



| Research Article / Araştırma Makalesi |

Technology Use in Special Education: An Examination of Special Education Teachers' Technological Pedagogical Content Knowledge and Implementation Skills

Özel Eğitimde Teknoloji Kullanımı: Özel Eğitim Öğretmenlerinin Teknolojik Pedagojik Alan Bilgisi ve Uygulama Becerileri Üzerine Bir İnceleme

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Keywords

1. Special education
2. Technology awareness
3. Technological pedagogical content knowledge
4. Special education teachers
5. Technology integration

Anahtar Kelimeler

1. Özel eğitim
2. Teknoloji farkındalığı
3. Teknolojik pedagojik alan bilgisi
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Abstract

Purpose: This study aims to examine the level of technology use among special education teachers within educational settings. Specifically, the research investigates teachers' technological pedagogical content knowledge (TPACK) awareness and implementation skills in relation to demographic variables such as gender, age, professional experience, type of school, and student level.

Method: Employing a mixed method research design, the study integrates quantitative and qualitative data to enable an in-depth and multifaceted analysis. Quantitative data were gathered through the TPACK-Application Scale, while qualitative insights were obtained via semi-structured interviews. The study sample consisted of 130 special education teachers working in schools operating under the Kastamonu Provincial Directorate of the Ministry of National Education. The qualitative part of the research was conducted with 11 teachers.

Findings: The quantitative findings demonstrated no statistically significant differences in TPACK-Application scores based on gender, age, or professional experience. However, technology use skills varied according to the student groups with whom teachers worked. Teachers educating students with severe disabilities and those with autism spectrum disorder exhibited higher levels of technology integration skills than teachers working with students with mild special needs. Moreover, teachers working in practice schools and primary schools displayed significantly higher levels of technology awareness and implementation skills compared to their counterparts in kindergarten and middle school settings. These results underscore the influence of student needs on teachers' technology integration practices. Qualitative data further indicated that limitations to effective technology use stem from infrastructure inadequacies, diverse student needs, socioeconomic constraints, and teachers' professional development requirements.

Highlights: The discussions revealed that there are differences in access to technology among schools, that teachers are willing to integrate technology but need digital tools and materials adapted to special education; therefore, there is a need to strengthen infrastructure, enhance professional development, and develop individualized digital learning strategies.

Öz

Amaç: Bu çalışma, özel eğitim öğretmenlerinin eğitim ortamlarında teknoloji kullanım düzeylerini incelemeyi amaçlamaktadır. Bu kapsamda, öğretmenlerin teknolojik pedagojik alan bilgisi (TPACK) farkındalıkları ve uygulama becerileri; cinsiyet, yaş, mesleki deneyim, okul türü ve öğrenci düzeyi gibi demografik değişkenler doğrultusunda değerlendirilmiştir.

Yöntem: Araştırma, nicel ve nitel verilerin bütüncül bir biçimde analiz edilmesine imkân tanıyan karma yöntem deseniyle yürütülmüştür. Nicel veriler TPACK-Uygulama Ölçeği ile toplanırken, nitel veriler yarı yapılandırılmış görüşmeler aracılığıyla elde edilmiştir. Çalışmanın örneklemini Kastamonu İl Millî Eğitim Müdürlüğüne bağlı okullarda görev yapan 130 özel eğitim öğretmeni oluşturmaktadır. Araştırmanın nitel bölümü 11 kişi ile yürütülmüştür.

Bulgular: Nicel bulgular, öğretmenlerin cinsiyet, yaş ve mesleki deneyim değişkenleri açısından TPACK-Uygulama Ölçeği puanlarında anlamlı bir farklılık bulunmadığını ortaya koymuştur. Bununla birlikte, öğretmenlerin teknoloji kullanım becerilerinin çalıştıkları öğrenci düzeyine göre değiştiği belirlenmiştir. Ağır düzeyde yetersizliği olan öğrenciler ve otizm spektrum bozukluğu olan öğrencilerle çalışan öğretmenlerin teknoloji entegrasyon becerilerinin, hafif düzeyde özel gereksinimi olan öğrencilerle çalışan öğretmenlere göre daha yüksek olduğu saptanmıştır. Ayrıca uygulama okulu ve ilkokullarda görev yapan öğretmenlerin teknoloji farkındalığı ve uygulama becerilerinin okul öncesi ve ortaokullarda görev yapan öğretmenlere kıyasla anlamlı düzeyde daha yüksek olduğu görülmüştür. Bu durum, öğrencilerin bireysel gereksinimlerinin öğretmenlerin teknoloji entegrasyon pratiklerini şekillendirdiğini göstermektedir. Nitel bulgular ise etkili teknoloji kullanımını sınırlandıran faktörlerin altyapı eksiklikleri, öğrenci özellikleri, sosyoekonomik koşullar ve öğretmenlerin mesleki gelişim ihtiyaçları olduğunu göstermiştir.

Önemli Vurgular: Görüşmeler, okullar arasında teknolojiye erişimde farklılıklar bulunduğunu, öğretmenlerin teknoloji entegrasyonuna istekli olduklarını ancak özel eğitime uyarlanmış dijital araç ve materyallere ihtiyaç duyduklarını; bu nedenle altyapının güçlendirilmesi, mesleki gelişimin artırılması ve bireyselleştirilmiş dijital öğrenme stratejilerinin geliştirilmesi gerektiğini ortaya koymuştur.

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INTRODUCTION

Special education is a type of education provided by special education programs and specialized personnel to meet the special needs of individuals who differ significantly from their peers in terms of their individual and developmental characteristics and educational competencies. Individuals who exhibit such differences are classified as "individuals in need of special education". The education of these individuals is aimed to be continued in general education schools with mainstreaming or integration methods starting from preschool period, but individuals with special education needs can also receive education in special education institutions or classes (Regulation on Special Education Services, 2018).

According to the Ministry of National Education's (MoNE) 2020-2021 statistics, there are 425,816 individuals with special education needs in Türkiye. Of these individuals, 45% (189,588 students) are included in mainstreaming or integration programs, while 55% (236,228 students) receive education in separate special education institutions or special education classes (MoNE, 2022). Students who participate in mainstreaming or integration programs follow the education program implemented in their own schools and Individualized Education Programs (IEP) are prepared based on these programs. This approach enables students with special education needs to take courses as part of the general education curriculum, even if they are not in special education classes. In this way, students with special education needs take a variety of courses that are part of the general education curriculum. Curricula updated in 2018 aim to provide students with basic skills, including communication in mother tongue and foreign languages, mathematics competence, science and technology competence, digital competence, learning to learn, initiative and entrepreneurial understanding, social and public competence, cultural awareness and expression (MoNE, 2018). While the special education process aims for professional teaching, it also includes individualized practices by experts in the field. At this point, special education teachers come to the fore.

Technology awareness of special education teachers has become an indispensable element of today's education system. These teachers are expected to have a high level of awareness about their ability to use technology to approach their students' education more effectively and to enrich the learning experiences of students with special needs (Anderson & Putman, 2020; Gül & Sönmez, 2023). The ability to use technology effectively in education can provide special education teachers with the ability to design more individualized and customized education programs with their students, provide special materials for students with learning difficulties, communicate and collaborate. In addition, by effectively utilizing the tools and applications offered by technology, it creates the opportunity to increase students' motivation and provide more diverse learning opportunities. Therefore, special education teachers' awareness of technology becomes an important skill that contributes to the education of their students (Cahyani et al., 2021; Demirok et al., 2019; Demirok & Baglama, 2018).

When the literature is examined, studies on the use of technology by special education teachers are mostly limited to the use of assistive applications (Aslan, 2018; Çay et al., 2020; Karaaslan et al., 2022; Kutlu et al., 2018). In these studies, it was determined that teachers' willingness to use these technologies was high. In the study conducted by Gül and Sönmez (2023), it was determined that their competencies on technological pedagogical content knowledge were limited. Although there have been studies on assistive technology use in special education, there is limited research that specifically explores the intersection of TPACK awareness and implementation skills among special education teachers in Türkiye (Bat & Uğur Erdoğan, 2022; Yurdakul et al., 2012). This study contributes to the literature by examining both the awareness and practical application dimensions of TPACK in special education contexts, using a mixed-method design to explore demographic and institutional variables. For this reason, the research will make important contributions in the process of determining the needs of teachers currently working in the field, developing content for the continuous development of pre-service teachers' technological literacy, and creating suggestions for taking measures for the future.

The main purpose of the research is to determine the level of technology use of special education teachers in the educational environment. In line with this purpose, technology awareness of special education teachers were determined. In this process, it was determined how demographic variables such as gender, age, experience, type of school, level of the student (severe, mild, mainstreaming for special education) affect their awareness. In this context, the sub-problems are as follows.

1. Does the level of technology use of special education teachers in the educational environment vary according to gender?
2. Does the level of technology use of special education teachers in the educational environment vary according to age?
3. Does the level of technology use of special education teachers in the educational environment vary according to experience?
4. Does the level of technology use of special education teachers in the educational environment vary according to the type of school they work in?
5. Does the level of technology use of special education teachers in the educational environment vary according to the level of the student?

METHOD

Mixed method used in the research process. Mixed method enables detailed analyses by using multiple data sources together and providing data diversification in processes where analyses using a quantitative or qualitative data source alone are insufficient to reveal the results of the problem situation (Creswell, 2011). When mixed method was used, explanatory sequential design was utilized. According to the explanatory sequential design, quantitative data are collected first and then qualitative data are collected and analyzed in depth. A qualitative approach was chosen to explain the quantitative findings. This study was conducted in accordance with ethical principles and was approved by the Social and Human Sciences Scientific Research and Publication Ethics Board of Kastamonu University (Decision No. 2, dated 04.09.2024). Prior to data collection, informed consent was obtained from all participants, and participation was based on voluntary involvement. Permission to use the measurement scale was obtained from the author who developed the scale. Quantitative data were collected between January and May 2024, while qualitative data were collected between September and December 2024.

Quantitative Method

TPACK-Application Scale adapted into Turkish by Ay (2015) was used to collect quantitative data. TPACK-Application Scale was developed by Yeh, Hsu, Wu, Hwang, and Lin (2014) in order to determine teachers' competencies to apply their technological pedagogical content knowledge in the teaching process. The scale includes 22 items related to TPACK skills. These items have a 5-point Likert-type structure ranging from 1 (I am completely incompetent) to 5 (I am completely competent). The scale consists of five pedagogical domains and eight knowledge dimensions. These pedagogical domains are learners, subject content, curriculum design, practical teaching and assessment. The knowledge dimensions of the domains are (i) using ICT in understanding learners, (ii) using ICT in understanding content, (iii) planning ICT-infused curriculum, (iv) using ICT designs, (v) using ICT-integrated instructional strategies, (vi) using ICT in instructional management, (vii) integrating ICT into instructional content, and (viii) using ICT in student assessment. Each pedagogical domain aims to assess teachers' ability to integrate technology into pedagogical processes. A high score in the learners dimension indicates that teachers have the ability to use ICT to identify students' learning difficulties, monitor their learning styles and support their development. A high score in the subject content dimension indicates competence in using ICT to better understand and present subject themes. Scores obtained from the TPACK-Practice scale were calculated by summing the responses to all items, resulting in a total scale score. Higher total scores indicated higher levels of TPACK-based practice. The use of total scale scores was preferred to obtain an overall measure of teachers' technology integration practices and to facilitate statistical analysis at the general competency level. The curriculum design dimension assesses teachers' ability to plan ICT-infused curriculum, use ICT designs and integrate instructional strategies with technology. A high score in the applied instruction dimension indicates that teachers are able to use ICT effectively in instructional management and content delivery. The assessment dimension measures teachers' ability to apply technology-based assessment methods. This scale provides a comprehensive assessment tool to understand how and to what extent teachers integrate technology in their pedagogical practices. Thus, the knowledge and skills of subject teachers are assessed in eight different knowledge dimensions.

Within the scope of the study, the scale was applied to special education teachers in schools affiliated to Kastamonu Provincial Directorate of National Education. The population size of the study was determined based on data reported in the final report of the TÜBİTAK-supported project "*Overcoming Barriers with STEM* (STEM ile Engelleri Aşıyoruz)," which indicated that 146 teachers were employed in schools affiliated with the Kastamonu Provincial Directorate of National Education at the time of the project (Avan, 2023). 89% of these teachers were reached.

Table 1. Characteristics of the Study Group (Distribution by Gender and Age)

	23-30	31-40	41-50	51 and above	Total
Male	21	14	7	3	45
Female	49	18	14	4	85
Total	70	32	21	7	130

When the table is examined, it reveals the gender distribution of the participants according to different age ranges. There were 130 participants in total, of which 45 were male and 85 were female. This shows that female participants have a high rate of 65.4% of the total. When analyzed according to age groups, it is seen that the highest participation is in the 23-30 age group. There were 70 participants in this age group, 21 of whom were male (30%) and 49 were female (70%). In the 31-40 age group, the number of participants decreased to 32, with 43.8% and 56.3% of the participants being male and female, respectively. In the 41-50 age group, the total number of participants decreases even further to 21, with 33.3% (7 people) being male and 66.7% (14 people) being female. The age group of 51 years and above is represented by only 7 respondents, with 42.9% (3 respondents) men and 57.1% (4 respondents) women. This distribution shows that there are significantly more female participants, especially in the younger age groups. It is noteworthy that the number of participants decreases with increasing age, and the representation rate of both genders is quite low in groups aged 51 and above. The most important reason for this situation is the popularity of this field in recent years.

Table 2. Characteristics of the Study Group (Professional Experience and Student Level)

	1-5	6-10	11-15	16-20	20 and above	Total
Mild level	17	9	7	3	4	40
Severe level	16	5	5	4	5	35
Autism	21	19	6	5	4	55
Total	54	33	18	12	13	130

The table shows the distribution of the participants in the study group according to the length of professional experience and the level of students they work with. In total, 130 teacher participated in the study, working in the mild, severe and autism categories. The data were evaluated according to the duration of professional experience. Participants working at mild level were represented by a total of 40 people. Most of this group (42.5%) had professional experience between 1-5 years. As the duration of experience increases, the number of participants decreases. In particular, the number of participants with 16-20 years and over 20 years of experience is limited to only 7 people in total. Participants working at a severe level consisted of 35 people. The highest level of participation is observed among people with 1-5 years of professional experience (45.7%). In this group, participation rates decrease as the duration of professional experience increases. Participants with 16-20 years and more than 20 years of experience were limited to 9 people in total. Participants working at the level of autism constitute the largest group with a total of 55 people. In this group, the highest participation rate was observed among those with 1-5 years of professional experience (38.2%). However, unlike the other groups, the number of participants with 6-10 years of experience is also quite high (34.5%). Nevertheless, there is a significant decrease in the participation rate when the duration of experience increases to 11 years and above.

Table 3. Normality Distribution Results of TPACK-Application Scale Scores

Scale	X	ss	Skewness		Kurtosis	
			Coefficient	Std error	Coefficient	Std error
TPACK-Application Scale	72.50	21.89944	-.402	.212	-.241	.422

The kurtosis and skewness coefficients of the TPACK-Application Scale scores were examined according to the normality analysis and it was found that they were between -1.5 and +1.5, which is accepted as valid in many sources (Çokluk et al., 2014; Tabachnick & Fidell, 2007).

Qualitative Method

In the second stage of the research, the use of technology by teachers in special education environment was discussed in depth with a semi-structured interview form prepared by the researchers. At this point, representatives from different groups were selected by considering various variables in the selection of teachers to be interviewed. Furthermore, in the selection of the teachers to be interviewed, planning was made according to factors affecting the results of the TPACK-Application Scale such as gender, age, seniority, the level of students they work with and the type of institution. Additionally, it was aimed to understand the diversity in technology use of teachers were selected from seniority levels and school types to examine different student groups (representativeness), to compare the approaches of low and high scoring groups towards technology and the difficulties they face (comparison), and to examine in detail the experiences of groups showing significant differences in technology use (depth). Therefore, teachers with the following reasons and characteristics were selected.

TPACK-Application Scale scores of teachers working with mild level students were found to be lower than the other groups. This makes it important to examine the needs and difficulties faced by teachers in this group regarding the use of technology. For this reason, two mildly employed teachers with 1-5 years of experience were selected to assess the needs of the teachers in this group with the most intensive experience in technology integration. The heavily employed teachers had higher scores compared to the mildly employed group. Understanding the reasons underlying this difference is important in order to assess which factors make this group more successful. Accordingly, two teachers with 6-10 years of experience working at the severe level were selected and the experiences of the moderate experience group regarding the use of technology were discussed. Teachers working at the autism level are among the groups showing the highest effectiveness in technology use. In order to understand how teachers in this group integrate technology, two underrepresented experienced teachers with 11 years of experience or more were interviewed.

When the situation is analyzed according to school type, special education teachers working in kindergarten have lower scores in technology use compared to other school types. This situation makes it valuable for teachers to express the difficulties they face in accessing and using technology. In this context, the needs of this group were examined in depth by selecting a teacher with a short experience working in a kindergarten. Teachers working in application schools are among the groups with the highest scores in technology use. In the Turkish education system, “application schools” refer to public special education schools affiliated with the Ministry of National Education, where students with special educational needs are supported in acquiring daily life skills through practice-oriented instruction and workshop-based activities (MoNE, 2018). These schools provide structured environments for functional skill development and hands-on learning (MoNE, 2023). It is important to focus on the successful implementation examples of these teachers and the reasons for this success. In this context, two teachers with 6-10 years of experience working in the application school were selected and the positive experiences of this group were evaluated. According to seniority, teachers with 1-5 years of seniority have the highest representation rate in the report. Understanding the experiences

of this group in the process of learning technology use can reveal the situations faced by teachers who are new to the profession. For this reason, two elementary school teachers working at a mild level were selected and their experiences at the beginning of seniority examined. In addition, teachers with 16-20 years of seniority are among the groups with high scores with experience. In order to examine the effect of long-term professional experience on the use of technology, a application school teacher working at a severe level was selected from this group and interviewed.

Semi-structured interviews were conducted after obtaining expert opinion for the questions to be used in the interview process. Semi-structured interviews were conducted using an interview form developed based on the research objectives. The interview questions were reviewed by three experts in the fields of science education and educational research to ensure content validity, clarity, and relevance. Based on the experts' feedback, necessary revisions were made to the wording and structure of the questions before the interview process was finalized and implemented. Although a separate pilot study was not conducted, the interview form underwent a rigorous expert review process. Three experts in educational research evaluated the interview questions in terms of content validity, clarity, and relevance. Based on their feedback, the wording and structure of the questions were revised accordingly before the interview process was finalized and implemented.

During the interview process, participants were explicitly encouraged to elaborate on their responses and provide concrete examples from their professional experiences (e.g., "Can you give a specific example from your classroom practice?", "Could you explain this in more detail?"). When necessary, probing questions were used to deepen understanding and clarify meanings. In addition, member checking was employed by summarizing participants' responses during the interviews and asking them to confirm the accuracy of the interpretations. This process helped ensure that the researchers' interpretations accurately reflected the participants' intended meanings, thereby strengthening the credibility of the findings (Lincoln & Guba, 1985).

The interview questions presented below constitute the final version of the semi-structured interview form used in the main data collection process.

- Which technologies do you use and how do you use them for the student groups you work with (mild, severe, autism)? Do you provide guidance to your students about the technologies they can use? How?
- Which instructional technologies do you use in your lessons? Can you give some examples?
- How familiar are you with the technologies that special student groups can use? Can you give some examples?
- What do you think about the accessibility of technologies that students with special needs can use in educational environments?
- What are the biggest challenges you face in the process of integrating technology into your lessons?
- Is the technology infrastructure and support adequate in the type of school you work in? What are your suggestions to make it better?
- What is the impact of your experience (over the years) in the use of technology? How did the trainings you received in this field contribute to your professional development process?
- What technology-oriented training or tools do you need to meet your professional needs?

Qualitative data obtained from the semi-structured interviews were analyzed using an inductive thematic analysis approach following the framework proposed by Braun and Clarke (2006). The analysis process consisted of several systematic stages. First, all interview recordings were transcribed verbatim, and the transcripts were read repeatedly to achieve familiarization with the data. In the initial coding stage, meaningful units of text related to teachers' technology-oriented training and tool needs were identified and coded inductively. Subsequently, the initial codes were compared, refined, and grouped into categories based on conceptual similarities, corresponding to the stage of searching for themes. These categories were then reviewed and organized into broader themes that reflected recurring patterns across the data set. Finally, the themes were clearly defined and named to represent the core meanings emerging from the participants' responses. This inductive process allowed the themes to emerge directly from the data without imposing predetermined categories, consistent with the principles of inductive thematic analysis (Braun & Clarke, 2006).

To enhance the trustworthiness of the qualitative analysis, a second coder who is an expert in science education and qualitative research independently coded a portion of the transcripts. Inter-coder agreement was calculated using the agreement formula proposed by Miles and Huberman (1994), and the agreement rate between the two coders was found to be 89%. Coding discrepancies were discussed until consensus was reached, which contributed to the consistency and credibility of the final coding scheme. The finalized codes and themes were reviewed to ensure internal coherence. In the findings section, representative participant quotations were used to support each theme and to provide transparency in the interpretation of the data.

FINDINGS

This section presents the findings obtained from both the quantitative and qualitative components of the study. The data are organized in accordance with the mixed method research design, allowing for a comprehensive understanding of special education teachers' technology awareness and implementation skills. First, the results from the quantitative analysis are detailed, followed by the qualitative findings derived from teacher interviews.

Quantitative Findings

The quantitative findings are based on data collected using the TPACK-Application Scale, which was administered to 130 special education teachers. The analyses focused on internal consistency, as well as comparisons across demographic variables such as gender, age, seniority, student level, and school type. The reliability analysis of the scale is presented below.

Table 4. Cronbach Alpha Reliability Coefficients of TPACK-Application Scale

Pedagogical Field	Knowledge Dimension	Cronbach Alpha	
Learner	Using ICT in understanding learners	.871	
Subject area	Using ICT to understand content	.885	
Program design	Program planning exhausted with ICT	.834	.956
	Using ICT designs	.926	
	Using ICT-integrated teaching strategies	.839	
Practical teaching	Using ICT in teaching management	.881	.964
	Using teaching content with ICT	.945	
Evaluations	Using ICT in student assessment	.905	
Total		.986	

Cronbach Alpha reliability coefficients of TPACK-Application Scale show that the scale has a high internal consistency. In the pedagogical content knowledge dimension, the reliability coefficients of the sub-dimensions of using ICT in understanding learners and understanding the subject area are 0.871 and 0.885, respectively. In the curriculum design dimension, the highest reliability coefficient is in using ICT designs with 0.926 and the lowest value is in planning a fatigued curriculum with ICT with 0.834. In the applied teaching dimension, the reliability coefficients of the sub-dimensions were 0.881 and 0.945, and the overall reliability was 0.964. A value of 0.905 was obtained in the evaluations dimension. The overall reliability coefficient of the scale was 0.986 and values above 0.8 were obtained in all sub-dimensions. These results indicate that the scale is a reliable tool for assessing the use of ICT in pedagogical practices.

Table 5. Independent Groups t Test Results for TPACK-Application Scale Scores of Teachers' Gender

Sub Scale	Gender	N	X	ss	sd	t	p
Learner	Male	45	9.6889	3.01377	128	-0.711	0.478
	Female	85	10.0824	2.9929	89.202		
Subject area	Male	45	6.2667	2.10411	128	-1.378	0.171
	Female	85	6.80	2.09762	89.503		
Program design	Male	45	25.2444	7.58334	128	-0.7	0.485
	Female	85	26.2706	8.13193	95.366		
Practical teaching	Male	45	19.5556	5.6309	128	-0.786	0.433
	Female	85	20.4588	6.52751	101.869		
Evaluation	Male	45	9.7556	2.90106	128	-0.317	0.752
	Female	85	9.9412	3.30711	100.461		
Total	Male	45	70.5111	20.80278	128	-0.752	0.453
	Female	85	73.5529	22.50741	96.102		

When the table is examined, it is seen that the gender of the teachers does not make a significant difference on their scores in different dimensions of TPACK-Application Scale. The p values obtained in all dimensions are greater than the statistical significance level of 0.05. Although small differences were observed between the scores of female and male teachers, these differences were not statistically significant. In the learner dimension, female teachers ($\bar{X}=73.55$) scored higher than male teachers ($\bar{X}=70.51$). Similarly, although the mean scores of female teachers were slightly higher than male teachers in the dimensions of subject area, curriculum design, applied instruction, evaluation and total score, these differences were not statistically significant. These results reveal that the TPACK-Application Scale scores of female and male teachers are generally similar and gender is not an effective factor on the scores in the scale dimensions.

Table 6: ANOVA Test Results for the Difference Between Teachers' Ages and Their Scores in TPACK-Application Scale

Sub Scale	Age	N	X	Ss	F	P	Difference
Learner	23-30	70	9.5286	3.08677	2.005	0.117	No Difference
	31-40	32	9.9688	3.28716			
	41-50	21	11.3333	2.19848			
	51 and above	7	9.8571	1.57359			
Subject area	23-30	70	6.4000	2.24835	0.861	0.463	No Difference
	31-40	32	6.6563	2.25202			
	41-50	21	7.2381	1.44585			
	51 and above	7	6.7143	1.49603			

Sub Scale	Age	N	X	Ss	F	P	Difference
Program design	23-30	70	24.7714	8.16172	1.171	0.324	No Difference
	31-40	32	27.1563	8.83581			
	41-50	21	27.8571	6.04389			
	51 and above	7	25.8571	4.98092			
Practical teaching	23-30	70	19.4429	6.61714	0.839	0.475	No Difference
	31-40	32	20.6563	6.73752			
	41-50	21	21.7619	4.55966			
	51 and above	7	20.0000	3.05505			
Evaluation	23-30	70	9.4429	3.39068	1.173	0.323	No Difference
	31-40	32	10.2813	3.30429			
	41-50	21	10.7619	2.32174			
	51 and above	7	9.7143	1.60357			
Total	23-30	70	69.5857	22.93058	1.135	0.338	No Difference
	31-40	32	74.7188	23.99494			
	41-50	21	78.9524	16.21258			
	51 and above	7	72.1429	11.92237			

According to the ANOVA test results, there is no significant effect of teachers' age groups on TPACK-Application Scale scores. The p values calculated for all dimensions were above the statistical significance level of 0.05. In the learner dimension, teachers in the 41-50 age group had the highest mean score ($\bar{X}=11.33$), while the lowest score was observed in the 23-30 age group ($\bar{X}=9.53$). Similarly, in the dimensions of subject area, curriculum design, applied instruction and evaluation, teachers in the 41-50 age group had higher averages than the other groups. In total scores, the 41-50 age group reached the highest mean ($\bar{X}=78.95$). However, these differences in all dimensions were not statistically significant. These results show that teachers' age is not a determining factor on the scores they obtained from TPACK-Application Scale. Since the small score differences observed between age groups are not statistically significant, it can be said that teachers have similar knowledge and skill levels regardless of their ages. Although it is noteworthy that teachers in the 41-50 age group have higher averages in many dimensions, the fact that these differences are not significant shows that the results are generally consistent across all age groups.

Table 7: ANOVA Test Results for the Difference Between Teachers' Seniority and Their Scores in TPACK-Application Scale

Sub Scale	Seniority Year	N	X	Ss	F	P	Difference
Learner	1-5 Years	54	9.5556	3.56961	1.237	0.299	No Difference
	6-10 Years	33	9.7576	2.71604			
	11-15 Years	18	10.500	2.45549			
	16-20 Years	12	11.500	2.57611			
	20 and above	13	9.8462	1.46322			
Subject area	1-5 Years	54	6.2593	2.41993	1.283	0.28	No Difference
	6-10 Years	33	6.6061	2.06063			
	11-15 Years	18	7.1111	1.99673			
	16-20 Years	12	7.5833	1.24011			
	20 and above	13	6.5385	1.26592			
Program design	1-5 Years	54	24.6852	9.30373	0.965	0.429	No Difference
	6-10 Years	33	26.0606	7.36944			
	11-15 Years	18	28.1111	6.99486			
	16-20 Years	12	28.3333	6.21338			
	20 and above	13	25.3846	4.92508			
Practical teaching	1-5 Years	54	19.1481	7.39558	0.907	0.462	No Difference
	6-10 Years	33	20.6061	5.93685			
	11-15 Years	18	21.4444	5.10158			
	16-20 Years	12	22.0833	5.19542			
	20 and above	13	19.5385	2.75727			
Evaluation	1-5 Years	54	9.4074	3.65244	0.987	0.417	No Difference
	6-10 Years	33	9.8788	3.3049			
	11-15 Years	18	10.6111	2.35494			
	16-20 Years	12	11.0833	2.57464			
	20 and above	13	9.6923	1.49358			
Total	1-5 Years	54	69.0556	25.9807	1.023	0.398	No Difference
	6-10 Years	33	72.9091	20.59181			
	11-15 Years	18	77.7778	18.24524			
	16-20 Years	12	80.5833	17.50043			
	20 and above	13	71	11.30634			

According to the ANOVA test results, there is no significant effect of teachers' seniority years on TPACK-Application Scale scores. The fact that the p values calculated for all dimensions are above 0.05 shows that the score differences between seniority groups are not statistically significant. In the learner dimension, teachers with 16-20 years of seniority had the highest mean score ($\bar{X}=11.5$), while teachers with 1-5 years of seniority had the lowest score ($\bar{X}=9.56$). Similarly, in the subject area dimension, teachers with 16-20 years of seniority ($\bar{X}=7.58$) had the highest score. In curriculum design and applied teaching dimensions, teachers with 16-20 years of seniority had the highest mean scores with $\bar{X}=28.33$ and $\bar{X}=22.08$, respectively, while teachers with 1-5 years of seniority had lower scores. In the evaluation dimension, teachers with 16-20 years of seniority had the highest mean score ($\bar{X}=11.08$), while this seniority group had the highest mean score in total scores ($\bar{X}=80.58$). However, none of these differences were found to be statistically significant. These results show that teachers' seniority is not a determining factor in TPACK-Application Scale scores and that teachers have similar knowledge and skill levels regardless of seniority.

Table 8: ANOVA Test Results for the Difference Between the Level of the Students the Teachers Work with and the Scores They Received in the TPACK-Application Scale

Sub Scale	Student Level	N	X	Ss	F	P	Difference
Learner	mild level	40	8.575	2.87239	7.078	.001	Mild level - Severe level
	severe level	35	10.9143	2.62758			
	Autism	55	10.3273	2.99416			Mild level - Autism
Subject area	mild level	40	5.525	1.92137	8.695	.000	Mild level - Severe level
	severe level	35	7.1714	1.94763			
	Autism	55	7.0545	2.06755			Mild level - Autism
Program design	mild level	40	21.65	7.18813	10.137	.000	Mild level - Severe level
	severe level	35	28.8857	6.53844			
	Autism	55	27.1273	8.08532			Mild level - Autism
Practical teaching	mild level	40	16.7	5.57099	10.468	.000	Mild level - Severe level
	severe level	35	22.2857	5.39919			
	Autism	55	21.2909	6.22026			Mild level - Autism
Evaluation	mild level	40	8.375	2.87953	7.237	.001	Mild level - Severe level
	severe level	35	10.7143	2.64098			
	Autism	55	10.4364	3.32646			Mild level - Autism
Total	mild level	40	60.825	20.02932	9.667	.000	Mild level - Severe level
	severe level	35	79.9714	18.64764			
	Autism	55	76.2364	22.03698			Mild level - Autism

The results of the ANOVA test show that the level of the students the teachers work with makes a significant difference on the scores in all dimensions of the TPACK-Application Scale. The p values calculated for all dimensions are below 0.05, indicating that there are statistically significant differences between the groups. The scores of teachers working at mild level were significantly lower in all dimensions and total score compared to teachers working in severe level and autism categories. For example, in the learner dimension, the mean score of mild teachers ($\bar{X}=8.58$) was significantly lower than that of severe teachers ($\bar{X}=10.91$) and teachers working in the autism category ($\bar{X}=10.33$) ($p=0.001$). Similarly, the scores of mildly employed teachers were significantly lower in the dimensions of subject area, curriculum design, applied instruction, evaluation and total score.

This suggests that teachers working in the severe and autism categories performed better in technology, pedagogical knowledge and implementation competencies. The lower scores of teachers working in the mild category may be due to the fact that teachers in this group have different levels of professional experience, student group needs, or professional development opportunities. These results provide important clues for understanding the impact of the student groups teachers work with on their professional knowledge and skills.

Table 9: ANOVA Test Results for the Difference between the Type of Institution in which Teachers Work and the Scores They Received in TPACK-Application Scale

Sub Scale	School Type	N	X	Ss	F	P	Difference
Learner	kindergarten	8	9.25	0.70711	3.029	0.008	Kindergarten-Practice school Secondary School-Practice School
	primary school	26	10.7308	2.55433			
	middle school	36	8.8611	3.14554			
	high school	3	8	4.58258			
	application school	36	11.2222	2.86966			
	vocational training	14	8.8571	3.05984			
	GRC	7	9.8571	2.67261			
Subject area	kindergarten	8	6	0.53452	2.537	0.024	Kindergarten-Practice school
	primary school	26	7.0769	1.83135			
	middle school	36	6.0278	2.21019			
	high school	3	5.6667	3.51188			
	application school	36	7.5	1.91982			
	vocational training	14	5.7857	2.29309			
	GRC	7	6.1429	2.26779			

Sub Scale	School Type	N	X	Ss	F	P	Difference
Program design	kindergarten	8	24.125	0.99103	4.263	0.001	Primary School-Kindergarten Kindergarten-Practice school Primary-Secondary School Secondary School-Practice School
	primary school	26	28.9231	6.56611			
	middle school	36	22.3611	8.68875			
	high school	3	19.6667	10.21437			
	application school	36	29.4444	6.86791			
	vocational training	14	23.0714	7.54947			
	GRC	7	25.2857	8.07701			
Practical teaching	kindergarten	8	18.25	1.28174	3.826	0.002	Kindergarten-Primary School Kindergarten-Practice school Secondary School-Primary School Secondary School-Practice School
	primary school	26	22.6154	4.57888			
	middle school	36	17.6389	7.0474			
	high school	3	15	7.93725			
	application school	36	22.6389	6.09521			
	vocational training	14	17.9286	4.859			
	GRC	7	19.8571	5.84319			
Evaluation	kindergarten	8	9	0	2.015	0.069	No Difference
	primary school	26	10.4615	3.17781			
	middle school	36	8.9167	3.45894			
	high school	3	7.6667	4.16333			
	application school	36	11.0278	3.06581			
	vocational training	14	9.2857	2.75761			
	GRC	7	9.8571	2.60951			
Total	kindergarten	8	66.625	2.87539	3.561	0.003	Kindergarten-Primary School Kindergarten-Practice school Primary School-Kindergarten Secondary School-Practice School
	primary school	26	79.8077	17.94886			
	middle school	36	63.8056	24.18597			
	high school	3	56	30.26549			
	application school	36	81.8333	20.34067			
	vocational training	14	64.9286	19.83185			
	GRC	7	71	21.20535			

According to the ANOVA test results, the type of institution in which teachers work creates a significant difference on the scores in some dimensions of TPACK-Application Scale. Statistically significant differences were found especially in learner, subject area, curriculum design, applied instruction, and total score dimensions. For example, in the learner dimension, the mean score of the practice school teachers ($\bar{X}=11.22$) was significantly higher than that of kindergarten ($\bar{X}=9.25$) and middle school ($\bar{X}=8.86$) teachers ($p=0.008$). Similarly, in the subject area dimension, the practice school teachers ($\bar{X}=7.5$) scored higher than kindergarten teachers ($\bar{X}=6.00$) ($p=0.024$). In the dimension of curriculum design, the practice school ($\bar{X}=29.44$) and primary school ($\bar{X}=28.92$) teachers scored significantly higher than kindergarten teachers ($\bar{X}=24.13$) ($p=0.001$).

In the applied teaching dimension, kindergarten teachers ($\bar{X}=18.25$) scored significantly lower than primary school teachers ($\bar{X}=22.62$) and practice school teachers ($\bar{X}=22.64$) ($p=0.002$). In addition, it is noteworthy that secondary school teachers ($\bar{X}=17.64$) scored lower than primary school and application school teachers. Although there was no significant difference in the evaluation dimension ($p=0.069$), the practice school teachers had the highest mean score in this dimension ($\bar{X}=11.03$). In the total scores, the practice school teachers ($\bar{X}=81.83$) and primary school teachers ($\bar{X}=79.81$) scored significantly higher than kindergarten ($\bar{X}=66.63$) and middle school ($\bar{X}=63.81$) teachers.

These results show that the type of institution teachers work in has a significant effect on their technology, pedagogical knowledge and implementation skills. The fact that practice school and primary school teachers have higher scores suggests that these types of institutions contribute more to teachers' professional development. The lower scores of kindergarten and middle school teachers suggest that these groups need more support and development opportunities in terms of technology and pedagogical practices. These differences provide important data for understanding the diversity in teachers' professional skills depending on the type of institution they work in.

Qualitative Findings

Following the quantitative phase, qualitative data were collected through semi-structured interviews conducted with a selected group of special education teachers. The purpose of this stage was to examine in depth the teachers' experiences, challenges, and perceptions regarding technology use in special education settings. The interview responses were analyzed thematically, and the findings were presented under relevant themes and categories that reflected the key issues emphasized by the participants. Within the scope of the study, semi-structured interviews were conducted with eleven teachers. The findings obtained from the interviews are presented in Table 10.

Table 10: Findings from Interviews with Teachers

Theme	Category.	Code	Teachers' Codes	Teacher Opinion Examples
Technology Use	Tools Used	Smart board, artificial intelligence, augmented reality	1, 2, 5, 6	We actively use the smart board in lessons and support it with digital content.
	Digital Applications	Gedex, ChatGPT, Otsimo	2, 3, 7	I introduce Otsimo and Gedex applications to my students, I use artificial intelligence supported education tools.
	Student Technology Experience	Student guidance, modeling	4, 9, 10	I model and gradually encourage students to use technology.
Access and Infrastructure	School Facilities	Internet, infrastructure, Lack of VR glasses	3, 5, 8	Our school has internet infrastructure but we do not have access to virtual reality applications.
	Individual Access to Technology	Tablet computer access	6, 7, 10	Most students do not have access to tablets or computers at home and can only use smartphones.
Challenges and Obstacles	Student Challenges	Behavioral problems, cognitive levels	1, 5, 9	Some students find it difficult to use technological tools effectively, their cognitive level is not adapted.
	Socio-economic barriers	Financial means, lack of technology training	2, 6, 8	Students' families cannot invest in technology, which has a negative impact on their development.
Teacher Qualifications	Vocational Trainings	Web 2.0 tools, STEM education	3, 4, 7	I try to use Web 2.0 tools in my projects, I would like to receive more training in this field.
	Technology Integration	Teaching with digital tools	5, 8, 11	I try to integrate technology into my lessons, but sometimes it is not effective because each student's learning style is different.

The use of technology in special education is an important tool that enriches teachers' classroom practices and supports students' learning processes. However, for this use to be effective, factors such as access, teacher competencies, infrastructure and individual needs of students need to be taken into consideration. When teachers' views on this issue are analyzed, both opportunities and challenges are clearly revealed.

Teachers reported that they frequently use smart boards, AI-enabled applications (ChatGPT, Otsimo, Gedex), augmented reality and digital games. While these technologies help students to participate more actively, they also allow teachers to enrich the course content. Teacher 2 (Moderate to Severe Intellectual Disability, Autism): "I introduce Otsimo and Gedex applications to my students, I use AI-supported educational tools. Especially for students with special needs, voice feedback applications are very useful." However, some teachers emphasized that it takes time for students to get used to the use of technology and that gradual guidance is needed. Methods such as modeling, providing hints, and guiding students individually aim to help students adapt to technology. Teacher 1 (Severe Autism): "We actively use the smart board in lessons and support it with digital content." This situation reveals the importance of the guidance role of teachers in the use of technology.

An analysis of the infrastructural facilities in schools reveals that some schools have a good technology infrastructure, while others have only smart boards. One of the biggest problems is students' lack of access to individual technology. Teacher 6 (Mild Autism): "Most of our students do not have computers or tablets at home. However, their ability to use smartphones is quite good. Unfortunately, they are not able to use educational applications over the phone effectively." This shows how socioeconomic inequalities have a direct impact on the use of technology in special education. Providing individual students with access to technology will make this process more effective. Teacher 3 (Moderate to Severe Intellectual Disability): "Our school has internet infrastructure, but we do not have access to virtual reality applications. More digital tools need to be developed for special education." Another point emphasized by teachers is that technical problems such as internet connection problems and malfunctioning of smart boards disrupt the teaching process.

There are some cognitive and behavioral challenges for special education students to adapt to technology. Students may have short attention spans, may have difficulty following instructions, or may not be able to use technological tools for their intended purpose. Teacher 9 (Autism - Level 3): "The fact that the student has moderate to severe intellectual disability, cannot learn to read and write, and cannot follow instructions makes it difficult to use technology. Sometimes they have difficulty understanding even the simplest commands." In this case, teachers have to take individual differences into account when using technology and adapt the learning process to the level of the student. Teacher 4 (Moderate to Severe Intellectual Disability): "I model and gradually encourage students to use technology." These data emphasize that technology does not have the same effect for every student and the importance of individualized use.

In-service trainings are of great importance for teachers to use technology effectively. However, some teachers stated that they should receive more training in this field. Teacher 7 (Mild Intellectual Disability): "I try to use Web 2.0 tools in my projects, I would like to receive more training in this field. Technology integration workshops in special education should be organized for teachers to use technology more consciously." While some of the teachers have a good command of technology, some of the others state that they lack knowledge on how to prepare customized materials for special education students. Teacher 11

(Moderate-Severe Intellectual Disability): "I try to integrate technology into my lessons, but sometimes it is not effective because each student's learning style is different." These data suggest that teachers need more professional support and training on technology integration.

DISCUSSION AND CONCLUSION

In this study, special education teachers' level of technology use in the educational environment was examined and analyzed in the context of demographic variables. The findings show that special education teachers' technology awareness is generally high, but this awareness may vary depending on various factors. When compared with previous studies, the findings of the research contain some similarities and differences.

In the analysis of the gender variable, no significant difference was found between the TPACK-Application Scale scores of male and female teachers. This result is also observed in previous studies (Gül & Sönmez, 2023; Karaaslan et al., 2022; Ocak et al., 2023). This finding shows that technological pedagogical content knowledge is a gender-independent skill and the use of technology in educational settings is not determined by a gender-based variable. However, some studies suggest that male teachers may have more positive attitudes towards technology (Demirok et al., 2019). In this context, it can be said that the factors affecting teachers' use of technology in the field of special education are not related to gender, but rather to professional development opportunities and access opportunities.

The findings for the age variable showed that the TPACK-Application Scale scores of teachers in the 41-50 age group were relatively higher, but this difference was not statistically significant. Previous research suggests that young teachers are more advantageous in using technology and experienced teachers may have difficulties in technology integration (Aslan, 2018). However, the findings obtained in this study show that the effect of age variable on technology integration is not decisive. This suggests that technology-oriented trainings for special education teachers in the professional development process may play a more important role than the age factor.

The results obtained in terms of seniority variable revealed that teachers' professional experience did not make a significant difference on TPACK-Application Scale scores. However, it was observed that teachers with 16-20 years of seniority had higher scores in some sub-dimensions. This may suggest that experienced teachers develop more skills in integrating technology into pedagogical processes over time. However, it can be said that seniority alone is not a determining factor, and that in-service trainings and access to technological equipment are the main determinants (Cahyani et al., 2021; Çay et al., 2020).

One of the most striking findings of the study was that there were significant differences in the level of technology use of teachers according to the student groups they worked with. Teachers working with students with severe disabilities and students with autism spectrum disorder were found to have higher technology use awareness and skills than teachers working with students with mild special needs. This finding is consistent with previous studies (Kutlu et al., 2018; Ramakrishnan et al., 2019). It can be thought that the use of technology as a supportive tool for students with severe special needs creates more needs and therefore teachers tend to use these technologies more. The fact that teachers working with students with mild special needs had lower scores in technology integration may be due to the more widespread use of traditional teaching methods for students in this group.

When the technology usage levels of the teachers were analyzed according to the type of school they work in, it was found that the technology awareness of the teachers working in the application schools was higher. This result suggests that the technology infrastructure of the application schools may be more advanced and teachers may receive more support in terms of professional development. On the other hand, kindergarten and middle school teachers' technology use awareness was relatively low. This may be due to the fact that kindergarten teachers have limited access to technology and technology use is less prioritized for students at this level. The low score of middle school teachers, on the other hand, raises the possibility that teachers may receive less support for technology integration at this level. Previous studies also show that teachers' awareness of technology use may vary depending on the type of school they work in (Ay, 2015; Peng & Daud, 2016).

Qualitative findings revealed teachers' experiences in using technology in more detail. Teachers stated that they frequently use smart boards, artificial intelligence supported applications (ChatGPT, Otsimo, Gedex), augmented reality and digital games in their lessons. However, it was stated that factors such as lack of technological infrastructure, internet access problems and limited digital tools suitable for the individual needs of students made it difficult to use technology. In particular, socioeconomic factors had a negative impact on students' access to technology and some students had limited access to technology individually. This result is in line with previous studies and shows that digital inequalities are one of the important factors limiting technology integration in the field of special education (Demirok et al., 2019; Demirok & Baglama, 2018; Seldura et al., 2024).

Teachers also expressed the need for more professional development opportunities to increase technology integration. Workshops on Web 2.0 tools, STEM-based teaching and technology integration in special education should be made more widely available for teachers. The development of customized digital content and materials for special education students can be an important step in increasing teachers' technology awareness.

Overall, this study shows that special education teachers' technology awareness and technology integration skills in pedagogical processes vary depending on various factors. The findings suggest that when developing policies and practices to increase the use of technology in special education, teachers' need for professional support and customized strategies for school type and student group should be taken into consideration.

Teacher interviews revealed that factors limiting the effective use of technology in special education include infrastructural deficiencies, individual student needs, socio-economic factors, and teachers' professional development needs. It was noted that teachers had varying experiences regarding access to technology, with some schools lacking sufficient technological tools. While many teachers expressed a willingness to integrate technology into their lessons, they also highlighted the need for digital tools and supportive educational materials specifically adapted for special education.

SUGGESTIONS

It is crucial that professional development opportunities provided to teachers are sustainable and continuous. Instead of one-off workshops, long-term programs and ongoing support mechanisms should be established.

Professional development programs should include targeted modules on digital content adaptation for diverse learners, hands-on training with inclusive technology tools (e.g., screen readers, symbol-based communication apps), and continuous mentoring support for teachers in special education contexts. Furthermore, school-level strategies such as establishing technology resource centers, appointing ICT mentors in special education, and ensuring equal device distribution are necessary to reduce infrastructural and socio-economic barriers.

Limitations

This study is limited by its regional focus, as the participants were drawn from schools affiliated with a single provincial directorate in Türkiye. Therefore, the findings may not be generalizable to all regions or countries. Additionally, while the study used a validated scale and semi-structured interviews, self-reporting may introduce bias. Future studies could benefit from longitudinal approaches or classroom observations to triangulate data.

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Statements of Publication Ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' Contribution Rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

This study was approved by the ethics committee with the decision of the Social and Human Sciences Scientific Research and Publication Ethics Board of Kastamonu University dated 04.09.2024 and numbered 2.

Use of Artificial Intelligence

Artificial intelligence (AI) tools were used solely for supportive purposes during the preparation of this manuscript. Specifically, AI-based language models such as ChatGPT (OpenAI) and Google Gemini were utilized to generate alternative title suggestions, check grammar, and enhance language clarity. No AI tools were used in the data analysis, interpretation of findings, or drawing conclusions. All AI-generated outputs were critically reviewed and edited by the authors in accordance with accepted ethical and academic standards. The AI tools are not credited as authors, and the authors take full responsibility for the content and integrity of the published article.

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