International Journal of Assessment Tools in Education
2025, Vol. 12, No. 2, 457–475

https://doi.org/10.21449/ijate.1548724

journal homepage: https://dergipark.org.tr/en/pub/ijate **_Research Article_**

Validity and reliability study of the school technology leadership scale according to teachers' perceptions

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ARTICLE HISTORY

Received: Oct. 1, 2024

Accepted: Mar. 4, 2025

Keywords:

School technology leadership,

School principals' leadership,

Teacher perceptions,

Technology leadership skills,

Scale adaptation.

Abstract: School principals should have school technology leadership skills in order to manage technology integration into teaching and learning activities effectively and efficiently. The 'School Technology Leadership Scale' was developed by Grace in 2020 to assess principals' technology leadership skills from the perspective of the teachers. The scale was presented in five dimensions, but Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were not conducted by Grace in 2020. In the present study, the scale was adapted and modified for a different national school system and language in Türkiye by following an eight-stage process. The factor structure and factor loadings were determined by conducting EFA without removing any items from the original scale, and a two-factor structure was obtained. The validity and reliability of the adapted scale were examined with Cronbach's alpha analysis, item analysis, composite reliability of the new scale structure, intraclass correlation coefficient (ICC) tests, EFA and CFA. The findings indicate that there is a concomitant increase in the perception of technological leadership as the score on the scale increases. The adapted scale is a suitable tool to assess the perceptions of teachers in relation to their principals' technology leadership skills. Determining the indicators of technology leadership skills are important since school principals should develop technological leadership skills to 1) facilitate access to novel technologies in an effective teaching and learning process, 2) support effective learning, 3) render the school management process more practical, transparent, rational and data-driven and 4) promote effective utilization of technology.

1. INTRODUCTION

Technology has entered every aspect of our lives and has influenced society through many changes from the past to the present. The Covid-19 pandemic has accelerated the process of change. Grace (2020) states that the 21st century generation includes students who started kindergarten in the fall of 2018 and all students thereafter, while all educators and principals were born in the 20th century. The digital natives, who were born during technological advancements, are digital immigrants who are resistant to change, and digital hybrids who are adapting to change. Education systems are that can adapt society to change. Schools have important impacts on the society. As open systems, schools constantly interact with their

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e-ISSN: 2148-7456

environment and have a crucial responsibility in preparing qualified individuals with the skills that society needs. According to Ghavifekr and Wong (2022), schools must educate students with 21st-century skills to meet the demands of Industry 4.0 and the rapidly developing technologies. Nowadays, schools are institutions where digital natives, digital hybrids, and digital immigrants coexist. Therefore, the developing economy, technology, globalization and social changes have transformed schools into complex structures and processes, leading to the need for quick decision-making in school management since 2000 (Gümüşeli, 2001).

School leadership is important to integrate Information and Communication Technology (ICT) into school system effectively (Hamzah *et al*., 2014). School principals have a crucial role for effective and efficient use of the technology due to the impact of technology on society and education (Esplin, 2017). According to Torrato *et al*. (2021), the roles of school principals are critical in ensuring students' learning. Therefore, school principals should provide a sustainable and dynamic digital learning culture (Ghavifekr & Wong, 2022). The school principal has two important roles, management and leadership (Akın-Mart & Tulunay-Ateş, 2021). In 21st-century schools, leadership and technology play a crucial role (Grace, 2020). Therefore, theories and models that examine leadership and the leadership process in achieving organizational excellence have emphasized the link of technology with leadership, highlighting the emergence of technology leadership (Hamzah *et al.*, 2014).

The increasing use of technology in all areas has made technology leadership an important issue in school management (Weng & Tang, 2014; Mendoza & Catiis, 2022). According to Sincar (2009), technology leadership is a determining factor in school leadership. Research on technology leadership, as noted by Chang *et al*. (2008), began in the United States in the 1990s and has not lost its importance since then. In recent years, research on the use of technology in schools has gained momentum (Gyeltshen, 2021). As Chang (2008) argues that technology leadership is not only about the use of technology, but also about developing and changing school culture. Therefore, technology leadership remains an important and current concept due to the constantly evolving technology (Kesim, 2020).

In the study context in Türkiye, the Ministry of Education (MEB) Strategic Plan focuses on the development of technological infrastructure, the integration of technology into the education system, the increase of teacher competencies for the use of digital content, and the increase of quality in education (MEB Strategic Plan, 2024). The Twelfth Development Plan (2023) emphasizes the development of the integration of information and communication technologies into education in a way that allows to increase quality, and the increase of digital competencies of students and educators. Among the long-term goals,

> "As digital technologies, personalized learning experiences, virtual and augmented reality, and artificial intelligence become prevalent in education, there will be a simultaneous recognition of the enduring significance of comprehensive teaching, guidance, and social interaction in shaping individual education. The education of the future will prioritize accessibility, diversification, and personalization, with curricula geared toward fostering the development of novel knowledge and skills" (The Twelfth Development Plan, 2023, p. 14).

In addition, 'providing digital competencies to educators' has been determined as the most important strategy of the report in the Türkiye Digital Roadmap (Saçak *et al.*, 2020).

With the widespread use of Web 2.0 applications in the 2020s, there is a need for school technology leaders who are aware of the importance of educational technologies in effective time management for teachers and student learning (Grace, 2020). Dexter and Barton (2021, p. 368) define school technology leadership as "the ability of school leaders to select effective technologies to support student learning and create effective opportunities for teachers to learn how to integrate them." A'mar and Eleyan (2022) emphasize that technology leadership encompasses all activities related to technology in schools, including decision-making, policies and implementation. Also, Grace (2020) points out that school technology leadership focuses on the integration of new technologies into the school environment.

Morgan (2014, p. 8) defines school technology leadership as "a series of instructional leadership practices related to technology integration that are distributed to multiple members of each school team and are consistent with three broad categories, direction setting, people development and organizational redesign." Therefore, technology changes the roles of school principals in terms of instructional leadership (Kwatubana, 2023). Instructional leadership, which includes technology leadership, is developing in a way that the success of computer and information technology applications in schools is a result of effective instructional leadership (Kwatubana, 2023). Technology leadership brings transparency, reliable data provision, practicality, and speed to instructional leadership practices. However, Akada and Şahin-Fırat (2022) argue that school technology leadership can speed up and facilitate school management processes. School technology leadership plays a key role in integrating technology into education because of directing the technology integration program of the school (Torrato *et al.*, 2021; Wu *et al.*, 2015). Additionally, school technology leadership is a type of leadership that requires effective use of technology in school management practices (Topçu & Ersoy, 2020). Within this scope, rational implementation and maintenance of management processes at the organizational level can be achieved. Therefore, it can be claimed that school technology leadership can also increase administrative effectiveness in the school. Ultimately, school technology leadership is a functional type of leadership that encompasses all necessary leadership skills to prepare the school for the 21st century and ensure the beneficial application of technology (Rayray, 2023). It is one of the essential characteristics that school principals should possess (Anderson & Dexter, 2005). The continuous development of technology and its impact on the education system are rapidly creating change in the education process. In this context, it is believed that verifying the instrument that assesses technology leadership skills, adapting the scale by considering different cultures, emerging technologies, and changing practices, would be beneficial for applications in the field.

1.1. The Importance of School Technology Leadership Study

Eight components of technology leadership in schools are identified as follows (Apsorn *et al.*, 2019), 1) developing a vision and operational guidelines for emerging technologies in schools, 2) establishing strategies and providing support to direct teachers and students towards the use of technology in the learning process, 3) preparing plans for the development of teachers' and staff's technological skills, 4) creating a suitable environment by providing resources for the use of information technology, 5) investigating problems that may arise during the use of new technologies and developing solutions to these problems, 6) serving as a model for the use of information technology in education and daily life, 7) creating learning communities by ensuring the information sharing and the establishment of information technology culture among school personnel, 8) developing decision-making strategies in solving problems that may arise at school.

According to Anderson and Dexter (2005), effective school formation is influenced significantly by the school principal. In this regard, as technology advances and becomes digital, it is necessary for school principals to acquire technology leadership skills to increase students' potential (Mendoza & Catiis, 2022). According to Banoğlu (2012), school principals who are technology leaders can ensure the integration of education and technology by integrating them seamlessly. Banoğlu (2012) summarizes the effective educational leader roles as 1) provides technology for educational activities and management while efficiently managing resources, 2) monitors and supports the use of educational technology and professional development of teachers and staff, 3) evaluates educational activities in the school using technology and 4) uses technology appropriately in communication and relationships with the school's environment.

As technology leaders, school principals should be innovative, resourceful, crisis managers, guides, coordinators, knowledge managers, producers and managers (Durnalı, 2018). According to Hsieh *et al.* (2014, p. 113), "the school principal should be literate in information technology to enable the school staff to use technology effectively in teaching, create a learning environment that facilitates students' learning motivation, and achieve the goal of becoming a highly acclaimed school." School principals who are also technology leaders should possess a technology culture to be able to meet the needs of digital natives growing up in a technology culture (Öztaban, 2020).

Researchers have identified essential leadership skills in technology as 1) allocating time for technological education, 2) establishing goals for the administrative and educational use of technology, 3) planning the use of educational technologies, 4) providing equal access to technological resources (Demiraçan, 2019; Durnalı, 2018). Researchers have also determined the key objectives related to technology, tools and infrastructure as 1) sourcing and finding resources for technology, tools and infrastructure, 2) developing strategies for technology integration, 3) ensuring the effective use of technology in teaching and learning, 4) providing technical support to faculty and staff, 5) developing policies and procedures related to technology, tools and infrastructure, 6) establishing goals for the administrative and educational use of technology, 7) planning for the use of educational technologies, 8) recognizing successful technology implementations, 9) understanding the elements that are effective in evaluation, 10) providing visionary leadership, 11) sourcing and finding resources for technology, tools and infrastructure, 12) preparing policies for voluntary participation in technological innovation and usage that align with societal values and 13) advocating for the benefits of technology and determine priorities for its usage (Demiraçan, 2019; Durnalı, 2018). Grady (2011) outlines the roles of a school technology leader as 1) setting the school's technology vision and goals and representing technology, 2) modelling technology use and supporting its use, 3) participating in professional development for the technology integration, 4) providing professional development opportunities for school stakeholders to facilitate technological learning activities, 5) supporting the use and integration of technology by providing technological tools, 6) advocating technology that enhances students' learning activities, 7) being aware of national technology standards and supporting their adoption, encouraging school stakeholders to do the same, 8) informing school stakeholders about the importance of using technology to enhance students' learning skills.

Improving the technology leadership skills of school administrators can contribute to the quality of schools and support adaptation to rapid technological development. In fact, the Türkiye Digital Roadmap report by Saçak *et al*. (2020) emphasizes that "when the strategy of 'providing digital competencies to educators' is implemented alone, more benefits are obtained than when other strategies are implemented alone" (p. 344). This is because technology can create qualified outputs as an element of quality education. According to Gonzales (2020), the technology leadership skills demonstrated by school principals reflect the quality of school leadership, while Nababan *et al.* (2021) argue that quality students are the output of a good school system. School principals' technology leadership supports teachers and students in integrating technology into education in a way that allows effective and efficient learning.

Technology leadership has been analyzed from different perspectives in national and international literature. In this context, the first of these studies was conducted by Aten (1996) and by Anderson and Dexter (2005) in USA, by Tanzer (2004) in Türkiye (cited in Durnalı, 2022). In Türkiye, Sincar's (2009) research on the technological leadership roles of primary school principals is a turning point and the scale developed in this study has been used in eight studies (Durnalı, 2022). In the international literature, the literature on school technology leadership has grown in the first decade of the 21st century and continued to grow in the second decade (Grace, 2020).

According to Grace (2020), scale development in the international literature began with the 'Teaching, Learning and Computing Survey' in 1998, and numerous measurement tools have been developed since then (e.g. Chang *et al*, 2008). Researchers in the international literature have developed scales for their own studies, based on the International Society for Technology in Education's (ISTE, 2018) standard for administrators, which is called the Educational Technology Standards for Administrators (NETS-A) (Grace, 2020). NETS-A, known as technology leadership standards, defines the knowledge and skills that school principals should have in the role of technology leadership in primary and secondary education with five parameters including digital citizenship, equity, visioneering, team and systems building, continuous improvement and professional growth (ISTE, 2018).

According to Akada and Şahin-Fırat (2022), various scale development studies in Türkiye are based on the NETS-A standards prior to 2018 (e.g. Akbaba-Altun, 2002; Banoğlu, 2012; Hacıfazlıoğlu *et al*., 2011; Şişman-Eren, 2010). In addition to these scales, scales have been developed regarding the school principal's level of technology use, attitudes, behaviours, roles and self-efficacy (e.g. Afshari *et al.*, 2012; Bülbül & Çuhadar, 2012; Durnalı, 2018; Ermiş & Somuncuoğlu-Özerbaş, 2021; Sezer, 2011; Seferoğlu & Akbıyık, 2005; Sincar, 2009; Stuart *et al*., 2009). The scale developed by Akada and Şahin-Fırat (2022) is based on the updated 2018 NETS-A standards and the perceptions of middle school teachers. The scale developed by Durnalı (2022) focuses on the behaviors of technology leaders and targets the perceptions of school teachers.

Grace (2020) conducted a thematic literature review for about a year and sought the opinions of educational technology experts and graduate students to develop a new instrument called 'School Technology Leadership Scale.' Grace (2020) comprehensively analyzed all aspects of school technology leadership and scales, including NETS-A standards and quantitative measures of school technology leadership. Grace (2020) obtained reliable results with a small number of items in the scale by focusing on assessing school principals' educational and technology leadership skills.

This present study is important in order to adapt the 'School Technology Leadership Scale' developed by Grace (2020) to different languages and cultures to assess principals' technology leadership skills according to the perceptions of both principals and teachers in ongoing studies. Furthermore, technology leadership should be examined through new perspectives to contribute to the literature in terms of developing and adapting scales as opinions on technology leadership change.

2. METHOD

In this study, a scale adaptation and a modification method (Gökdemir & Yılmaz, 2023) were employed, comprising the execution of EFA and CFA, the identification of scale dimensions, and the establishment of a new nomenclature that is aligned with the theoretical framework

2.1. Research Model

The objective of this study is to adapt the 'School Technology Leadership Scale', originally developed by Grace (2020), into Turkish. To ascertain the psychometric properties of the scale, a series of item statistics and reliability tests, in addition to validity tests, EFA and CFA analyses were conducted during the eight-stage adaptation process.

2.2. Participants

The participants included 280 volunteer primary school teachers who worked in official schools in a metropolitan city in the 2023-2024 academic year. The participants were determined through the application of the simple random sampling technique. As stated by Tabachnick and Fidell (2001), a sample size of approximately 150 is deemed sufficient for exploratory factor analysis (Çokluk *et al.*, 2023). As Çokluk *et al.* (2023) note, the sample size should be at least twice the number of items. In this regard, the construct validity of the scale was evaluated through EFA, utilizing data obtained from 180 primary school teachers. The existing structure of the scale was then assessed through CFA, employing data from 100 primary school teachers, distinct from those included in the EFA analysis. The demographic information of the teachers is presented in Table 1.

Table 1. *Participants' demographic information.*

Demographics (n:280)		*n*	%
Gender	Male	91	32.5%
	Female	189	67.5%
Education level	Bachelor's degree	228	81.4%
	Master's degree	45	16.1%
	Doctoral degree	7	2.5%
Average Age	42.18±9.62		
Average Tenure	18.18±9.63		

Table 1 indicates that the average age of the participants is 42 years, with the average tenure of 18 years. The data revealed that 67.5% of the teachers were female, 32.5% were male. Furthermore, 81.4% of the teachers held a bachelor's degree, 16.1% held a master's degree and 2.5% held a doctoral degree.

2.3. Data Collection Tool

Grace (2020) developed the "School Technology Leadership Scale According to Teachers' Perceptions" by examining published scales in the field and creating a 20-item scale with five factors based on the study by Chang (2008). As a result, the items in the dimensions served as indicators (Grace, 2020). The scale was designed in a four-point Likert scale, responses to the items ranged from '*Strongly Agree*' to '*Strongly Disagree*.'

Grace (2020) preferred to use the classical test theory instead of EFA when there was insufficient data to ensure accurate statistical analysis. Grace (2020) determined the analysis techniques based on the literature and data from scale development experts. Additionally, Grace (2020) conducted item analyses, Cronbach's alpha, inter-item correlation range, mean inter-item correlation and corrected item-total correlation. According to the findings of Grace (2020) , the inter-item correlations for each dimension were as follows, 1) "the vision, planning and management dimension" ranged from .511 to .810, (item 1, 2, 3, 4), 2) "the personnel development and training dimension" ranged from .519 to .741, (item 5, 6, 7, 8), 3) "the technological and infrastructure support dimension" ranged from .670 to .815, (item 9, 10,11,12), 4) "the evaluation and research dimension" ranged from .604 to .934, (item 13, 14, 15, 16) and 5) "the interpersonal and communication skills dimension" ranged from .226 to .787, (item 17, 18, 19, 20). However, the Cronbach's alpha value varied between .805 and .940 for the sub-dimensions. The findings indicated that the dimensions were largely reliable. Grace (2020) suggested conducting further studies to test the reliability and validity of all dimensions. Additionally, Grace (2020) recommended to identify a larger study group to apply other analysis types such as EFA. As proposed by Grace (2020), future studies might encompass dimension analysis, modification of substances identified within dimensions and the utilization of diverse statistical measurement techniques in data analysis.

2.3.1. *A Turkish adaptation of the data collection tool and modification of the scale dimensions*

Researchers employ a variety of methods in the context of scale adaptation studies. In this context, the utilization of EFA, and then, the utilization of CFA in scale adaptation studies is subject to variation. As Orçan (2018) notes, EFA and CFA are employed concurrently in some studies, whereas in others, only CFA is utilized and the use of only CFA in adaptation studies may give rise to certain issues. To address this, multiple CFA analyses can be conducted to ensure compliance with the model. It is essential to perform EFA in order to identify cultural differences and to detect any potential errors (Orçan, 2018). Consequently, EFA and then CFA were conducted in this study in accordance with the recommendation of the scale owner.

The objective of scale adaptation studies is to examine both psycholinguistic features (language adaptation) and psychometric properties (Karaçam, 2019). In the present study, firstly, the most appropriate scale for the study was determined through a comprehensive literature review. Subsequently, the scale owner was contacted to ascertain whether the scale had previously been adapted into Turkish. Permission was then sought for the adaptation and utilization of the scale. As the original study (Grace, 2020) did not employ EFA, the objective of this scale adaptation study was to ascertain the scale sub-dimensions resulting from EFA analyses, resulting in the determination of the scale dimensions and the introduction of new nomenclature that is aligned with the theory. The adaptation and modification of scale dimensions (Gökdemir & Yılmaz, 2023) were completed in an eight-stage process, the procedures of which are described in the following section.

In the first stage (Translation into Turkish), the translation into Turkish was conducted by four experts in English, who were both linguistically fluent and specialized in this field. Four experts translated the original language text into Turkish. The translations were compared and analyzed, and the most appropriate translation was determined.

In the second stage (Expert Opinions), the opinions of three experts in Turkish and foreign languages were sought regarding expressions that were unclear and contained errors. While the foreign language expert evaluated the translation, the Turkish language expert evaluated the suitability of the translation for Turkish. An information technology teacher analyzed the translation in terms of its terminological appropriateness and the necessary arrangements were made accordingly.

In the third stage (Back Translation), the Turkish expressions were translated into English, the original language. The back-translators were different experts from the first translators. Then, three linguists compared the original text with the back-translated text, and Turkish translations were revised by seeking expert opinion to investigate the reasons for the differences.

In the fourth stage (Pilot Application with the Real Participants), the items of the scale were discussed with 5 primary school teachers and 5 school principals who had completed postgraduate in the educational administration field and their opinions were taken.

In the fifth stage (Expert Opinions), the opinions of three teachers and one school principal with a doctorate degree in educational administration field, and four academicians from two different universities, were obtained, and the necessary arrangements were made. Since the scale adaptation process was followed without removing items, the question "What are your opinions regarding the sub-dimensions and scale items of the School Technology Leadership Scale?" was asked. The participants stated that the items reflected current skills. It was seen that there was no negative opinion regarding the scale items in general.

In the sixth stage (Initial Application Process), the scale was administered to a sample of 40 primary school teachers to assess the comprehensibility of the statements in the 'School Technology Leadership' scale. The comprehensibility of the statements was evaluated through statistical analyses, which indicated that no issues were identified. At this stage, linguistic equivalence was not determined. It was checked whether the scale items were perceived correctly by each participant. The scale was subsequently administered to additional teachers.

In the seventh stage (Second Implementation Process), the scale adapted by the researchers to measure school leaders' technology leadership skills was administered to 280 primary school teachers. The data were collected using Google Forms and face-to-face interviews. After the applications were completed, the incorrect ones from the face-to-face questionnaires were excluded from the analysis. The collected data were used to determine the psychometric properties of the School Technology Leadership Scale.

In the eighth stage (Analyses of the Second Application), Cronbach's alpha and item-total correlations were evaluated for reliability testing. EFA was employed to determine the structure of the items in the scale pool. CFA was conducted to verify the theoretical structure obtained by EFA. The CFA analysis was applied to a different data set than the one used in the EFA study.

2.4. Data Analysis

Item analysis and factor analysis were examined in the validity studies of the scale (Karasar, 2020). The construct validity of the scale was tested using EFA with data from 180 primary school teachers, and the existing structure of the scale was confirmed using CFA with data from 100 primary school teachers. According to Cohen and Cohen (1983), data from at least 10 participants for each item is sufficient in CFA analysis. Sample adequacy was analyzed using Kaiser-Meyer-Olkin (KMO) and the suitability of the data for factor analysis was analyzed using the Bartlett test. The number of factors was determined through the use of a scree plot and an examination of the eigenvalues. The reliability and internal consistency of the scale were analyzed with Cronbach's alpha coefficient, item-total correlation, composite reliability and intra-class correlation coefficient (ICC) tests. CFA was used to test the compatibility of the current structure of the scale with the applied study group. In this context, goodness-of-fit criteria were considered when explaining the model using CFA (Osborne, 2014). A path diagram was created based on the model results, and the standardized factor loadings of the included items were examined. The LISREL 8.5 software was used for CFA and IBM SPSS 28th version was used EFA and other tests.

3. FINDINGS

3.1. Reliability Analyses

Prior to the EFA analysis, tests were conducted to evaluate the reliability of the items, the results of which are presented in Table 2. As Karasar (2020) notes, reliability refers to the extent to which similar results are obtained when processes are repeated. It is therefore a crucial concept in any scientific investigation. Cronbach's alpha test is one of the most widely employed tests of scale reliability in the social sciences (Osborne, 2014). In accordance with the Cronbach's alpha test, a reliability alpha coefficient of 'α' between .80 and 1.00 indicates a highly reliable scale, while a coefficient between .60 and .79 denotes a quite reliable scale. A reliability coefficient of .40-.59 indicates low reliability, while a coefficient of .00-.39 indicates that the scale is not reliable (Alpar, 2020). A high reliability coefficient indicates that the scale is internally consistent (Karaca-Akarsu & Özdemir, 2021). The item-total correlation serves to determine the internal consistency of the scale (Çamur & Göğüş, 2023). In this context, internal consistency refers to the agreement between test items, whereas item-total correlation denotes the relationship between the total scores of the test and the scores obtained from the items of the test (Büyüköztürk, 2020; Karasar, 2020). The items exhibited high reliability according to Cronbach's alpha (.971) (Osborne, 2014). Upon examining the item-total correlations of the scale presented in Table 2, it can be observed that all items had item-total correlation values above .3. Therefore, it can be stated that the necessary conditions were met in terms of item-total correlations (Cristobal *et al*., 2007). The internal consistency was high due to the high and positive item-total correlation, indicating the relationship between the total scores of the test and the scores obtained from the test items (Büyüköztürk, 2020; Karasar, 2020). Consequently, a high and positive item-total correlation indicated that the behaviors were similar, and the internal consistency was high (Büyüköztürk, 2020).

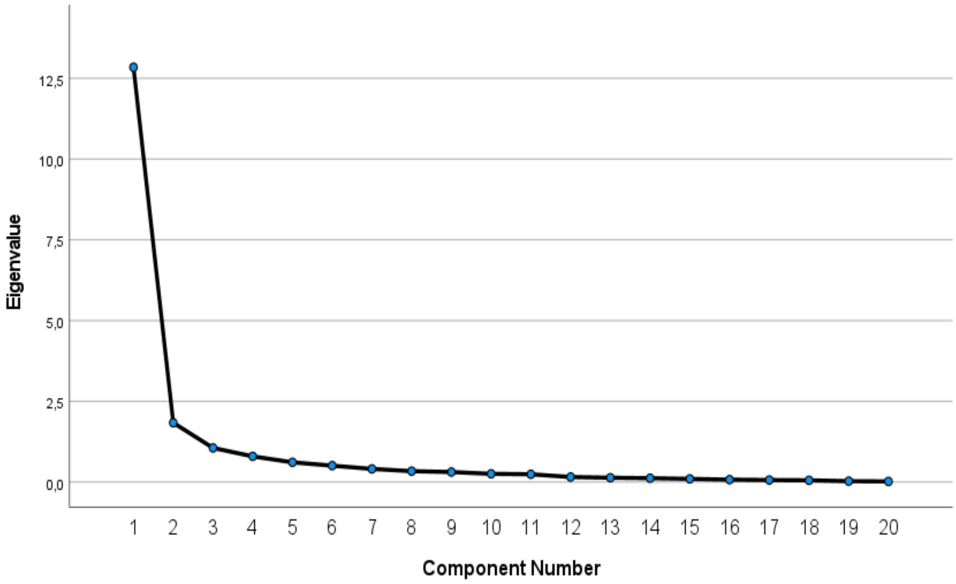
Table 2. *Item statistics and reliability test results for the scale.*

Items No.	Item mean	Item standard deviation.	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Item 1	3.427	0.616	.736	.970
Item 2	3.514	0.574	.653	.971
Item 3	3.451	0.599	.727	.970
Item 4	3.443	0.598	.762	.970
Item 5	3.243	0.696	.795	.969
Item 6	3.212	0.722	.825	.969
Item 7	3.141	0.745	.849	.969
Item 8	3.137	0.727	.856	.969
Item 9	3.400	0.586	.793	.970
Item 10	3.243	0.690	.825	.969
Item 11	3.459	0.579	.688	.971
Item 12	3.267	0.681	.825	.969
Item 13	3.098	0.765	.846	.969
Item 14	3.337	0.631	.834	.969
Item 15	3.263	0.719	.847	.969
Item 16	3.196	0.716	.847	.969
Item 17	3.082	0.802	.760	.970
Item 18	3.278	0.702	.634	.971
Item 19	3.075	0.736	.762	.970
Item 20	3.208	0.646	.762	.970
Cronbach's Alpha	(.971)			

3.2. Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is a sophisticated multivariate statistical technique that is widely employed in social sciences, education and psychology (Taherdoost, *et al.*, 2020). As defined by Osborne (2014, p. 4), "EFA is a group extraction and rotation technique designed to model completely unobserved or hidden constructs". Sub-dimensions formed by the scale items are determined by this method (Akcay et al., 2018). Conversely, the suitability of the data for exploratory factor analysis is determined through the utilization of the Kaiser-Meyer-Olkin KMO and Barlett Tests. While Kaiser-Meyer-Olkin (KMO) analysis assesses the suitability of the sampling for factor analysis, Bartlett's test determines the suitability of the data for factor analysis (Akcay *et al.*, 2018; Seçer, 2013; Taherdoost, *et al.*, 2020). The Bartlett's test of sphericity (suitability for factor analysis) is conducted to examine the verticality of the relationships between the items included in the analysis. The adequacy of the sample provides information that is useful for both grouping the questionnaire items as factors and for explaining the structures in a more effective manner (Taherdoost *et al.*, 2020). In the present study, in order to determine the EFA, the Varimax rotation method was employed, with consideration given to Principal Component Analysis. Principal component analysis represents one of the general dimension analyses and is a simplified version in terms of calculation (Osborne, 2014). As posited by Castello and Osborne (2005), the objective of the rotation process is to streamline and elucidate the data structure. Varimax rotation is the most commonly employed rotation method, with the objective of maximizing the variance within a factor, thereby increasing larger loadings and minimizing smaller loadings (Castello & Osborne, 2005; Osborne, 2014). In this regard in the study, EFA was conducted in accordance with the Varimax rotation method, with the results presented in Table 3. The number of factors to be included in the scale was determined on the basis of the scree plot and eigenvalue results, which are presented in Figure 1. The eigenvalues were employed in the calculation of the variance explained by the factors and in the determination of the number of factors. An eigenvalue exceeding one indicated that the factor was stable (Çokluk *et al.*, 2023). The scree plot facilitated factor reduction by revealing the dominant factors (Çokluk *et al.*, 2023). The results of the EFA are presented in Figure 1.

Figure 1. *Scree plot of the Eigenvalue for EFA.*



Upon examination of the scree plot in Figure 1, it became evident that the eigenvalues exhibited a flattening trend after two factors. This observation led to the conclusion that a two-factor structure was present. However, the final factor structure can be determined through exploratory factor analysis (EFA). The factor loadings of the items for EFA are presented in Table 3.

Table 3. *Factor loads for EFA.*

Item No.	Factor	
	1. Factor	2. Factor
Item 13	.871	*<.3*
Item 19	.820	*<.3*
Item 20	.809	*<.3*
Item 15	.807	*.402*
Item 16	.802	*.420*
Item 17	.787	*<.3*
Item 12	.744	*.439*
Item 8	.728	*.465*
Item 10	.725	*.518*
Item 7	.706	*.512*
Item 14	.704	*.465*
Item 11	.619	*.517*
Item 2	*<.3*	.852
Item 4	*<.3*	.851
Item 3	*<.3*	.824
Item 9	*.441*	.768
Item 1	*.425*	.761
Item 5	*.473*	.726
Item 6	*.498*	.671
Item 18	*.425*	.583

KMO: .857. Bartlett Test χ^2: 1068.7 (p<.05)
Variance Explaining Ratio: %73.42
Extraction Method: Principal Component Analysis

Upon reviewing Table 3, it was determined that the Turkish version of the scale, consisting of 20 items, exhibits two-dimensional structure based on the collected data. Upon examining the factor loads, it was found that all factor loads were above .3. The KMO test (KMO: .857) indicated that the sample size was sufficient and the Bartlett Test (χ^2:1068.7 (p<.05)) was also conducted. The KMO value was .857, higher than .60, indicating an adequate level of sampling adequacy (Büyüköztürk, 2020). Furthermore, Bartlett's test yielded a statistically significant result (p<.05).

The results demonstrated that the assumption of sphericity was met, with a value less than .05. The Kaiser-Meyer-Olkin (KMO) result and Bartlett's test support the suitability of exploratory factor analysis (EFA). Ultimately, it was established that the two-factor structure accounted for 73.42% of the variance. The items pertaining to the first factor are associated with the theoretical field of "*managing applications*," whereas the items pertaining to the second factor are related to "*guiding and supporting*" school technology leadership.

3.3. Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) was used to test the model validity for the compatibility of the current structure of the scale with the applied sample, and the results are presented in Table 4. CFA is an essential analytical tool for structure validation and other aspects of psychometric evaluation and is a type of structural equation modelling (Brown & Moore, 2012). According to Brown and Moore (2012), CFA confirms the number of factors and factor loadings of the scale.

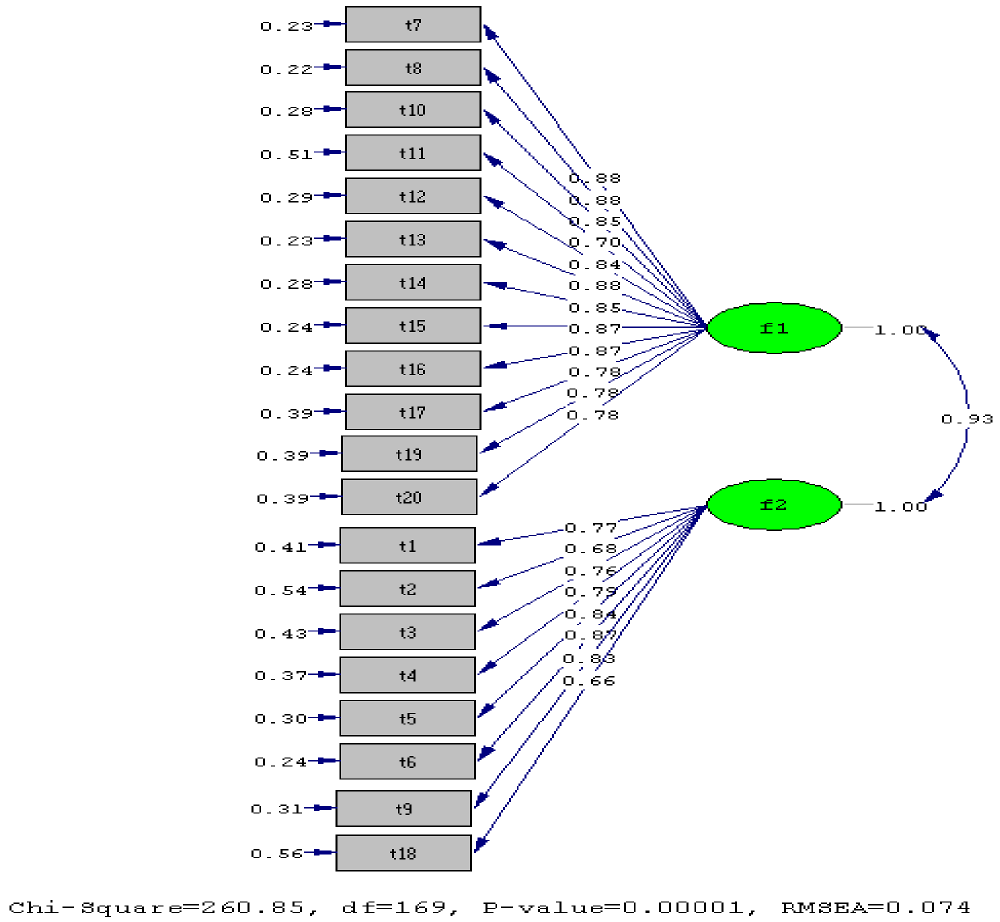
Table 4. *Fit Values for CFA.*

Criteria	Goodness of Fit Values	Good	Acceptable
RMSEA	.074	$0 \leq$ RMSEA $\leq .05$	$.05 \leq$ RMSEA $\leq .08$
χ^2/df	1.543	$0 \leq \chi^2/df \leq 2$	$0 \leq \chi^2/df \leq 3$
SRMR	.042	$0 \leq$ SRMR $\leq .05$	$.05 \leq$ SRMR $\leq .10$
NFI	.99	$.95 \leq$ NFI ≤ 1.00	$.90 \leq$ NFI $\leq .95$
GFI	.99	$.95 \leq$ GFI ≤ 1.00	$.90 \leq$ GFI $\leq .95$
AGFI	.99	$.90 \leq$ AGFI ≤ 1.00	$.85 \leq$ AGFI $\leq .90$
PGFI	.80	$.95 \leq$ PGFI ≤ 1.00	$.50 \leq$ PNFI $\leq .95$
CFI	.98	$.95 \leq$ CFI ≤ 1.00	$.90 \leq$ NFI $\leq .95$
RFI	.99	$.95 \leq$ RFI ≤ 1.00	$.90 \leq$ RFI $\leq .95$

df:169 χ^2:260.85 n: 100

Table 4 illustrates that the goodness of fit index (GFI: .99), the adjusted goodness of fit index (AGFI: .99), the consistent goodness of fit index (PGFI: .80) and the normed fit index (NFI: .99) were all highly satisfactory. Additionally, the comparative fit index (CFI: .98), relative fit index (RFI: .99), root mean square of standardized error squares (SRMR: .042) and root mean square of approximate errors (RMSEA: .074) were also considered (Schumacker & Lomax, 2004). The path diagram resulting from the model is presented in Figure 2. However, the path diagram is also a schematic representation of the results of the structural equation modelling analysis, showing summary outputs of the model such as factor loadings, *t*-values, unexplained variances and goodness-of-fit indices (Çapık, 2014).

Figure 2. *PATH diagram for factor loads.*



Upon examining Figure 2, the standardized factor loadings of the items included in the model through CFA are greater than .3 (Schumacker & Lomax, 2004). The results demonstrate that the generated model meets the necessary criteria in terms of standardized factor loadings. Based on the findings of the analysis, the adapted scale is a valid and reliable scale. The scale operates on a 4-grade Likert measurement level, with a minimum achievable score of 20 and a maximum score of 80. Given that all expressions within the scale embody positive constructs, one can infer that as the score derived from the scale rises, there is an increase in the perception of technological leadership. The results of the test conducted to ascertain the reliability and internal consistency levels of the novel factor structure are presented below. Table 5 presents the results of the reliability analyses conducted for the School Technology Leadership Scale. Item statistics and general reliability indicators were evaluated on two dimensions of the scale, Managing and Directing Applications and Guiding and Supporting.

As indicated in Table 5, the overall Cronbach's alpha value of the scale was determined to be .975. This demonstrates that all items of the scale exhibit high internal consistency. Upon analysis of the sub-dimensions, the Cronbach's Alpha value for the Managing Applications dimension was determined to be .966, while the Guiding and Supporting dimension exhibited a value of .941. As both values exceed .90, it can be concluded that the sub-dimensions are highly reliable. Upon the analysis of the Composite Reliability values, it was determined that the composite reliability value was .943 in the Managing Practices dimension and .930 in the Guiding and Supporting dimension. These values provide evidence to support the construct reliability of each dimension of the scale, with values exceeding the recommended threshold of .70. Furthermore, the item-total correlation values for all items fell within the range of .662 to .912. The findings demonstrate that each item is consistently associated with the overall scale and is capable of distinguishing between different levels of the construct. Upon the removal of each item, there was no appreciable decline in the Cronbach's Alpha value of the scale. This demonstrates that the items contribute to the scale in a balanced manner, and that the exclusion of any item will not negatively impact the overall reliability. The results of the analyses indicate that the 'School Technology Leadership Scale' exhibits a notably high degree of internal consistency and reliability. Furthermore, the sub-dimensions of the scale demonstrate the capacity to provide a valid measurement. The findings provide substantial support for the usability and psychometric properties of the scale.

Table 5. *Item statistics and reliability test results of the School Technology Leadership Scale*

Dimension	Item No.	Item mean	Item standard deviation.	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Reliability
Managing and Directing Applications	t7	3.160	0.748	.872	.961	Cronbach's Alpha=.966 Composite Reliability=.943
	t8	3.150	0.770	.895	.961	
	t10	3.260	0.691	.813	.963	
	t11	3.460	0.610	.717	.965	
	t12	3.270	0.723	.820	.963	
	t13	3.080	0.787	.879	.961	
	t14	3.360	0.659	.809	.963	
	t15	3.280	0.712	.873	.961	
	t16	3.220	0.733	.912	.960	
	t17	3.130	0.799	.773	.964	
	t19	3.050	0.757	.763	.964	
	t20	3.160	0.692	.742	.965	
Guiding and Supporting	t1	3.440	0.671	.765	.934	Cronbach's Alpha=.941 Composite Reliability=.930
	t2	3.510	0.628	.759	.935	
	t3	3.370	0.661	.851	.929	
	t4	3.390	0.650	.874	.927	
	t5	3.220	0.719	.823	.930	
	t6	3.230	0.750	.820	.931	
	t9	3.410	0.621	.776	.934	
	t18	3.260	0.733	.662	.942	

Cronbach's Alpha for the Scale: .975

Table 6 presents the findings of the Intraclass Correlation Coefficient (ICC) analysis, which was conducted to evaluate the reliability of the scale. In the aforementioned analyses, the measurement stability and reliability of the scale were examined at two distinct levels, single measures and average measures. The results are presented in the following section.

Table 6. *The results of the interclass correlation coefficient (ICC) analysis are presented below.*

	ICC	95% Confidence Interval Lower Limit	95% Confidence Interval Upper Limit	*F* Test (with True Value 0) Statistics	*Fd1*	*Fd2*	*p*
Single measurements	.645	.578	.713	40.599	99	1881	<.001
Average Measurements	.973	.965	.980	40.599	99	1881	<.001

The confidence interval, 95%, ranged from .578 to .713, providing support for the consistency of the result. Furthermore, the *F*-test result was statistically significant ($p<.001$), demonstrating that the observed differences in the measurements were not random and that the model was indeed significant.

Upon analysis of Table 6, the ICC value for the average measurements was calculated to be .973. This is a notably high value, indicating that the average measurements have an excellent reliability level. The confidence interval, 95%, was between .965 and .980, providing substantial evidence in support of the consistency of the measurements. The *F*-test was also statistically significant in this case ($p<.001$). Furthermore, a two-way mixed-effects model was employed in the analysis, wherein individuals were regarded as random effects and measurements as fixed effects. The definition of absolute agreement between measurements was utilized.

The ICC results demonstrated that the scale exhibited high reliability. While the reliability was moderate at the individual measurement level, it was found to be excellent at the average measurement level. The use of the scale at the group level will result in more consistent outcomes, thereby reducing measurement errors. It can be posited that the scale provides a sufficient degree of reliability in individual evaluations; however, it is imperative to exercise caution when utilizing it.

4. DISCUSSION and CONCLUSION

The "School Technology Leadership Scale", developed by Grace in 2020 with a thematic literature review, assesses teachers' perceptions of school principals' technology leadership skills. In this study, the 'School Technology Leadership Scale', originally developed by Grace (2020), was adapted into Turkish through an eight-stage process. The modification involved renaming the two sub-dimensions in accordance with the theory. The process was conducted in parallel with the recommendation of Grace (2020) as EFA should be employed in future studies. Grace (2020) was unable to apply EFA due to insufficient sampling and suggested that EFA be conducted for future studies. According to EFA and CFA results in this present study, the analysis without item extraction revealed the two-factor structure. Two factors of the *school technology leadership* include 1) *managing and directing applications* and 2) *guiding and supporting*. The results imply that the score derived from the scale increase, there is an increase in the perception of teachers regarding to school technological leadership of school principals. The adapted scale to the Turkish language and national school system was found to be valid and reliable for this study group.

The adapted scale is suitable to assess the technology leadership skills of school principals based on teacher perceptions. The scale reflects the identified essential leadership skills in technology by previous researchers (Demiraçan, 2019; Durnalı, 2018; Grady 2011; Grace 2020). In this context, it can be claimed that these roles are based on the roles of the school technology leader of this two-factor scale. The items in the adapted scale, the factors reflect the performance indicators in the dimensions of equity and digital citizenship advocacy, visionary planning, empowering leadership, system design and connected learner, which are the updated ISTE (2018) standards. Therefore, the school technology leader possesses characteristics such as being an advocate for equal opportunities, having a visionary approach to planning, being an empowering leader, a system designer and a continuous learner (ISTE, 2018). It can be stated that studies form the basis for the role of school principals, the components of technology leadership and technology leadership standards. Therefore, identifying and learning the levels of these skills is important for school leadership. Technology skills emerge as a determining factor in the quality of the education and management system in schools. The formation of intellectual capital based on 21st-century skills is effective. Additionally, it can be concluded that it is an important factor in meeting the needs of digital natives and digital hybrids.

In the last two years, three different scales have been developed in Türkiye (Akada & Şahin-Fırat, 2022; Durnalı, 2022; Ermiş & Somuncuoğlu-Özerbaş, 2021). Akada and Şahin-Fırat's (2022) scale focuses on ISTE 2018 standards, Durnalı's (2022) on technology leader behaviors, and Ermiş and Somuncuoğlu-Özerbaş's (2021) on technology leader self-efficacy. The study by Ermiş and Somuncuoğlu-Özerbaş (2021) is based on school principals' perceptions, while other studies are based on middle school teachers' perceptions. All three scales have more than two factors. Unlike these scales, the adapted scale in Turkish language reflects the perceptions of primary school teachers. It is a previously validated and reliable scale used in the research. The scale can contribute to the literature on educational management, create perspectives on school technology leadership, and serve as a source for further studies. However, determining technology leadership levels can be an effective indicator for school principals to identify and develop areas for improvement, establish an innovative school culture, change society and improve the quality of education. The school principals should develop technological leadership skills, 1) to facilitate access to novel technologies in an effective teaching and learning process, 2) to support effective learning, 3) to render the school management process more practical, transparent, rational and data-driven and 4) to promote effective utilization of technology by teachers and students. Technology leadership may continue to be relevant and maintain its currency due to constantly evolving technology in the coming years and therefore, the development and adaptation process of such scales should continue. This is because technology has a dynamic structure and affects all elements of society.

The adapted scale is based on the perceptions of teachers working in official primary schools in Istanbul. Therefore, the scale can be conducted in different study groups. The limitation of this study is that the pilot application was not conducted with two language versions on a group of participants who speak both languages fluently within the scope of linguistic equivalence, the correlation between the scores was not determined, and it was not used for equivalence. Recommendations for further studies also include that the relationship between school technology leadership skills and different organizational concepts can be examined, Data and evidence-based analyses can be created on the technology leadership skills of school principals, and efforts can be made to develop the technological leadership skills of technology leaders based on the analysis results. Postgraduate education programs, leadership academies and certification programs can be created for school technology leadership. Recommendations for practitioners include that the technology leadership skill requirements of school principals can be identified. In this way, educational programs can be organized by shedding light on which skills need to be developed.

Acknowledgments

We would like to thank Dr. Hakkı Polat for his sincere support during statistical analysis, thanks valuable faculty members for expert opinions, and thanks all teachers who voluntarily participated in the study.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the authors. **Ethics Committee Number**: Istanbul Okan University, Ethics Committee, 165, 556 April 12th, 2023. Additionally, permission was obtained from the Istanbul Provincial Directorate of National Education on June 1st, 2023, with approval number E-59090411. The research was conducted with volunteer teachers who signed informed consent forms obtained from the state schools. This study is associated with the first author's doctoral thesis titled "The Impact of School Principals' Technology Leadership Skills on Their Competency-Based Job Performance" and the second author is thesis advisor.

Contribution of Authors

The authors contributed to the entire study. The study was carried out and reported in collaboration. This study is associated with the first author's **(Tugba Ögücü)** doctoral thesis (Ögücü, 2025) and the second author **(Aytaç Göğüş)** is thesis advisor.

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