys consist of items developed to measure an underlying construct in order to track individuals over time or compare different groups (van de Schoot et al., 2012). For these constructs to be compared across groups, the survey must function similarly in each group, meaning that measurement invariance must be established (D'Urso et al., 2022). Through measurement invariance, researchers aim to determine whether a scale exhibits the same measurement properties across two or more samples (Fischer & Karl, 2019). In this study, measurement invariance analyses were conducted. Digital transformation has altered the ways people live, work, and interact. Gender and age play a role in how individuals perceive, apply, and experience this transformation (Genz & Schnabel, 2023; Kim et al., 2021; Larsson & Viitaoja, 2019; Tran Van Hai, 2022). Similarly, Venkatesh et al. (2003) note that gender and age act as moderating factors in technology usage. In this study, participants were categorized by age based on Prensky's (2001) distinction between digital natives and digital immigrants. Prensky (2001) defines individuals born after 1985 as digital natives and those born earlier as digital immigrants. The terms digital natives and digital immigrants are popular in the literature. A search using the keywords "Digital Natives" and "Digital Immigrants" revealed 369 publications in the Web of Science database and 399 publications in the Scopus database. A search using only the keyword "Digital Natives" found 2,173 publications in the Web of Science database and 807 in the Scopus database (as of September 2024).

In areas such as digital transformation, which are rapidly changing and influenced by demographic factors, ensuring measurement invariance across gender and age is considered essential for obtaining meaningful results. Moreover, establishing measurement invariance across gender and age allows for reliable comparisons of the impact of the factors predicted by the Unified Theory of Acceptance and Use of Technology on different demographic groups.

Method

In this study, the process of scale development and validation was based on Schwab (1980). The scale was developed using a three-step procedure: (1) item development,

STEP	CONTENT	METHOD	QUESTIONNAIRE
Instrument Development	Define the target and purpose Model choice Design dimensions Initial instrument development	Literature review Expert consultation	Version 1.0 (12 items)
Validation	Content validation	Expert assessment	Version 2.0 (9 items)
	Construct validation	Exploratory factor analysis • Kaiser Meyer Olkin (KMO) • Bartlett's test of sphericity • Scree Plot	Version 3.0 (8 items)
		Confirmatory factor analysis	Version 4.0 (8 items)
Reliability	Reliability analysis	Cronbach's alpha Corrected item-total correlation Composite reliability (CR) Average variance extracted (AVE)	Version 4.0 (8 items)

Figure 1. Scale development process.

(2) content validation, and (3) construct validation (Schwab, 1980). In the first step, the study's target population (teachers) and the purpose (assessing perceptions of digital transformation) were defined, and while generating the items, UTAUT was adopted as the guiding theoretical framework. The content of the digital transformation scale to be measured was designed, and the initial form was created. For content validation, expert evaluation was sought. For construct validation, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted. The process followed is shown in Figure 1.

Development of Scale Items

When developing a scale, the items should not be randomly selected but based on a solid theoretical framework. The theoretical structure defines which traits or behaviors the scale aims to measure (Mumford et al., 1996). In this study, the UTAUT, which considers multiple variables to evaluate technology usage, is still widely used, and has proven successful in identifying the variables that influence digital transformation. UTAUT was considered the most appropriate model for this research

(Bajunaied et al., 2023; Hewavitharana et al., 2021; Jayawardena et al., 2023; Rejali et al., 2023; Strzelecki, 2024; Tolkun & Tekin, 2022; Yildiz Durak, 2019). A comprehensive literature review was conducted, and items were generated using a deductive approach for each component of the theory—performance expectancy, behavioral intention, social influence, and facilitating conditions (Hinkin, 1995). This step is considered crucial for establishing the structural validity of the measurement tool (Mumford et al., 1996).

While developing the scale items, care was taken to express them in simple terms that even participants unfamiliar with technology could understand and to ensure that the items were related to participants' real-world experiences (Jang et al., 2022). Several considerations were taken into account during item preparation: ensuring high validity (directly measuring the behavior in question) and clarity for participants. In line with these criteria, a pool of 12 items was prepared.

Content Validity

To ensure that the scale reflects the intended structure (Morgado et al., 2017), the draft items were presented to

three experts familiar with the UTAUT. Based on their recommendations, feedback from five academics specializing in educational sciences was also sought, with particular emphasis on including an expert in measurement and evaluation. Experts were asked to evaluate each of the candidate items in the item pool. Several techniques are commonly used to assess content validity, with two of the most widely accepted being the Davis and Lawshe techniques. The Davis Technique focuses on determining the content validity index (CVI) based on expert evaluations. In this method, experts rate the scale items as either “appropriate” or “inappropriate.” Items are typically scored on a scale from 1 to 4 (1: Definitely inappropriate, 2: inappropriate, 3: appropriate, and 4: definitely appropriate). An acceptable CVI value is generally 0.80 or higher, meaning that at least 80% of the experts find the item appropriate, indicating that the item has sufficient content validity (Davis, 1992).

The Lawshe Technique is another structured approach to assessing content validity. Lawshe’s content validity ratio (CVR) formula is used for this purpose. In this technique, experts are asked to evaluate each item as “essential,” “useful but not essential,” or “not essential.” The CVR value is calculated based on the proportion of experts who mark the item as “essential.” The CVR calculation formula is as follows:

$$CVR = \frac{n_e - N/2}{N/2}$$

n_e : Number of experts who marked the item as “essential.” N : Total number of experts

A positive CVR value indicates that the item is deemed “essential” by the experts. In the Lawshe Technique, as the number of experts increases, the minimum acceptable CVR value decreases. However, as a general rule, a CVR value of 0.50 or higher is considered sufficient for content validity (Lawshe, 1975). Based on expert feedback, two items were removed from the draft form following the application of these content validity techniques. For the remaining items, the CVI value calculated using the Davis technique was 0.90. Additionally, the CVR value calculated using the Lawshe Technique was found to be greater than 0.50.

Based on the feedback from the experts and the techniques used, the final version of the items was reviewed by a linguist. At this stage, the linguist evaluated the items in terms of grammatical rules. The final version was then prepared for the preliminary pilot testing phase.

Preliminary Application

A preliminary pilot study of the scale, which was developed based on expert opinions and reviewed by a

linguist, was conducted with a participant group of 43 individuals representing the target population. During this application, participants were encouraged to openly express any difficulties or misunderstandings they encountered. At the end of the pilot study, the findings were evaluated with the experts who contributed to the scale development process, and based on their recommendations, one item that posed issues in terms of “comprehensibility” was removed from the scale. As a result of these steps, a new version of the scale consisting of a total of nine items was prepared and made ready for implementation.

Data Collection Process

In the study, participants were asked to read and provide consent through an informed voluntary consent form, which was conducted within the school environment. The researchers thoroughly explained the purpose of the study, its implementation method, confidentiality principles, and the voluntary nature of participation. After these explanations, data were collected from the teachers who agreed to participate in the study. Forms, including the Personal Information Form, the Digital Transformation Scale, the 21st Century Technology Literacy Skills Scale, and the Resistance to Change Scale, were distributed to the teachers. Some forms were collected on the same day, while others were retrieved from the schools by the researchers a few days later, and the participants were thanked for their contributions.

Data Analysis

The draft scale was examined for construct validity using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). During the EFA, the principal axis factoring method, which is commonly used in factor analysis, was preferred (de Winter & Dodou, 2012; Tabachnick & Fidell, 2007). When determining the cut-off point for factor loadings, various approaches in the literature were considered, and the generally recommended loading value of 0.40 was adopted (Field, 2009; Hair et al., 2010; Tabachnick & Fidell, 2007). Items with a loading value above 0.30 and a difference of less than 0.10 in loading values across two factors were considered cross-loading items and were removed from the scale (Hair et al., 2010; Worthington & Whittaker, 2006). Additionally, since it was assumed that the factors were correlated, the promax method, one of the oblique rotation techniques, was used in the EFA (Grieder & Steiner, 2021). Based on the CFA results, values such as chi-square goodness of fit (χ^2/df), goodness of fit index (GFI), root mean square error of approximation (RMSEA), comparative fit index (CFI), and

Table 1. Acceptable Limits for Fit Indices.

Fit indices	χ^2/SD	RMSEA	SRMR	CFI	TLI
Perfect fit	≤ 5	≤ 0.05	< 0.08	≥ 0.95	≥ 0.95
Acceptable fit	≤ 3	$\leq 0.08/\leq 0.10$	≤ 0.05	≥ 0.90	≥ 0.90

Source: Hu and Bentler (1999); Sümer (2000); Tabachnick and Fidell (2007); Kline (2005); Savci and Aysan, (2016).

standardized root mean square residual (SRMR) were calculated to evaluate the model's fit (Çokluk et al., 2010). Acceptable limits are presented in Table 1.

In this study, the average variance extracted (AVE) and composite reliability (CR) values, as recommended by Fornell and Larcker (1981), were calculated to determine convergent validity. The AVE value is expected to be at least 0.50, and the CR value should be higher than the AVE value (Fornell & Larcker, 1981). Additionally, to assess the reliability of the scale, Cronbach's alpha internal consistency coefficient and test-retest reliability values were calculated (DeVellis, 2017).

Furthermore, measurement invariance was conducted to determine whether the scale measures the same construct across different demographic groups. Measurement invariance is typically assessed by examining changes in χ^2 (Byrne et al., 1989). Additionally, it is recommended to calculate the Tucker-Lewis Index (TLI), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), and Comparative Fit Index (CFI) values (Cheung & Rensvold, 2002; Vandenberg & Lance, 2000; van de Schoot et al., 2012). The threshold for ΔCFI and ΔTLI is at least 0.01, and for $\Delta RMSEA$ and $\Delta SRMR$, the threshold is 0.015 (Chen, 2007; Cheung & Rensvold, 2002). In this study, we aimed to determine whether the digital transformation scale demonstrated measurement invariance across gender (male and female) and age (below 40 and above 40) categories. The age categorization was made according to Prensky's (2001) distinction between digital natives and digital immigrants. Based on the balanced number of participants, they were divided into two groups: digital natives under the age of 40 ($n = 117$) and digital immigrants over the age of 40 ($n = 127$). To ensure invariance, the chi-square difference test was used along with the ΔCFI , ΔTLI , $\Delta RMSEA$, and $\Delta SRMR$ criteria.

Study Group

To ensure the validity and reliability of the scale, data were collected from a sufficiently large and appropriate sample representing the target group. During the scale development process, five different study groups were involved: Pilot Study, EFA, CFA, Criterion Validity,

and Test-Retest samples. When reviewing the relevant literature on sample size in scale development, some authors suggest that a minimum sample size of 200 is recommended (Hair et al., 2010; P. Kline, 1994), while others propose determining the sample size based on the number of items. It is generally accepted that there should be at least 10 participants per item, but an ideal participant-to-item ratio is recommended to be 15 or 20 (Clark & Watson, 1995; DeVellis, 2017). In this context, a pilot study was initially conducted with 43 teachers working in eastern Turkey. For Exploratory Factor Analysis (EFA), data were collected from 214 teachers in the same region, while Confirmatory Factor Analysis (CFA) was conducted with 211 teachers working in a city in southeastern Turkey. Additionally, the criterion validity of the digital transformation scale was assessed with a randomly selected sample of 244 teachers from both cities. The test-retest reliability of the digital transformation scale was evaluated with 116 teachers over a 3-week interval. In conclusion, the scale development process involved a total of 828 teachers working in different cities. Demographic information about the study group is presented in Table 2.

Data Collection Instruments

In this study, data were collected using the 21st Century Technology Literacy Skills Scale (TLSS), Resistance to Change Scale (RCS), Digital Transformation Scale (DTS), and Personal Information Form.

Personal Information Form: This form, prepared by the researchers, aimed to collect information about the teachers' gender, school type, and professional seniority.

21st Century Technology Literacy Skills Scale (TLSS): Developed by Kalaycı and Eşgi (2024), this 14-item scale was used to assess criterion validity. It is a five-point Likert scale (1: strongly disagree–5: strongly agree) and has three sub-dimensions: understanding technology, using technology, and paying attention. The internal consistency coefficient of the scale was reported as 0.90 by Kalaycı and Eşgi (2024), while in this study, it was found to be 0.94.

Resistance to Change Scale (RCS): Originally developed by Oreg (2006) and adapted into Turkish by Çalışkan (2019), this 15-item scale is also a five-point

Table 2. Demographic Information of the Study Group.

Variables	Pre-pilot application sample		EFA sample		DFA sample		Criterion validity sample		Test-retest sample	
	N	%	N	%	N	%	N	%	N	%
Gender										
Female	20	46.5	116	54.2	123	58.3	136	55.7	64	55.2
Male	23	53.5	98	45.8	88	41.7	108	44.3	52	44.8
School type										
Primary school	8	18.6	43	20.1	75	35.5	65	26.7	30	25.9
Secondary school	13	30.2	52	24.3	36	17.1	49	20.1	24	20.7
High school	6	14.0	47	22.0	50	23.7	63	25.8	27	23.3
Other (Bilsem, special education etc...)	16	37.2	72	33.6	50	23.7	67	27.5	35	30.2
Professional seniority										
5 years and less	7	16.3	25	11.7	40	19.0	36	14.8	23	19.8
6–10 years	13	30.2	27	12.6	20	9.5	26	10.7	10	8.6
11–15 years	9	20.9	58	27.1	59	28.0	68	27.9	31	26.7
16–20 years	14	32.6	39	18.2	31	14.7	42	17.2	17	14.7
21 years and above			65	30.4	61	28.9	72	29.5	35	30.2
Total	43		214		211		244		116	

Note. Efforts were made to ensure that the participants were balanced in terms of gender, school type, and professional seniority, and that the groups were homogeneous. EFA = exploratory factor analysis; CFA = confirmatory factor analysis.

Likert scale (1: strongly disagree–5: strongly agree). It has three sub-dimensions: cognitive reaction, emotional reaction, and behavioral reaction. The internal consistency coefficient of the scale was reported as 0.94 by Çalışkan (2019), while in this study, it was found to be 0.78.

Digital Transformation Scale (DTS): The DTS, developed as part of this study, has demonstrated psychometric properties. Detailed information regarding the scale's psychometric features is presented in the findings section.

Findings

Construct Validity

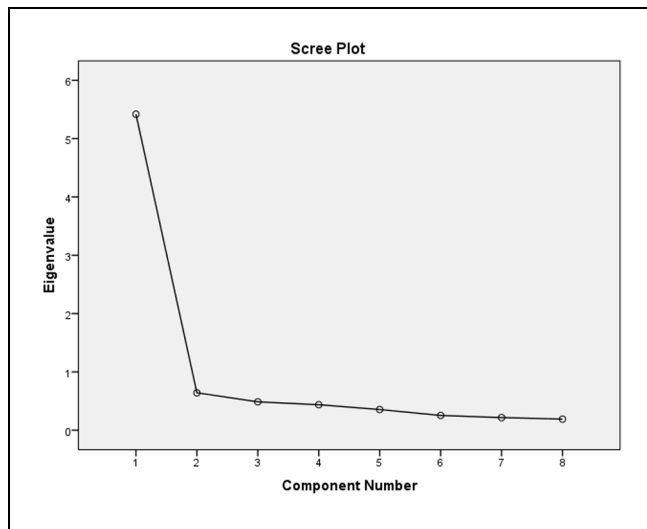
Exploratory Factor Analysis (EFA). Factor analysis is one of the most commonly used techniques in scale development studies to achieve construct validity (Çokluk et al., 2010). In this study, EFA was conducted with data obtained from 214 teachers working in eastern Turkey. Before conducting factor analysis, the suitability of the data for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity. The results showed a KMO value of 0.910, and for Bartlett's test, $\chi^2 = 1235.442$ ($p < .000$). A KMO value above 0.90 and significant results from Bartlett's test indicate that the data are suitable for EFA (Çokluk et al., 2010; Field, 2009; Tabachnick & Fidell, 2007).

Using principal component analysis, EFA was conducted on eight items. In EFA, it is important to reveal relationships between items with as few factors as possible. In this context, factors with eigenvalues of 1 or higher should be considered (Hutcheson & Sofroniou, 1999). Additionally, an item's factor loading must be 0.40 or higher, and the difference between the factor loading on its respective factor and other factors should be 0.10 or greater (Büyüköztürk, 2012). According to these criteria, the item loadings were deemed appropriate, but item nine loaded on multiple factors, with a difference in loadings less than 0.10. Therefore, this item was excluded from the analysis. As a result, the remaining eight items were found to form a single-factor structure, which met the specified criteria. The results of the EFA are presented in Table 3.

The factor loadings of the items ranged from 0.730 to 0.874, indicating that the items represent the scale well (Field, 2009; Hair et al., 2010; Tabachnick & Fidell, 2007). As shown in Table 3, the eigenvalue of the one-factor structure was 5.419, explaining 67.73% of the total variance. It is expected that the total variance explained exceeds 30%, and a higher variance explained indicates a better representation of the construct (Büyüköztürk, 2012; Comrey & Lee, 1992; Çokluk et al., 2010; Savcı

Table 3. EFA Results for the Digital Transformation Scale.

Item	Factor loading value	Variance explained	Core value
3	0.874	67.73	5.419
8	0.859		
5	0.858		
1	0.830		
2	0.825		
6	0.813		
7	0.786		
4	0.730		

**Figure 2.** Scree plot for the digital transformation scale.

et al., 2018; Tavşancıl, 2010). Therefore, the scale is considered to measure digital transformation effectively.

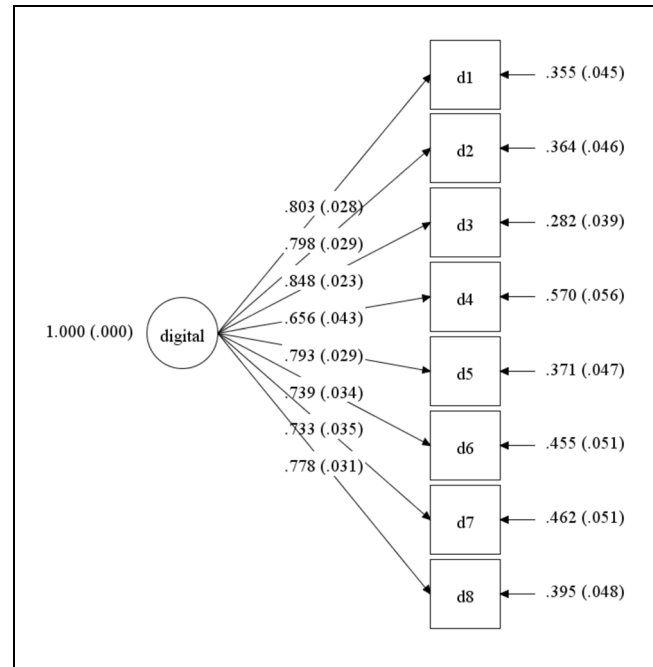
A scree plot is used to determine the number of factors in the scale. The plot shows factor eigenvalues, and the point where the plot begins to flatten indicates the number of factors (Cattell, 1966).

The scree plot for the Digital Transformation Scale is presented in Figure 2.

The scree plot shows that the graph flattens after 1, confirming that the scale is one-dimensional (Cattell, 1966).

Confirmatory Factor Analysis (CFA). The one-dimensional structure revealed by EFA was tested using CFA with data collected from 206 teachers (Figure 3).

The CFA results confirmed that the eight-item, one-dimensional model of the Digital Transformation Scale had good fit indices ($\chi^2 = 64.304$, $df = 19$, $\chi^2/df = 3.384$, RMSEA = 0.078, SRMR = 0.03, CFI = 0.95, TLI = 0.93),

**Figure 3.** CFA results for the digital transformation scale.

as shown in Figure 3. The factor loadings of the items ranged from 0.656 to 0.848, and they were statistically significant (Buyukozturk, 2012).

Criterion Validity

The criterion validity of the Digital Transformation Scale was evaluated using the 21st Century Technology Literacy Skills Scale and the Resistance to Change Scale. Data were collected from a sample of 244 teachers for this analysis. Correlation analysis was conducted with the collected data. The results of the criterion validity are presented in Table 4.

The analysis in Table 4 shows that there was a positive correlation between the Digital Transformation Scale and the 21st Century Technology Literacy Skills Scale ($r = .79$, $p < .01$), and a negative correlation with the Resistance to Change Scale ($r = -.32$, $p < .01$).

Reliability

The reliability of the Digital Transformation Scale was assessed using Cronbach's alpha internal consistency coefficient and test-retest reliability. The reliability studies were conducted across three different samples (Table 5).

In the sample used for Exploratory Factor Analysis (EFA), the Cronbach's α internal consistency reliability coefficient was determined to be .93. For the

Table 4. Criterion Validity Correlations for the Digital Transformation Scale.

Variables	21st century technology literacy	Resistance to change scale
Digital transformation scale	0.79**	−0.32**

** $p < .01$.

Confirmatory Factor Analysis (CFA) sample, this coefficient was found to be .91. Additionally, for the sample used in the criterion validity analysis, the Cronbach's α value was recorded as .92. As presented in Table 5, these results indicate that the reliability coefficients calculated for all three samples were at a high level. Furthermore, to evaluate whether the digital transformation scale yielded consistent results over time, the test-retest method was applied. The test-retest analysis was conducted with 102 teachers from the CFA sample, with data collected at 3-week intervals. The correlation between the two administrations was found to be .73. Additionally, the composite reliability (CR) of the developed scale was calculated to be 0.92, and the average variance extracted (AVE) for convergent validity was determined to be 0.59. These findings support the reliability of the scale.

Item Analysis

The item-total correlation value was calculated for each item in the scale. Item-total correlations of .40 and above are considered satisfactory (Aday & Cornelius, 2006). Items with values above this threshold are considered to have excellent discriminatory power. A positive correlation indicates that items are consistently related to other items within the same scale. The discriminatory power of DTS items was evaluated using the top and bottom 27% rule and corrected item-total correlation coefficients. In the EFA sample, correlation coefficients ranged from .61 to .75, and the 27% difference ranged from 9.01 to 6.41 (t -values; $p < .001$). In the CFA sample, these values were 0.58 to 0.67 and 8.14 to 6.27, respectively; in the criterion validity sample, they were 0.60 to 0.68 and 8.71 to 6.35 (t -values; $p < .001$). The results are presented in Table 6.

Measurement Invariance

The categories determined by gender and age variables were evaluated across four levels of measurement invariance: configural, metric, scalar, and strict. The results are presented in Table 7.

Tests for gender invariance yielded the following fit statistics for the different models: The configural model

Table 5. Reliability Values of the Digital Transformation Scale.

Scale	Cronbach alpha (EFA sample)	Cronbach alpha (CFA sample)	Cronbach alpha (in the criterion validity sample)	The test-retest analysis	CR	AVE
Digital transformation Scale	.93	.91	.92	0.73**	0.92	0.59

** $p < .01$.**Table 6.** Item Analysis.

EFA sample			CFA sample			Criterion validity sample		
Item	R_{jx}	T	Item	r_{jx}	t	Item	r_{jx}	t
1	.70	8.21***	1	.62	6.19***	1	.65	8.31***
2	.70	7.33***	2	.64	7.75***	2	.62	6.22***
3	.75	7.16***	3	.68	6.42***	3	.74	8.16***
4	.61	6.41***	4	.58	6.28***	4	.66	6.35***
5	.74	9.01***	5	.67	8.14***	5	.67	7.20***
6	.68	6.94***	6	.61	7.11***	6	.68	8.71***
7	.67	7.71***	7	.61	6.27***	7	.62	7.42***
8	.71	8.89***	8	.66	7.41***	8	.60	6.21***

*** $p < .001$.

Based on these results, it can be concluded that the items in the scale adequately reflect the overall structure of the test.

Table 7. Measurement Model Results.

Model	$\chi^2/(df)$	CFI	TLI	RMSEA	SRMR	Model comparison	$\Delta\chi^2 (df)$	$p(\chi^2)$	ΔCFI	ΔTLI	$\Delta RMSEA$	$\Delta SRMR$
Gender (N = 211)												
Model 1: full configural	94.673/36	0.947	0.917	0.094	0.041							
Model 2: full metric	101.092/43	0.947	0.931	0.085	0.076	Metric-configural	6.419 (7)	.491	0.000	0.014	-0.009	0.035
Model 3: full scalar	111.385/50	0.944	0.938	0.081	0.081	Scalar-metric	10.293 (7)	.271	-0.003	0.007	-0.004	0.005
Model 4: full strict	131.214/58	0.934	0.936	0.085	0.062	Strict-scalar	19.829 (8)	.172	0.010	-0.002	0.004	-0.019
Age (N = 211)												
Model 1: full configural	101.601/38	0.955	0.933	0.090	0.036							
Model 2: full metric	103.757/45	0.958	0.948	0.077	0.049	Metric-configural	2.156 (7)	.950	0.003	0.015	-0.013	0.013
Model 3: full scalar	106.995/52	0.961	0.958	0.068	0.051	Scalar-metric	3.238 (7)	.979	0.003	0.010	-0.009	0.002
Model 4: full strict	124.206/60	0.954	0.957	0.070	0.085	Strict-scalar	19.829 (8)	.862	-0.007	-0.001	0.002	-0.034

$p > .01$.

had $\chi^2 (36) = 94.673$, CFI = 0.947, TLI = 0.917, RMSEA = 0.094, and SRMR = 0.041. For the metric model, the values were $\chi^2 (43) = 101.092$, $p = .491$, CFI = 0.947, TLI = 0.931, RMSEA = 0.085, and SRMR = 0.076, indicating invariance. Similarly, the scalar model showed $\chi^2 (50) = 111.385$, $p = .271$, CFI = 0.944, TLI = 0.938, RMSEA = 0.081, and SRMR = 0.081, confirming invariance. Lastly, the strict model displayed $\chi^2 (58) = 131.214$, $p = .172$, CFI = 0.934, TLI = 0.936, RMSEA = 0.085, and SRMR = 0.062, confirming invariance. Therefore, the dataset met the requirement for invariance of the gender measure across the metric, scalar, and strict models. This is supported by insignificant χ^2 difference tests and consistent changes in CFI, TLI, RMSEA, and SRMR. The nonsignificant $p(\chi^2)$ values provide additional evidence that invariance holds.

Tests for age invariance yielded the following fit statistics for the different models: The configural model had $\chi^2 (38) = 101.601$, CFI = 0.955, TLI = 0.933, RMSEA = 0.090, and SRMR = 0.036. For the metric model, the values were $\chi^2 (45) = 103.757$, $p = .950$, CFI = 0.958, TLI = 0.948, RMSEA = 0.077, and SRMR = 0.049, indicating invariance. Similarly, the scalar model showed $\chi^2 (52) = 106.995$, $p = .979$, CFI = 0.961, TLI = 0.958, RMSEA = 0.068, and SRMR = 0.051, confirming invariance. Lastly, the strict model displayed $\chi^2 (60) = 124.206$, $p = .862$, CFI = 0.954, TLI = 0.957, RMSEA = 0.070, and SRMR = 0.085, confirming invariance. Therefore, the dataset met the requirement for invariance of the age measure across the metric, scalar, and strict models. This is supported by insignificant χ^2 difference tests and consistent changes in CFI, TLI, RMSEA, and SRMR. Moreover the nonsignificant $p(\chi^2)$ values provide additional evidence that invariance holds.

Conclusion and Discussion

In this study, we developed the DTS to evaluate the perceptions of digital transformation among teachers in schools in Turkey. First, we conducted a literature review and created an initial pool of 12 items. For content validity, feedback on the appropriateness and clarity of the items was gathered from three experts familiar with the UTAUT, followed by input from five other field experts. In doing so, we applied the Davis and Lawshe techniques. As a result of the methods used, including the pilot study and EFA, four items were eliminated. The remaining eight items were then evaluated for construct validity using three different samples. To determine construct validity, both EFA and CFA methods were employed. The criterion validity of the DTS was tested by examining its relationship with the 21st Century Technology Literacy Skills Scale (TLSS) and the RCS. Cronbach's alpha values were calculated for each sample,

and reliability analyses were conducted using the test-retest method. Corrected item-total correlation coefficients and differences between the top and bottom 27% groups (*t*-values) were also calculated. The EFA results for the DTS indicated a one-factor structure with items having eigenvalues greater than 1. Factors should explain between 40% and 60% of the total variance (Hair et al., 1986; Scherer et al., 1988; Tavşancıl, 2010). The results showed that the one-factor structure explained a large proportion of the total variance. Each item's factor loading should be at least 0.30 (Büyüköztürk, 2012; Şencan, 2005; Sipahi et al., 2008), and all of our items met this criterion. The CFA results from different samples also confirmed that the model had acceptable fit indices (Büyüköztürk, 2012; Çokluk et al., 2010; T. J. Kline, 2005).

According to the criterion validity analysis, a positive relationship was found between the DTS and the TLSS scores, indicating that higher perceptions of digital transformation are associated with improved technology literacy skills. A negative relationship was observed between the DTS and RCS scores, suggesting that as perceptions of digital transformation increase, resistance to change decreases. In the reliability analysis, Cronbach's alpha coefficients were found to be sufficient in all three samples. The test-retest method also confirmed the reliability of the scale. In the item analyses, the DTS demonstrated satisfactory corrected item-total correlation coefficients. The differences between the top and bottom 27% groups were statistically significant in all samples. In conclusion, the DTS has been shown to be a reliable and valid measurement tool.



According to the UTAUT, moderating factors such as gender, age, experience, and voluntariness play a significant role in technology acceptance (Omar et al., 2019; Venkatesh et al., 2003). These factors determine how individuals approach technology and under what conditions they begin to adopt and use it. When examining digital transformation processes in the field of education, the perceptions that teachers develop in line with these factors have a significant impact on the digitalization process. Analyzing the differences in teachers' perceptions of digital transformation based on factors such as gender and age allows for more effective implementation of digital education strategies. In this context, the DTS was developed to measure the perceptions of digital transformation among teachers in Turkey. Validity and reliability tests of the scale were conducted on five different samples, and the results demonstrated that the DTS is a reliable measurement tool. Furthermore, measurement invariance analyses based on UTAUT factors such as gender and age revealed the consistency of digital transformation perceptions among teachers and the influence of these factors on their perceptions.

When teachers have a high perception of digital transformation, the quality and efficiency in education increase, whereas when this perception is low, the process of adopting and using technology is negatively affected. Therefore, accurately measuring teachers' perceptions of digital transformation is critical to the success of digitalization in education. In the future, the application of the DTS across different cultural and demographic groups will contribute to evaluating digital transformation processes from different perspectives. Understanding how teacher groups from various cultural and socio-demographic backgrounds perceive these processes can help develop new approaches to global digitalization strategies. The final version of the scale developed in this study is presented in Appendix 1.

Limitations and Future Research

This study contributes to the understanding of teachers' perceptions of digital transformation through the development and validation of the DTS. However, it is important to acknowledge some limitations. First, the sample was drawn exclusively from teachers in specific regions of Turkey, which may limit the generalizability of the findings. Future research should consider expanding the sample to include teachers from various geographical locations and educational contexts to enhance the external validity of the scale. Second, while this study effectively validated the DTS using confirmatory factor analysis, the research relied on cross-sectional data. Longitudinal studies are recommended to further assess the scale's stability and the changes in teachers' perceptions of digital transformation over time. This will help establish the scale's robustness and its applicability in different educational settings. Third, this study focused on the measurement of teachers' perceptions regarding digital transformation. Future research could explore the impact of these perceptions on teaching practices and student outcomes, providing valuable insights into the practical implications of digital transformation in education. Lastly, the DTS should be tested in various educational settings, including different educational levels (e.g., primary, secondary, and higher education) and subjects, to determine its effectiveness and relevance across diverse teaching environments. Addressing these limitations will allow future studies to contribute to a more comprehensive understanding of digital transformation in education and the factors influencing its successful implementation.

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All authors contributed to the conception and design of the study, read, and edited the manuscript, and suggested improvements at several stages during the preparation and revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

Data will be made available on reasonable request.

References

- Aday, L. A., & Cornelius, L. J. (2006). *Designing and conducting health surveys: A comprehensive guide*. John Wiley & Sons.
- Agostino, D., & Costantini, C. (2022). A measurement framework for assessing the digital transformation of cultural institutions: The Italian case. *Meditari Accountancy Research*, 30(4), 1141–1168. <https://doi.org/10.1108/medar-02-2021-1207>
- AL-Ali, M., & Marks, A. (2022). A digital maturity model for the education enterprise. *Perspectives Policy and Practice in Higher Education*, 26(2), 47–58. <https://doi.org/10.1080/13603108.2021.1978578>
- Alpaslan, M. M., Ulubey, Ö., & Ata, R. (2021). Adaptation of technological pedagogical content knowledge scale into Turkish culture within the scope of 21st century skills. *Psycho-Educational Research Reviews*, 10(1), 77–91.
- Ambarwati, R., Harja, Y. D., & Thamrin, S. (2020). The role of facilitating conditions and user habits: a case of Indonesian online learning platform. *The Journal of Asian Finance, Economics and Business*, 7(10), 481–489. <https://doi.org/10.13106/jafeb.2020.vol7.no10.481>
- Aydin, Ü. Y., & Atasoy, B. (2023). Primary school teachers' opinions on distance education via EBA platform during the COVID-19 epidemic. *Gazi University Journal of Gazi Faculty of Education*, 43(3), 1687–1714.
- Bajunaied, K., Hussin, N., & Kamarudin, S. (2023). Behavioral intention to adopt FinTech services: An extension of unified theory of acceptance and use of technology. *Journal of Open Innovation Technology Market and Complexity*, 9(1), 100010.
- Büyüköztürk, S. (2012). *Handbook of data analysis for social sciences* (14th ed.). Pegem A Publishing.
- Byrne, B. M., Shavelson, R. J., & Muthén, B. (1989). Testing for the equivalence of factor covariance and mean structures: The issue of partial measurement invariance. *Psychological Bulletin*, 105, 456–466. <https://doi.org/10.1037//0033-2909.105.3.456>
- Çalışkan, A. (2019). Resistance to change: A study of scale adaptation. *Süleyman Demirel University Journal of Faculty of Economics and Administrative Sciences*, 24(2), 237–252.
- Cattell, R. B. (1966). The screen test for the number of factors. *Multivariate behavioral research*, 1(2), 245–276.
- Ceylan, S., Çetin, S. N., Tozanli, Y., & Isler, M. (2024). Middle school students' orientations toward the use of the EBA portal: A content analysis of theses published in the YÖKTEZ database between 2018–2023. *National Journal of Education*, 4(6), 1122–1131.
- Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling A Multidisciplinary Journal*, 14(3), 464–504. <https://doi.org/10.1080/10705510701301834>
- Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural equation modeling*, 9(2), 233–255. https://doi.org/10.1207/S15328007SEM0902_5
- Christensen, R., & Knezek, G. (2017). Validating the technology proficiency self-assessment questionnaire for 21st century learning (TPSA C-21). *Journal of Digital Learning in Teacher Education*, 33(1), 20–31. <https://doi.org/10.1080/21532974.2016.1242391>
- Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment*, 7(3), 309–319. <https://doi.org/10.1037/1040-3590.7.3.309>
- Çokluk, O., Sekercioglu, G., & ve Büyüköztürk, S. (2010). *Multivariate statistics for social sciences: SPSS and Lisrel applications*. Pegem A Publishing.
- Comrey, A. L., & Lee, H. B. (1992). *A first course in factor analysis* (2nd ed.). Lawrence Erlbaum Associates.
- D'Urso, E. D., De Roover, K., Vermunt, J. K., & Tijnstra, J. (2022). Scale length does matter: Recommendations for measurement invariance testing with categorical factor analysis and item response theory approaches. *Behavior Research Methods*, 54(5), 2114–2145. <https://doi.org/10.3758/s13428-021-01690-7>
- Davis, L. L. (1992). Instrument review: Getting the most from a panel of experts. *Applied Nursing Research*, 5(4), 194–197. [https://doi.org/10.1016/S0897-1897\(05\)80008-4](https://doi.org/10.1016/S0897-1897(05)80008-4)
- DeVellis, R. F. (2017). *Scale development: Theory and applications* (4th ed.). Sage Publications.
- de Winter, J. C. F., & Dodou, D. (2012). Factor recovery by principal axis factoring and maximum likelihood factor analysis as a function of factor pattern and sample size. *Journal of Applied Statistics*, 39(4), 695–710. <https://doi.org/10.1080/02664763.2011.610445>
- Erkam Sulak, S. (2019). Development of the digital literacy scale: A validity and reliability study. *Social Sciences Studies Journal*, 5(31), 1329–1342. <https://doi.org/10.26449/sssj.1345x>
- Field, A. (2009). *Discovering statistics using IBM SPSS Statistics*. Sage Publications Limited.
- Fischer, R., & Karl, J. A. (2019). A primer to (cross-cultural) multi-group invariance testing possibilities in R. *Frontiers in Psychology*, 10, 1507. <https://doi.org/10.3389/fpsyg.2019.01507>

- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of marketing research*, 18(1), 39–50. <https://doi.org/10.1177/002224378101800104>
- Genz, S., & Schnabel, C. (2023). Digitalization is not gender-neutral. *Economics Letters*, 230, 111256. <https://doi.org/10.1016/j.econlet.2023.111256>
- Ghomi, M., & Redecker, C. (2019). Digital competence of educators (DigCompEdu): Development and evaluation of a self-assessment instrument for teachers' digital competence. In *Proceedings of the 11th International Conference on Computer Supported Education (CSEDU 2019)* (pp. 541–548). Science and Technology Publications.
- Grieder, S., & Steiner, M. D. (2021). Algorithmic jingle jungle: A comparison of implementations of principal axis factoring and promax rotation in R and SPSS. *Behavior Research Methods*, 54(1), 54–74. <https://doi.org/10.3758/s13428-021-01581-x>
- Hair, J. F., Anderson, R. E., Jr, & Tatham, R. L. (1986). *Multivariate data analysis with readings*. Macmillan Publishing Co., Inc.
- Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (Eds.). (2010). *Multivariate Data Analysis* (7th ed.). Pearson Education.
- Hewavitharana, T., Nanayakkara, S., Perera, A., & Perera, P. (2021). Modifying the unified theory of acceptance and use of technology (UTAUT) model for the digital transformation of the construction industry from the user perspective. *Informatics*, 8(4), 81. <https://doi.org/10.3390/informatics8040081> November.
- Hinkin, T. R. (1995). A review of scale development practices in the study of organizations. *Journal of Management*, 21(5), 967–988. <https://doi.org/10.1177/014920639502100509>
- Horzum, M. B., Akgün, Ö. E., & Öztürk, E. (2014). The psychometric properties of the technological pedagogical content knowledge scale. *International Online Journal of Educational Sciences*, 6(3), 544–557.
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling A Multidisciplinary Journal*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>
- Hutcheson, G. D., & Sofroniou, N. (1999). The multivariate social scientist: Introductory statistics using generalized linear models.
- Iivari, N., Sharma, S., & Ventä-Olkkonen, L. (2020). Digital transformation of everyday life – How COVID-19 pandemic transformed the basic education of the young generation and why information management research should care? *International Journal of Information Management*, 55, 102183. <https://doi.org/10.1016/j.ijinfomgt.2020.102183>
- Ismail, S. N., Omar, M. N., Don, Y., Purnomo, Y. W., & Kasa, M. D. (2022). Teachers' acceptance of mobile technology use towards innovative teaching in Malaysian Secondary Schools. *International Journal of Evaluation and Research in Education (IJERE)*, 11(1), 120–127. <https://doi.org/10.11591/ijere.v11i1.21872>
- Jang, Y., Choi, S., & Kim, H. (2022). Development and validation of an instrument to measure undergraduate students' attitudes toward the ethics of artificial intelligence (AT-EAI) and analysis of its difference by gender and experience of AI education. *Education and Information Technologies*, 27(8), 11635–11667. <https://doi.org/10.1007/s10639-022-11086-5>
- Jayawardena, C., Ahmad, A., Valeri, M., & Jaharadak, A. A. (2023). Technology acceptance antecedents in digital transformation in hospitality industry. *International Journal of Hospitality Management*, 108, 103350. <https://doi.org/10.1016/j.ijhm.2022.103350>
- Kalayci, R., & Esgi, N. (2024). Development of the 21st century technology literacy skills scale, validity and reliability study. *European Journal of Education Studies*, 11(5), 175–195. <https://doi.org/10.46827/ejes.v11i5.5293>
- Kim, J., & Lee, K. S. S. (2022). Conceptual model to predict Filipino teachers' adoption of ICT-based instruction in class: Using the UTAUT model. *Asia Pacific Journal of Education*, 42(4), 699–713. <https://doi.org/10.1080/02188791.2020.1776213>
- Kim, S., Choi, B., & Lew, Y. K. (2021). Where is the age of digitalization heading? The meaning, characteristics, and implications of contemporary digital transformation. *Sustainability*, 13(16), 8909. <https://doi.org/10.3390/su13168909>
- Kline, P. (1994). *An easy guide to factor analysis*. Routledge.
- Kline, T. J. (2005). *Psychological testing: A practical approach to design and evaluation*. Sage. <https://doi.org/10.4135/9781483385693>
- Kontić, L., & Vidicki, Đ. (2018). Strategy for digital organization: Testing a measurement tool for digital transformation. *Strategic Management*, 23(2), 29–35.
- Koral Gümüşoglu, E., & Akay, E. (2017). Measuring technology acceptance level of teachers by using unified theory of acceptance and use of technology. *International Journal of Languages' Education and Teaching*, 5(4), 378–394.
- Küslü, F. (2022). *Teachers' critical digital literacy skills examined in terms of various variables* [Doctoral dissertation, Anadolu University, Institute of Educational Sciences]
- Larsson, A., & Viitaoja, Y. (2019). Identifying the digital gender divide: How digitalization may Affect the future working conditions for women. In A. Larsson & R. Teigland (Eds.), *The digital transformation of labor* (pp. 235–253). Routledge. <https://doi.org/10.4324/9780429317866-14>
- Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology*, 28(4), 563–575. <https://doi.org/10.1111/j.1744-6570.1975.tb01393.x>
- Lin, C. Y., Li, C., Mahmood, S., Guo, F., & Qian, Z. (2024). Integrating culture and tourism: A resilient scale for digital transformation innovation. *Journal of the Knowledge Economy*, 15, 16122–16155. <https://doi.org/10.1007/s13132-024-01753-y>
- Luo, W., Berson, I. R., Berson, M. J., & Li, H. (2021). Are early childhood teachers ready for digital transformation of instruction in Mainland China? A systematic literature review. *Children and Youth Services Review*, 120, 105718. <https://doi.org/10.1016/j.childyouth.2020.105718>
- Magsamen-Conrad, K., Upadhyaya, S., Joa, C. Y., & Dowd, J. (2015). Bridging the divide: Using UTAUT to predict

- multigenerational tablet adoption practices. *Computers in Human Behavior*, 50, 186–196. <https://doi.org/10.1016/j.chb.2015.03.032>
- Mahlow, C., & Hediger, A. (2019). Digital Transformation in Higher Education-Buzzword or Opportunity? *eLearn Mag*, 2019(5), 13.
- Morgado, F. F., Meireles, J. F., Neves, C. M., Amaral, A. C., & Ferreira, M. E. (2017). Scale development: ten main limitations and recommendations to improve future research practices. *Psicologia: Reflexão e Crítica*, 30(0), 3. <https://doi.org/10.1186/s41155-016-0057-1>
- Mumford, M. D., Costanza, D. P., Connelly, M. S., & Johnson, J. F. (1996). Item generation procedures and background data scales: Implications for construct and criterion-related validity. *Personnel Psychology*, 49(2), 361–398. <https://doi.org/10.1111/j.1744-6570.1996.tb01804.x>
- Nadeem, A., Abedin, B., Cerpa, N., & Chew, E. (2018). Digital transformation & digital business strategy in electronic commerce-the role of organizational capabilities. *Journal of theoretical and applied electronic commerce research*, 13(2), 1–8.
- Neslin, S. A., & Shankar, V. (2009). Key issues in multichannel customer management: Current knowledge and future directions. *Journal of Interactive Marketing*, 23(1), 70–81. <https://doi.org/10.1016/j.intmar.2008.10.005>
- Nikolopoulou, K., Gialamas, V., & Lavidas, K. (2021). Habit, hedonic motivation, performance expectancy and technological pedagogical knowledge affect teachers' intention to use mobile internet. *Computers and Education Open*, 2, 100041. <https://doi.org/10.1016/j.caeo.2021.100041>
- Omar, M. N., Ismail, S. N., & Kasim, A. L. (2019). The influence of mobile technology adoption among secondary school teachers using the UTAUT2 model. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(4), 3827–3831. <https://doi.org/10.35940/ijrte.d8204.118419>
- Oreg, S. (2006). Personality, context, and resistance to organizational change. *European Journal of Work and Organizational Psychology*, 15(1), 73–101. <https://doi.org/10.1080/13594320500451247>
- Pettersson, F., Siljebo, J., Wolming, S., & Ferry, M. (2024). A validated questionnaire for measuring digitalization as sociocultural change in educational contexts. *The International Journal of Information and Learning Technology*. <https://doi.org/10.1108/IJILT-08-2023-0149>
- Prensky, M. (2001). Digital natives, digital immigrants part 2: Do they really think differently? *On the horizon*, 9(6), 1–6. <https://doi.org/10.1108/10748120110424843>
- Rejali, S., Aghabayk, K., Esmaeli, S., & Shiwakoti, N. (2023). Comparison of technology acceptance model, theory of planned behavior, and unified theory of acceptance and use of technology to assess a priori acceptance of fully automated vehicles. *Transportation Research Part A Policy and Practice*, 168, 103565. <https://doi.org/10.1016/j.tra.2022.103565>
- Saglam, M. (2021). Realization of digital transformation as the vision of the future in businesses and the Turkish adaptation of the digital transformation scale. *Istanbul Ticaret University Journal of Social Sciences*, 20(40), 395–420. <https://doi.org/10.46928/iticusbe.764373>
- Savci, M., & Aysan, F. (2016). Relationship between impulsivity, social media usage and loneliness. *Educational Process International Journal*, 5(2), 106–115. <https://doi.org/10.12973/edupij.2016.52.2>
- Savci, M., Ercengiz, M., & Aysan, F. (2018). Turkish adaptation of the social media disorder scale in adolescents. *Archives of Neuropsychiatry*, 55(3), 248. <https://doi.org/10.29399/npa.19285>
- Scherer, R. F., Wiebe, F. A., Luther, D. C., & Adams, J. S. (1988). Dimensionality of coping: Factor stability using the ways of coping questionnaire. *Psychological Reports*, 62(3), 763–770. <https://doi.org/10.2466/pr0.1988.62.3.763>
- Schwab, D. P. (1980). Construct validity in organizational behavior. In B. M. Staw & L. L. Cummings (Eds.), *Research in Organizational Behavior* (Vol. 2, pp. 3–43). JAI Press.
- Sencan, H. (2005). Factor analysis and validity. *Validity and Reliability*, 1, 355–414.
- Sipahi, B., Yurtkoru, E. S., & Çinko, M. (2008). *Data analysis with SPSS in social sciences*. Beta Publishing.
- Smirani, L., & Boulahia, J. (2022). Using the unified theory of acceptance and use of technology to investigate the adoption of open educational resources by faculty members. *International Journal of Information Technology*, 14(6), 3201–3211. <https://doi.org/10.1007/s41870-022-00918-9>
- Strzelecki, A. (2024). Students' acceptance of ChatGPT in higher education: An extended unified theory of acceptance and use of technology. *Innovative higher education*, 49(2), 223–245.
- Sümer, N. (2000). Structural equation models: Basic concepts and sample applications. *Türk Psikoloji Yazıları*, 3(6), 49–74.
- Sun, Y., Liu, L., Peng, X., Dong, Y., & Barnes, S. J. (2014). Understanding Chinese users' continuance intention toward online social networks: An integrative theoretical model. *Electronic Markets*, 24, 57–66.
- Su, X., Huang, X., Zhou, C., & Chang, M. (2017). A technological pedagogical content knowledge (TPACK) scale for geography teachers in senior high school. *Eğitim ve Bilim*, 42(190), 325–341.
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*. 5. Bask. Pearson.
- Tavsancil, E. (2010). *Measuring attitudes and data analysis with SPSS*. Nobel Publishing.
- Tekin, A., & Polat, E. (2014). Technology policies in education: Turkey and some other countries. Theory and Practice in Education. *Çanakkale Onsekiz Mart University Journal of Faculty of Education*, 10(5), 1259–1263.
- Teo, T. (2010). Examining the influence of subjective norm and facilitating conditions on the intention to use technology among pre-service teachers: a structural equation modeling of an extended technology acceptance model. *Asia Pacific Education Review*, 11, 253–262.
- Teo, T., & Noyes, J. (2014). Explaining the intention to use technology among pre-service teachers: a multi-group analysis of the Unified Theory of Acceptance and Use of Technology. *Interactive Learning Environments*, 22(1), 51–66. <https://doi.org/10.1080/10494820.2011.641674>
- Tolkun, S., & Tekin, A. (2022). Digital transformation in the Turkish tax system and its role in the effectiveness of tax

- security. *Anadolu Akademi Sosyal Bilimler Dergisi*, 4(2), 290–314.
- Tran Van Hai, T. (2022). Effect of gender and regions on determinants of digital transformation adoption in creative services. *Quality-Access to Success*, 23(186). <https://doi.org/10.2466/pr0.1988.62.3.763>
- Vandenberg, R. J., & Lance, C. E. (2000). A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. *Organizational Research Methods*, 3(1), 4–70. <https://doi.org/10.1177/109442810031002>
- van de Schoot, R., Lugtig, P., & Hox, J. (2012). A checklist for testing measurement invariance. *European Journal of Developmental Psychology*, 9(4), 486–492. <https://doi.org/10.1080/17405629.2012.686740>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27, 425–478.
- Vial, G. (2021). Understanding digital transformation. In A. Smith & B. Jones (Eds.), *Digital Futures: The transformation of business and society* (pp. 45–60). Taylor & Francis. <https://doi.org/10.4324/9781003008637-4>
- Wang, A. Y. (2022). Understanding levels of technology integration: A TPACK scale for EFL teachers to promote 21st-century learning. *Education and Information Technologies*, 27(7), 9935–9952. <https://doi.org/10.1007/s10639-022-11033-4>
- Wang, C. S., Jeng, Y. L., & Huang, Y. M. (2017). What influences teachers to continue using cloud services? The role of facilitating conditions and social influence. *Electronic Library*, 35(3), 520–533. <https://doi.org/10.1108/el-02-2016-0046>
- Worthington, R. L., & Whittaker, T. A. (2006). Scale development research: A content analysis and recommendations for best practices. *Counseling Psychologist*, 34(6), 806–838.
- Yildiz Durak, H. (2019). Examining the acceptance and use of online social networks by preservice teachers within the context of unified theory of acceptance and use of technology model. *Journal of Computing in Higher Education*, 31(1), 173–209. <https://doi.org/10.1007/s12528-018-9200-6>
- Yildiz, E. P. (2022). Teacher Education in the Digital Transformation Process in North Cyprus: A Situation Analysis Study. *International Education Studies*, 15(1), 187–199. <https://doi.org/10.5539/ies.v15n1p187>
- Yilmaz Ergül, D., & Tasar, M. F. (2023). Development and validation of the teachers' digital competence scale (TDi-CoS). *Journal of Learning and Teaching in Digital Age*, 8(1), 148–160. <https://doi.org/10.53850/joltida.1204358>
- Yureva, O. V., Burganova, L. A., Kukushkina, O. Y., Myagkov, G. P., & Syradoev, D. V. (2020). Digital transformation and its risks in higher education: Students' and teachers' attitude. *Universal Journal of Educational Research*, 8(11B), 5965–5971. <https://doi.org/10.13189/ujer.2020.082232>

Appendix I. Digital Transformation Scale.

Digital Transformation Scale

Please read the following statements carefully. Then mark the appropriate option from the options given on the right side of the statement.

① Strongly Disagree ② Disagree ③ Neutral ④ Agree ⑤ Strongly Agree

1	I use digital technologies (computer, tablet, smartphone, etc.).	①	②	③	④	⑤
2	I adapt easily to developments in digital technologies.	①	②	③	④	⑤
3	I use digital technologies in educational activities.	①	②	③	④	⑤
4	I think it is useful to use digital technologies in educational activities.	①	②	③	④	⑤
5	I enjoy using digital technologies.	①	②	③	④	⑤
6	Using digital technologies (computers, tablets, smartphones, etc.) has become a habit for me.	①	②	③	④	⑤
7	The effort I put into using digital technologies (computers, tablets, smartphones, etc.) is reasonable.	①	②	③	④	⑤
8	I think that I will continue to use digital technologies (computer, tablet, smartphone, etc.).	①	②	③	④	⑤