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| Research Article / Araştırma Makalesi |

The Effect of Technology Assisted Argumentation Based Teaching on Technological Pedagogical Content Knowledge Self Assessments of Preservice Teachers

Teknoloji Destekli Argümantasyon Tabanlı Öğretimin Öğretmen Adaylarının Teknolojik Pedagojik Alan Bilgisi Öz Değerlendirmelerine Etkisi[1]

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Keywords

1. Technological pedagogical content knowledge
2. Pre-service teachers
3. Technology supported argumentation based teaching
4. Argumentation
5. Self-assessment

Anahtar Kelimeler

1. Teknolojik pedagojik alan bilgisi
2. Öğretmen adayları
3. Teknoloji destekli argümantasyon tabanlı öğretim
4. Argümantasyon
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Abstract

Purpose: This study investigates the effect of technology-supported argumentation-based teaching on pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) self-assessment.

Design/Methodology/Approach: A quasi-experimental design with a pretest-posttest control group was used in the research. Participants of the study are 43 pre-service mathematics teachers who take the Analytic Geometry-I course. They were studying in the third grade in the faculty of education at a state university in Turkey in the fall semester of the 2019-2020 academic year. In the research process of the study, the subject of transformation geometry was taught to the experimental group using technology-supported argumentation-based teaching practice. The lessons are planned to last four weeks (12 lesson hours), three lessons per week. In the first week of the lessons, the translational transformation, reflection transformation in the second and third weeks, and rotational transformation in the fourth week were discussed. TPACK-SAS (self-assessment scale), which was used as a data collection tool in the study, was applied to both groups before the first week (pre-test) and after the last week (post-test).

Findings: The research findings observed that the participants' self-evaluations about TK (technology knowledge) were relatively low. In addition, it was observed that pre-service teachers' post-test mean scores regarding the sub-dimensions of PK (pedagogical knowledge), PCK (pedagogical content knowledge), and TPACK (Technological Pedagogical Content Knowledge), which mainly includes pedagogy knowledge, were high.

Highlights: As a result of the research, it was concluded that the technology-supported argumentation-based transformation geometry teaching practice did not affect the TPACK self-evaluation of the pre-service teachers in the experimental group. Studies similar to this with pre-service teachers can be carried out with students at different educational levels on transformation geometry or another mathematics subject.

Öz

Çalışmanın amacı: Bu çalışmanın amacı, teknoloji destekli argümantasyon tabanlı öğretimin öğretmen adaylarının Teknolojik Pedagojik Alan Bilgisi (TPAB) öz değerlendirmelerine etkisini araştırmaktır.

Materyal ve Yöntem: Araştırmada öntest-sontest kontrol gruplu yarı deneysel desen kullanılmıştır. Araştırmanın katılımcıları, 2019-2020 eğitim öğretim yılı güz döneminde Türkiye'de bir devlet üniversitesinin eğitim fakültesinde üçüncü sınıfta okuyan ve Analitik Geometri-I dersini alan 43 matematik öğretmeni adayıdır. Araştırma sürecinde deney grubuna teknoloji destekli argümantasyon tabanlı öğretim uygulaması kullanılarak dönüşüm geometrisi konusu işlenmiştir. Dersler dört hafta (12 ders saati), haftada 3 ders olacak şekilde planlanmıştır. Derslerin ilk haftasında öteleme dönüşümü, ikinci ve üçüncü haftalarında yansıma dönüşümü ve dördüncü haftasında dönme dönüşümü ele alınmıştır. Araştırmada veri toplama aracı olarak kullanılan TPAB-ÖDÖ (öz değerlendirme ölçeği) her iki gruba da ilk haftadan önce (ön test) ve son haftadan sonra (son test) uygulanmıştır.

Bulgular: Araştırma bulgularında, katılımcıların TB (teknoloji bilgisi) ile ilgili öz değerlendirmelerinin nispeten düşük olduğu görülmüştür. Ayrıca öğretmen adaylarının özellikle pedagoji bilgisini içeren PB (pedagojik bilgi), PAB (pedagojik alan bilgisi), TPAB (Teknolojik Pedagojik Alan Bilgisi) alt boyutlarına ilişkin son test puan ortalamalarının yüksek olduğu görülmüştür.

Önemli Vurgular: Araştırma sonucunda, teknoloji destekli argümantasyon tabanlı dönüşüm geometrisi öğretimi uygulamasının, deney grubundaki öğretmen adaylarının TPAB öz değerlendirmelerine etkisinin olmadığı sonucuna ulaşılmıştır. Öğretmen adaylarıyla gerçekleştirilen bu çalışmaya benzer çalışmalar, dönüşüm geometrisi veya matematiğin başka bir konusu üzerinde farklı eğitim düzeylerindeki öğrencilerle yapılabilir.

[1] This study has been produced from the doctoral thesis of the first author, which was conducted under the consultancy of the second author.

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INTRODUCTION

Considering the components that make up the education process, teachers who are the designers of the process and have a direct influence on the process are more prominent among other components (Demirtas et al., 2011). In this context, the issue of teacher qualification is fundamental (Darling Hammond, 2000; Rivkin et al., 2005). Shulman, known for his studies on teacher competence, claimed that there was a disconnection between the content knowledge teachers should acquire and the teaching knowledge and that there was no connection between these types of knowledge (McNamara, 2002). Shulman (1986, 1987) introduced the concept of pedagogical content knowledge (PCK), which is formed by the inclusion of pedagogical knowledge in content knowledge that determines a teacher's success in teaching.

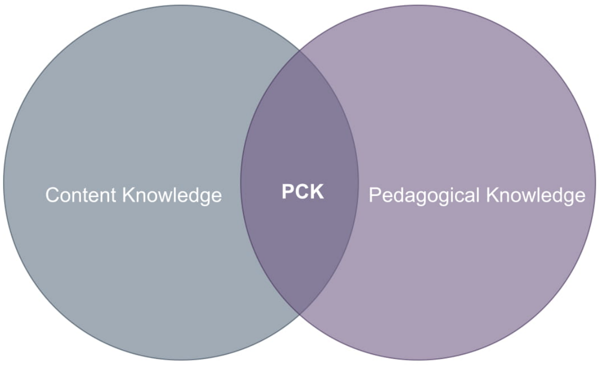

Figure 1. Pedagogical content knowledge model (Shulman, 1987)

Shulman (1987) expressed the concept of PCK as being able to explain the subject as clearly as possible for learners. For this, teachers use the most valuable representations (forms of representation), the most appropriate examples, associations by analogy and the most understandable explanations in teaching.

The PCK model has become a fundamental model in teacher education, regardless of the branch, with the studies conducted by researchers based on this model (Evens et al., 2015). The Ministry of National Education (MoNE) (2017a) states that a good teacher should have a high level of knowledge of the subjects covered by his branch and a command of the curriculum and PCK. In the field competencies of the mathematics teacher, the importance of planning an appropriate education to ensure mathematical development within the curriculum framework is emphasized. It was underlined that the knowledge about mathematics subjects in the curriculum should be mastered, and the use of appropriate tools and equipment for teaching (MoNE, 2017b).

Based on Shulman's PCK model, researchers interested in this subject investigated different type of knowledge specific to the teaching profession and the relationships between these types of knowledge. Moreover, they developed other models on the subject due to their studies (Ball et al., 2008; Fennema & Franke, 1992; Grossman, 1990; Harris et al., 2009; Marks, 1990; Niess, 2005).

One of the different models developed as a result of this research is Technological Pedagogical Content Knowledge (TPACK), which explains the teaching knowledge required for technology integration (Stoilescu, 2011; Tabach, 2011). TPACK is a new knowledge model formed by adding a technology component to the PCK model introduced by Shulman (Abbitt, 2011a; Cox, 2008; Mishra & Koehler, 2006). Today, one of the main areas affected by technology is education. Developments in science and technology necessitate integrating technology with the learning-teaching process (Liao, 2007). It is imperative to benefit from technology, which is thought to positively affect the teaching-learning process of mathematics, to conduct appropriate teaching activities for students, and to provide them with the opportunity to exchange information (National Council of Teachers of Mathematics (NCTM), 2000). Accordingly, teachers who design and manage the teaching process are expected to integrate technology into the teaching process and include technology in their lessons quite effectively (Chen, 2010). As a natural consequence of this situation, technology knowledge has been added to the areas teachers should know about (Ivy, 2011).

Mishra and Koehler (2006) describe TPACK as the intersection of content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK). In addition to these three domains of knowledge and their intersections, they also defined the domains of knowledge they named as Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK). Here, they considered the interactions of the PK, CK and TK domains in binary combinations. In the studies (Angeli & Valanides, 2009; Mishra & Koehler, 2006; Niess, 2005; Niess et al., 2006; Niess et al., 2007), different components related to TPACK were defined, and new models have been proposed for the integration of education and technology. The model proposed by Mishra and Koehler (2006) is essential in that it forms the foundations of the theoretical framework regarding TPACK (Akkoc et al., 2011; Griggs, 2010). This model introduced by Mishra and Koehler (2006) constitutes the basic framework of TPACK in this study, which deals with the TPACK self-evaluation of pre-service teachers.

In the TPACK model suggested by Mishra and Koehler (2006), three main components are related to the teaching profession. These are the basic types of knowledge PK, CK and TK.

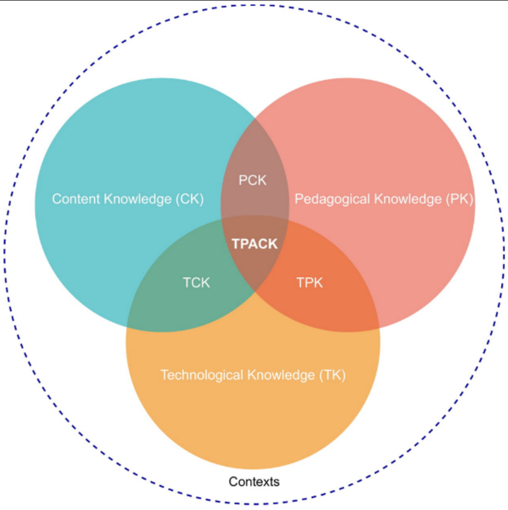

Figure 2. Mishra and Koehler's TPACK model (Koehler & Mishra, 2009)

As seen in Figure 2, the TPACK model includes seven components. Here, TPK, TCK, PCK and TPACK are the interactions of dual PK, CK and TK combinations. Here, CK is the knowledge about the content that a teacher will teach (Koehler & Mishra, 2009; Mishra & Koehler, 2006). PK is a vast field of knowledge about the practices and strategies necessary for the teaching process, the general aims of education, and the basic principles and values of teaching. TK refers to the ability of a teacher to use certain technologies (blackboard, book, chalk, etc.) found in almost every classroom, as well as computers, the internet and technologies that are constantly renewed. PCK is the field of knowledge that includes deciding which teaching methods and techniques are compatible with the subject (Koehler & Mishra, 2008; Mishra & Koehler, 2006). TCB is defined as "understanding the effects of content and technology on each other and the points where they limit each other" (Koehler & Mishra, 2008). A teacher with a deep TPK should be aware of the technologies most appropriate to the subject area and be able to identify technologies that will contribute to teaching (Harris et al., 2009; Koehler & Mishra, 2008). TPK is a type of knowledge that expresses how technology can be adapted to different learning and teaching environments appropriately (Cox, 2008; Koehler & Mishra, 2009). TPACK is a way of thinking about the complex relationships between technology, pedagogy and content. The use of content-based pedagogical knowledge is particularly emphasized in the definitions and features of TPACK, and three types of knowledge and the interaction between them are highlighted (Cox, 2008; Mishra & Koehler, 2006).

According to Niess et al. (2009), TPACK means that teachers should consider how they can teach mathematical concepts related to the subject taught and the thoughts that form the basis of these mathematical concepts in a way that students can understand by using technology and consider which way they should follow in teaching. Therefore, TPACK should be handled in a way specific to the field and the content intended to be taught (Cox & Graham, 2009; Niess, 2005; Schmidt et al., 2009). Hence, this study considers a teaching practice that blends the argumentation-based learning approach and technology, which is suitable for the subject of transformation geometry. Argumentation is putting forward some claims, explaining the connection between the data that forms the basis for these claims, and justifying the claims (Toulmin, 2003). Argumentation requires considering students' thoughts and evaluating them by comparing the underlying reasons (Reid & Knipping, 2010). The argumentation model of Toulmin (2003), which consists of six components such as data, claim, reason, qualifier, rebuttal and supporter, was taken as a basis. During the research process of the study, argumentation-based teaching practices would contribute to pre-service teachers' teaching-technology integration skills and subject knowledge.

In addition to knowledge, it is also essential for a person to be self-confident. It is difficult for people with insufficient self-confidence to use their knowledge effectively (Canturk Gunhan & Baser, 2007; Gawith, 1995). Self-assessment, also expressed as a perception of self-efficacy is an assessment of a person's potential to do any job. In other words, self-assessment is a person's belief about whether he/she can perform that job as it should (Azar, 2010; Bandura, 1997; Siegle & McCoach, 2007). Studies in the literature on the subject have shown that teachers 'self-assessment levels have an effect on designing an effective teaching process and successfully managing the process, students' success and self-assessment (Akbas & Celikkaleli, 2006; Bandura, 1997; Gurol et al., 2010; Ozdemir, 2008; Smith, 1996; Tschannen-Moran & Hoy, 2001). There are studies on TPACK self-evaluation levels of teachers and pre-service teachers. These studies also reveal that the level of self-evaluation is among the factors affecting TPACK (Abbitt, 2011b; Abbitt & Klett, 2007; Archambault & Crippen, 2009; Atasoy et al., 2015; Canbazoglu Bilici, 2012; Isman & Canan, 2008; Schmidt et al., 2009; Topcu & Masal, 2020). Based on these studies, the motivation of pre-service teachers, who are the future teachers, and their self-evaluation levels that affect their performance in the teaching process should be high.

In the literature, no research blends the argumentation-based learning approach with technology and handles the self-assessment variable related to TPACK together. Since TPACK is content-specific, it is thought this study will contribute to the relevant literature. Therefore, the study aims to investigate the effect of technology-supported argumentation-based teaching practice on pre-service teachers' TPACK self-assessment. For this aim, the main problem of the study is "What is the effect of technology-supported argumentation-based instruction on TPACK self-evaluation levels of pre-service mathematics teachers?" Sub-problems of the research are given below.

1. Is there a statistically significant difference between the TPACK self-evaluation levels of pre-service teachers in the experimental and control groups?

2. Is there a statistically significant difference between the experimental group's TPACK self-assessment pre-test and post-test scores of pre-service teachers?

METHOD

Research Pattern

In this study, quasi-experimental research design was used. The experimental research design provides the opportunity to intervene on the independent variables that are aimed to be analyzed. As a result of this intervention, it enables to determine whether there is a change in the dependent variable, and if so, in what direction. Thus, cause and effect relationships between variables can be revealed and interpreted (Cepni, 2014; Gurbuz & Sahin, 2017). Participants could not be randomly assigned to the groups because the classes in which the participants were located were pre-formed by the Dean's Office and the group sizes were not suitable for random assignment. For this reason, the study was designed as a pretest-posttest control group quasi-experimental design in which the existing classes are randomly assigned as experimental and control groups.

Participants

Participants of the study are 43 pre-service mathematics teachers who take the Analytic Geometry-I course. They were studying in the third grade in the faculty of education at a state university in Turkey, in the fall semester of 2019-2020 academic year. Participants were created by purposeful sampling. In purposeful sampling, people who are considered to be suitable to find an answer to the research problem are included in the study group (Gurbuz & Sahin, 2017; Plano Clark & Creswell, 2015). Participants could not be randomly assigned to the groups, but the branches were randomly assigned as experimental and control groups. The distribution of pre-service teachers in the experimental and control groups is presented in Table 1.

Table 1. Participants

Groups	Gender		Total
	Female	Male	
Experiment	15	6	21
Control	19	3	22
Total	34	9	43

Since the university entrance exam scores of the participants were very close to each other, it was thought that the mathematics knowledge of the groups was at a similar level. The pre-test results show that the experimental and control groups are equal to each other. The results of the independent groups t test conducted in order to compare the pre-test scores of the Technological Pedagogical Content Knowledge Self-Assessment Scale (TPACK-SAS) of the pre-service mathematics teachers in the experimental and control groups are presented in Table 2.

Table 2. T test results of TPACK-SAS pre test scores

	Groups	N	$\overline{X}$	SD	df	t	p
PK pretest	Experiment	22	5.57	0.70	41	-0.846	0.402
	Control	21	5.74	0.62			
CK pretest	Experiment	22	4.10	0.94	41	-0.274	0.785
	Control	21	4.17	0.73			
TK pretest	Experiment	22	4.50	1.20	41	-0.112	0.912
	Control	21	4.54	0.96			
TCKwT* pretest	Experiment	22	5.42	0.75	41	0.234	0.816
	Control	21	5.36	0.92			
PCK pretest	Experiment	22	5.58	0.74	41	-1.270	0.211
	Control	21	5.85	0.65			
TPACK pretest	Experiment	22	5.25	0.47	29.93	0.255	0.801
	Control	21	5.19	0.90			
TPACK-SAS pretest	Experiment	22	5.15	0.50	41	-0.470	0.641
	Control	21	5.23	0.58			

* TCKwT: Teaching content knowledge with technology. An explanation about this dimension of the scale is given under the title of data collection tool.

In Table 2, it is seen that there is no statistically significant difference between the pre-test scores of the experimental and control groups in each of the sub-dimensions that make up TPACK-SAS (p> 0.05). Accordingly, it can be said that the experimental and control groups are equivalent to each other in terms of TPACK self-assessment level before the experiment.

Data Collection Tool

For the aim of the study, TPACK-SAS developed by Kartal (2017) was used as the data collection tool. This scale consists of a total of 67 items including PK (15 items), TK (11 items), CK (8 items), TCK (5 items), TPK (10 items), PCK (11 items) and TPACK (7 items). It consists of 7 factors. Kartal (2017) conducted the validity and reliability analyzes by applying this scale to 557 pre-service teachers. As a result of these analyzes, it was seen that the TCK and TPK factors from 7 factors in the scale were combined. The new factor created by the combination of TCK and TPK factors was named as Teaching Content Knowledge with Technology (TCKwT). As a result, the scale now includes 6 factors. The reliability coefficients of the scale, both made by Kartal (2017) and calculated as a result of the analysis made in this study, are given in Table 3.

Table 3. TPACK-SAS reliability values

Factors	Cronbach alpha (α)	
	The values obtained by Kartal (2017)	The values calculated in this study
PK	0.967	0.905
TK	0.931	0.918
CK	0.930	0.804
TCKwT	0.967	0.930
PCK	0.953	0.906
TPACK	0.933	0.836
TPACK-SAS	0.980	0.945

It is seen that the values in Table 3 are greater than 0.8. Accordingly, it can be said that the scale is reliable (Kalayci, 2014).

Pilot Study, Implementation Process and Data Collection

The pilot implementation of the study was carried out in the spring semester of the 2018-2019 academic year. The study was carried out with a single group of 17 pre-service teachers studying at the same university with higher grades. The pilot implementation aimed to test the activities planned to be used in the primary implementation process. In addition, it was aimed to develop and optimize the process and to test the technology-supported argumentation-based teaching practice that the researcher and pre-service teachers will experience for the first time. Thus, technology-supported argumentation-based teaching practice was experienced, and possible problems that may occur during the primary implementation process were identified. The pilot implementation was carried out at specified times outside the current curriculum of the participants. (3 lessons per week for four weeks in total). All of the participants in the pilot practice participated in the study voluntarily. Since the GeoGebra program was used in the planned teaching practice, the lessons were taught in the computer laboratory. Since the pre-service teachers had previous knowledge and experience with GeoGebra software, there was no need for any training on using GeoGebra prior to the pilot implementation. However, the pilot process showed that the participants' knowledge of GeoGebra needed to be improved in transformation geometry activities. For this reason, before the immediate implementation, the participants in the experimental group were given two-week (4 hours in total) of GeoGebra training, 2 hours a week. GeoGebra was preferred in the study because it is easy to use, accessible, and Turkish language.

The study's first author taught the lessons in the experimental group and another lecturer in the control group. The lessons are planned to last four weeks (12 lesson hours), three lessons per week. In the first week of the lessons, the translational transformation, reflection transformation in the second and third weeks, and rotational transformation in the fourth week were discussed. TPACK-SAS, used as a data collection tool in the study, was applied to both groups before the first week (pre-test) and after the last week (post-test). In the experimental group, the lessons were taught with technology-supported argumentation-based teaching. Sixteen activities prepared by technology-supported argumentation-based teaching were used in the lessons. The activities are compatible with the transformation geometry content specified in the middle and high school mathematics curricula and included in the teacher training programs. In order to prepare activities suitable for the content, middle school and high school mathematics textbooks, textbooks used in mathematics lessons in education faculties and the relevant literature were examined. As a result of this examination, it was seen that the activities in high school mathematics books were suitable for the level of pre-service teachers and the use of GeoGebra (Altun, 2018; Emin et al., 2018; Kemancı et al., 2018; MoNE, 2017c; Unlu & Er, 2015). Therefore, it is thought that it would be appropriate to use the activities in these textbooks in studies. Some of the activities in these textbooks were adapted for the aim of the study, and some activities were used directly. Regarding the activities, the opinions of three mathematics education experts were taken. As a result of the evaluation, it was determined that the activities were suitable for the subject of transformation geometry and technology-supported argumentation-based teaching.

The activities were projected onto a screen that all participants could see through a projection by the researcher. Thus, the pre-service teachers could follow the instructions given by the researcher. After the GeoGebra work, an argumentation process was formed by discussing the questions in the activity. Throughout the activity, the information that the pre-service teachers reached, the correlations they put forward, and their generalizations were noted on the blackboard located on the other side of the laboratory and in a position where everyone could see them.

The transformation geometry teaching in the control group was carried out with the current teaching method. The current teaching method expressed here refers to predominantly teaching through the presentation. In the control group, the content in the experimental group was taught, and the questions in the experimental group were solved. No digital technology was used in the control group, and drawings made on the classroom board were used.

Analysis of Data

The data of the study were analyzed using the licensed SPSS 22 package program at a 95% confidence level (p = 0.05). Skewness and kurtosis coefficients were examined to determine whether the data showed normal distribution. The skewness and kurtosis coefficients of the data obtained from the TPACK-SAS pre-test and post-test are presented in Table 4.

Table 4. Skewness and kurtosis coefficients of TPACK-SAS data

	Groups		Mean	SD	Skewness	Kurtosis
PK	Control	Pre-test	5.57	0.70	-0.210	-0.676
		Posttest	5.65	0.58	-0.056	0.492
	Experiment	Pre-test	5.74	0.62	-0.211	-0.674
		Posttest	5.95	0.66	-1.186	1.643
CK	Control	Pre-test	4.10	0.94	0.134	1.407
		Posttest	4.37	1.01	-0.442	0.567
	Experiment	Pre-test	4.17	0.73	0.673	-0.393
		Posttest	4.46	0.84	0.119	-0.769
TK	Control	Pre-test	4.50	1.20	-0.501	-0.422
		Posttest	4.82	1.03	-0.409	0.869
	Experiment	Pre-test	4.54	0.96	-0.274	-0.763
		Posttest	4.90	0.80	-0.298	-0.985
TCKwT	Control	Pre-test	5.42	0.75	0.301	-0.754
		Posttest	5.59	0.69	-0.075	-0.274
	Experiment	Pre-test	5.36	0.92	-0.626	0.115
		Posttest	5.44	0.71	-0.691	0.464
PCK	Control	Pre-test	5.58	0.74	0.504	-0.658
		Posttest	5.67	0.67	0.513	-0.238
	Experiment	Pre-test	5.85	0.65	-0.126	-0.666
		Posttest	5.75	0.53	-0.177	-0.206
TPACK	Control	Pre-test	5.25	0.47	0.437	-0.103
		Posttest	5.34	0.63	0.188	-0.165
	Experiment	Pre-test	5.19	0.90	-0.602	0.643
		Posttest	5.54	0.78	-0.631	-0.579
TPACK-SAS	Control	Pre-test	5.15	0.50	0.278	-0.415
		Posttest	5.32	0.48	-0.340	-0.619
	Experiment	Pre-test	5.23	0.58	0.123	-0.936
		Posttest	5.41	0.59	-0.606	0.284

It is seen that the skewness and kurtosis coefficients presented in Table 4 are between -2 and +2 values. It can be said that the data are distributed normally if the skewness and kurtosis coefficients are between -2 and +2 (George & Mallery, 2020). Accordingly, in the analysis of TPACK-SAS pre-test and post-test data, independent groups t-test was used to make comparison between groups, and dependent groups t-test was used for in-group comparison. When interpreting arithmetic means, 1.00-3.00 range is considered as "low level", 3.01-5.00 range as "medium level" and 5.01-7.00 range is considered as "high level" (Tekin, 2007).

In cases where a statistically significant difference was detected as a result of the t tests, the effect size (Cohen d) was calculated to examine and interpret this significance more effectively. Cohen d statistic is not affected by the sample size. Thus, it enables the analysis results to be interpreted more effectively (Ozsoy & Ozsoy, 2013; Yildirim & Yildirim, 2011). According to Cohen (1988), if the effect size is less than 0.2, it is evaluated as a weak (small) effect, if it is greater than 0.8, it is evaluated as a strong (large) effect (Yildirim & Yildirim, 2011). On the other hand, Leech, Barrett, and Morgan (2008) stated that, in addition to this assessment of Cohen (1988), an effect size of 1 or more can be interpreted as a very large effect.

FINDINGS

In order to examine whether technology-supported argumentation-based instruction has an effect on TPACK self-evaluation level, TPACK-SAS post-test scores of experimental and control groups were compared. In addition to this comparison between the groups, TPACK-SAS pre-test and post-test scores (within the group) of the experimental group were also compared. Independent groups t test results made in order to compare the posttest scores of the pre-service teachers in the experimental and control groups regarding the sub-dimensions that make up the TPACK-SAS are presented in Table 5.

Table 5. T test results of TPACK-SAS sub-dimensions post test scores

	Groups	N	$\overline{X}$	SD	df	t	p
PK posttest	Control	22	5.65	0.58	41	-1.602	0.117
	Experiment	21	5.95	0.66			
CK posttest	Control	22	4.37	1.01	41	-0.334	0.740
	Experiment	21	4.46	0.84			
TK posttest	Control	22	4.82	1.03	41	-0.277	0.783
	Experiment	21	4.90	0.80			
TCKwT posttest	Control	22	5.59	0.69	40.76	0.727	0.471
	Experiment	21	5.44	0.71			
PCK posttest	Control	22	5.67	0.67	41	-0.408	0.685
	Experiment	21	5.75	0.53			
TPACK posttest	Control	22	5.34	0.63	41	-0.958	0.344
	Experiment	21	5.54	0.78			

When Table 5 is examined, it is seen that there is no statistically significant difference between the posttest scores of the experimental and control groups regarding the sub-dimensions that make up the TPACK-SAS ($p > 0.05$). In addition, when the averages in the sub-dimensions were examined, it was seen that the pre-service teachers in both groups had the lowest average in the CK sub-dimension and the highest average in the PCK sub-dimension. When the sub-dimensions with a low average are examined, it is seen that TK comes right after CK in both groups. It was determined that the averages of the sub-dimensions PK, PCK, TPACK, which include pedagogy knowledge, are above 5. Independent groups t test results made in order to compare the posttest scores are presented in Table 6.

Table 6. T test results of TPACK-SAS post test scores

	Groups	N	$\overline{X}$	SD	df	t	p
TPACK-SAS Post Test	Control	22	5.32	0.48	41	-0.555	0.582
	Experiment	21	5.41	0.59			

When Table 6 is examined, it is seen that there is no statistically significant difference between the post-test average of the experimental group and the post-test average of the control group ($t = -0.555$; $p > 0.05$). Y It is understood from the results of the t test that technology supported argumentation based transformation geometry teaching does not have a statistically significant effect on pre-service teachers' TPACK self-evaluation levels. In addition, it was observed that the TPACK-SAS post-test mean scores of pre-service teachers were above 5 for both groups.

The dependent groups t test results, which were made in order to compare the pre-test and post-test scores (within the group) of the pre-service teachers in the experimental group regarding the sub-dimensions that make up the TPACK-SAS are presented in Table 7.

Table 7. T test results of TPACK-SAS sub-dimensions pre and post test scores

	Test	N	$\bar{X}$	SD	df	t	p
PK	Posttest	21	5.95	0.66	20	1.484	0.153
	Pre-test	21	5.74	0.62			
CK	Posttest	21	4.46	0.84	20	1.779	0.090
	Pre-test	21	4.17	0.73			
TK	Posttest	21	4.90	0.80	20	3.204	0.004
	Pre-test	21	4.54	0.96			
TCKwT	Posttest	21	5.44	0.71	20	0.511	0.615
	Pre-test	21	5.36	0.92			
PCK	Posttest	21	5.75	0.53	20	-0.713	0.484
	Pre-test	21	5.85	0.65			
TPACK	Posttest	21	5.54	0.78	20	2.036	0.055
	Pre-test	21	5.19	0.90			

When Table 7 is examined, it is seen that p values are greater than 0.05 except for TK sub-dimension. This shows that there is no statistically significant difference between pre-test and post-test scores for sub-dimensions except TK sub-dimension ($p > 0.05$). Table 7 indicates that the difference between pretest and posttest scores for only the TK sub-dimension is statistically significant ($t = 3.204$; $p < 0.05$). From here, it can be said that technology-supported argumentation-based transformation geometry teaching has an effect on the self-evaluation levels of the pre-service teachers in the experimental group regarding TK, which is one of the TPACK components. In order to examine and interpret this finding more effectively, the effect size (Cohen d) was calculated.

$$d = \frac{t}{\sqrt{N}} = \frac{3{,}204}{\sqrt{21}} = 0{,}699$$

The value of d = 0.699 shows that the effect of technology-supported argumentation-based instruction on the self-assessment of TK of pre-service teachers in the experimental group is at a moderate level.

The dependent groups t test results regarding the whole TPACK-SAS of the pre-service teachers in the experimental group are presented in Table 8.

Table 8. T test results of TPACK-SAS pre and post test scores

	Test	N	$\bar{X}$	SD	df	t	p
TPACK-SAS	Posttest	21	5.41	0.59	20	1.683	0.108
	Pretest	21	5.23	0.58			

When Table 8 is examined, it is seen that there is no statistically significant difference between the experimental group's TPACK-SAS post-test average and pre-test average ($t = 1.683$; $p > 0.05$). In other words, it can be said that technology-assisted argumentation-based transformation geometry teaching does not have a statistically significant effect on the TPACK self-evaluation levels of pre-service teachers in the experimental group.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This study investigates the effect of technology-supported argumentation-based teaching on pre-service teachers' TPACK self-assessment. It was determined that there was no statistically significant difference between the TPACK-SAS post-test averages. Canbazoglu Bilici (2012) conducted a two-stage study with pre-service science teachers. In the first stage, the participants' TPACK self-efficacy levels were detected, and no increase was observed in the second stage. This result reached by Canbazoglu Bilici (2012) in the second stage of her study coincides with the result reached in this study.

It was observed that pre-service teachers' post-test mean scores were high, especially in the sub-dimensions of PK, PCK, and TPACK, which included pedagogy knowledge. Similarly, in their study with senior-year education faculty students, Sad, Acikgul, and Delican (2015) concluded that scores requiring pedagogy knowledge are higher than others. In another study, Landry (2010) reached a similar conclusion regarding the TK knowledge field in her study with middle school mathematics teachers. Self-assessment averages for TK were relatively lower than other dimensions. This was also revealed by Archambault and Crippen

(2009) in their study with teachers about the TPACK model. The same study determined that teachers have high confidence in PK and PCK, similar to the results obtained in this study.

It was determined that there was a statistically significant difference between the pre-test and post-test scores of the pre-service teachers in the experimental group only for the TK sub-dimension. It was observed that the effect of technology-supported argumentation-based instruction on this was moderate. Different from the result here, Atasoy et al. (2015) stated in their study that there was an increase in self-efficacy related to TPK and TCK components. The researchers stated that these increases may have resulted from the decrease in pre-service teachers' anxiety about integrating technology into the teaching process and the fact that they encountered exemplary activities related to teaching-technology integration. Contrary to Atasoy et al. (2015)'s work, in this study, it was seen that the increase in self-evaluations about TCKwT did not make a statistical meaning. It is thought that this situation is due to the pre-service teachers' evaluations of TPACK needing to be made aware of their actual situation.

In the study, a significant increase was observed in TK. However, it is noteworthy that the mean scores for TK are lower than other components before and after the practice. As Topcu and Masal (2020) stated, this situation may be attributed to the need for more mathematics teachers regarding technical details such as hardware and software. Significant increases in self-assessment regarding TK can be explained by the contribution GeoGebra activities provide to pre-service teachers' technological self-confidence. However, considering that the self-evaluation regarding TK is at a medium level after the implementation process, this contribution is not at the expected level.

It was concluded that the technology-supported argumentation-based transformation geometry teaching practice did not affect the experimental group teachers' self-evaluations regarding TCKwT and TPACK. More comprehensive and detailed studies can be conducted to investigate the causes of this situation.

This teaching practice requires the design of activities suitable for the argumentation process and teaching-technology integration. Therefore, developing pre-service teachers' skills to design such activities is essential. In this context, pre-service teachers' ability to design such activities can be examined, and practice can be made to improve these skills.

In the research findings, the self-evaluation of the pre-service teachers about TK was relatively low. Teachers should have a good knowledge of technology to teach using technology. Studies similar to this with pre-service teachers can be carried out with students at different educational levels on transformation geometry or another mathematics subject.

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Statements of publication ethics

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

Researchers' contribution rate

The first and the second author jointly carried out the processes of conceptualization of the theoretical framework, the determination of the research questions and the design of the method. The first author carried out the processes of data collection, data analysis and discussion of the results under the supervision of the second author. The first author wrote a Turkish draft of the manuscript on which both authors worked in cooperation. The second author edited the English version. The first author applied the article template before submission, and submitted the manuscript to the journal.

Ethics Committee Approval Information

The study is derived from the first author's doctoral thesis. The research process started in 2017 and the data were obtained before 2020 (2019-2020 Fall Semester). For this reason, the research is among the studies that do not require ethics committee approval.

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