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Determining The Technological And Pedagogical Content Knowledge Level Of The 4th Grade Teachers On The Unit; Electric In Our Life[1]

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Abstract

This study aims to determine the level of the technological and pedagogical context knowledge of the fourth-grade teachers in a specific unit entitled "Electiricity in Our Life". Total of 53 teachers from the three cities contributed to this study. In order to obtain more detailed information about teachers' TPACK levels, a mixed research method with acombination of both quantitative and qualitative data collection tools was employed. For data collection, four different data collection tools were used: Questionnaire of Nature of Science, Conceptual Test related to electricity, vignette, and content representations. In addition, percentages, and frequencies were calculated and Pearson's correlation analysis technique was used. The results revealed that elementary teachers did not have sufficient knowledge about content knowledge. Moreover, insufficient knowledge was also observed in teachers' pedagogical knowledge, learning difficulties, assessments, and learning environment, which are the components of pedagogical content knowledge. Also, according to the results, teachers had limited knowledge ofoverall technological knowledge and subject-related technology knowledge.

Keywords: Nature of Science, Content Representation, Elementary Teacher, Technological Pedagogical Content Knowledge, Electricity in Our Life

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Dördüncü Sınıf Öğretmenlerinin Yaşamımızdaki Elektrik Ünitesi Kapsamında Teknolojik Pedagojik Alan Bilgisi Seviyelerinin Belirlenmesi

Öz

Bu araştırmanın amacı dördüncü sınıf öğretmenlerinin yaşamımızdaki elektrik ünitesi kapsamında Teknolojik Pedagojik Alan Bilgisi seviyelerinin belirlenmesidir. Araştırmaya üç ilden toplam 53 Sınıf Öğretmeni katılmıştır. Bu çalışmada sınıf öğretmenlerin TPAB seviyeleri hakkında daha ayrıntılı bilgi elde etmek için hem nicel hem de nitel veri toplama araçlarının bir arada kullanıldığı karma bir araştırma yöntemi kullanılmıştır. Veri toplama aracı olarak Bilimin Doğası Görüş Anketi, Elektrik ile İlgili Kavram Testi, vignette ve İçerik Sunum Formu olmak üzere dört farklı veri toplama aracı kullanılmıştır. Ayrıca verilerin analizinde yüzde ve frekans değerleri ile Pearson korelasyon analizi gibi teknikleri kullanılmıştır. Araştırma sonucunda elde edilen bulgulara göre, Sınıf Öğretmenlerinin yeterli düzeyde konu alanı bilgisine sahip olmadıkları sonucu ortaya çıkmıştır. Sınıf Öğretmenlerinin program bilgisi, öğrenme güçlükleriyle ilgili bilgisi, öğretim strateji ve yöntem bilgisine ilişkin bilgisi, değerlendirme bilgisi ve ortam olmak üzere 5 bölümde ele alınan Pedagojik Bilgi bakımından da yeterli düzeyde bilgiye sahip olmadıkları sonucu ortaya çıkmıştır. Benzer biçimde sınıf öğretmenlerinin Genel ve Konuya Özgü Teknolojik Bilgi seviyeleri de yeterli düzeyde olmadığı sonucuna varılmıştır.

Anahtar Kelimeler: Bilimin Doğası, Ders Senaryo Örneği, İçerik Sunum Formu, Sınıf Öğretmeni, Teknolojik Pedagojik Alan Bilgisi, Yaşamımızdaki Elektrik Ünitesi

1. INTRODUCTION

In this century, many different opinions have emerged about the knowledge and skills that teachers should have. To eliminate the conceptual complexity of this issue, the concept of Pedagogical Content Knowledge (PCK) was first introduced by Shulman (1986, 1987). Since then, the concept of PCK was discussed in many national and international studies and it was accepted as a teacher competency and strongly emphasized (BozandBoz, 2008). With the increase in the importance of information and communication concepts and their effects on many events in our lives, social development and change have become necessary and this process of change was clearly expressed and emphasized on behalf of Turkey's education system in the 2023 Education Vision Document published in 2018 (MEB, 2018). Due to the changes and developments, the concept of PCK has been re-stated as technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006). TPACK, which was introduced by Mishra and Koehler (2006), is one of the models that integrate technology into education as a mindset that can evaluate the digital competencies of teachers (Topçu&Masal, 2020). TPACK covers three components: content knowledge (CK), pedagogical knowledge (PK) that represents educational practices and methods, and knowledge about regular technologies as well as modern technologies and their use (TK) (Koehler, Mishra and Yahya, 2007). As a result of the interaction of these three components with each other four different types of knowledge

emerged: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPACK), (Mishra & Koehler, 2006; Savaş, Öztürk& Yılmaz Tüzün, 2010).

When the literature is examined, it is found that Graham (2001) examined TPACK from a constructivist perspective and the relationship between them. In a study conducted by Archambault and Barnett (2009) with 596 teachers in the United States, the structure of the TPACK model was analyzed using factor analysis for the model to be expanded. In another study, Jang and Tsai (2012) worked with science and mathematics teachers in Taiwan and examined the effects of the use of interactive whiteboards on TPACK.Kıylık (2016) examined elementary teacher candidates' TPACK levels and the effects of various variables on TPACK. Yüngül (2018) also determined the TPACK competency levels of elementary teacher candidates and examined the relationship between pre-service teachers' intention to use technology and their TPACK levels. In another study, Baran and Canbazoğlu Bilici (2015) reviewed Turkish literature on TPACK and found that surveys mainly used as data collection tools, and those studies were mainly in science and mathematics fields. Although there exist other studies that focus on either teachers or teacher candidates in science, mathematics, and foreign language fields (Dikkartın Övez&Akyüz, 2013; Akturk&Saka Ozturk, 2019; CanbazoğluBilici&Yamak, 2014; Kılıç, Aydemir&Kazanç, 2019), there is a limited number of studies that focus on elementary teacher candidates' TPACK levels. Moreover, the existing studies were generally descriptive studies and did not use various data collection tools (Schmidt, Baran, Thompson, Mishra, Koehler and Shin, 2009; Timur&Taşar, 2011; Tatlı, Akbulut, &Altınışık, 2016). This study aims to examine fourth- grade teachers' TPACK competencies. The results of this study are critical in determining the current status of elementary teachers' TPACK levels and providing recommendations for in-service training programs.

2. METHOD

Research Method

According to the literature, teachers' knowledge about a specific topic cannot be determined by using only one instrument (Kaya, 2010). Therefore, elementary teachers' TPACK level (technological knowledge, pedagogical knowledge, and content knowledge) were examined by using various data collection tools: teachers' opinions about the nature of science

questionnaire, academic achievement test with open-ended questions,vignette example, and lesson plan matrix. In this context, the simultaneous triangulation method, one of the mixed research methods, was used in this study. In simultaneous triangulation method, qualitative and quantitative data are collected together. Besides, although their analyses are conducted separately, their findings are joined for interpretation (Baki&Gökçek, 2012).

The aim of this study is to determine the TPACK levels of fourth-grade teachers. Depending on this purpose, the elementary teachers' views on the nature of science, the levels of conceptual knowledge, overall program knowledge, subject (electricity) program knowledge, learning difficulty knowledge, learning environment knowledge, teaching strategy and methods knowledge, general assessment knowledge, general technological knowledge, and general technological knowledge within the scope of teaching the subject of electricity were investigated. And also, the relationships among the four components of pedagogical knowledge of elementary teachers (curriculum knowledge, learning difficulties knowledge, teaching strategy and method knowledge, and assessment knowledge), and between classroom teachers' technological knowledge and pedagogical and content knowledge were sought.

Participants

This study was conducted with the participation of 53 elementary school teachers teaching in fourth-grade from three different cities in 2014-2015 school year. There were 17 female teachers and 36 male teachers and they all voluntarily participated in the study.

Data Collection Tools

Concept knowledge test for electiricity

The concept knowledge test was developed based on the science curriculum by the researchers. First, an item pool with 16 questions was developed and reviewed by three facultymembers whose expertise was in elementary school science education and two elementary school teachers. Based on the expert views, four questions were dropped out, which left 12 questions. The questions were related to basic concepts about electricity, electrical circuits, and the formation and use of electricity.

Understanding of science and scientific inquiry

In order to determine elementary teachers' opinions about the nature of science, the Student Understanding of Science and Scientific Inquiry (SUSSI) was developed by Liang, Chen, Chen, Kaya, Adams, Macklin, and Ebenezer (2008) was used. The questionnaire was translated into Turkish by Kaya and it has 24 items with six factors: observations and inferences, tentative nature of scientific theories, scientific laws and theories, social and cultural influences on science, imagination and creativity in scientific investigations, and methodology in scientific investigations.The five-point Likert-type questionnaire has a reliability coefficient value of .72.

Identification of elementary teachers' pedagocical knowledge

In this study examining teachers' TPACK level, bothvignettes and lesson plan matrix were used.

Vignette

Through vignettes, it was aimed to determine elementary teachers' TPACK levels more objectively. In this context, a detailed one-hourvignette was created based on the concept of electricity for fourth-grade students. The script was evaluated by two faculty members of Science Education at Faculty of Education, one faculty member of Elementary Education at Faculty of Education, and three fourth-grade teachers. Based on the expert views, thevignette was finalized. After the valididy and reliability checks, some sections of the script were cut off by the researchers and the participants were asked to fill out the gaps while answering various questions. This allowed researchers to identify elementary teachers' pedagogical knowledge, and technological knowledge levels. The participants were provided only one hour to fill the gaps in the vignette and not allowed to use any source including textbooks.

Content representations (Co-Re)

Content Representation was developed by Loughran, Milroy, Berry, Gunstone and Muhall (2001) and it aims to determine teachers' TPACK levels. The researchers translated the matrix into Turkish and added four different items. Due to the changes in the matrix, expert opinions were obtained. After the revisions, the matrix became a form suitable for measuring TPACK levels.

Data Analysis

Data analysis related to content knowledge

In order to collect data on the concept sub-dimension of content knowledge, twelve questionswere prepared in line with the literature review and expert opinions. In the analysis of the data from these items, the 0, 1, and 3.5 scoring system proposed by Vazquez-Alonso and Manassero-Mas (1999) were used. In order to determine elementary teacher candidates' opinions of the nature of science, the following guide was used to interpret the mean values of each item in the SUSSI: Naive (1-1.80), Poor (1.81-2.60), Transitional or Mixed (2.61-3.40), Less Informed (3.41-4.20), and Informed (4.21-5.00). An independent samples t-test was conducted to determine whether there is a difference between teacher candidates' opinions of nature of science.

Data analysis related to pedagogical and technological knowledge

In order to determine the pedagogical and technological knowledge of the elementary teachers, the Content Presentation form was administered first and then they were asked to evaluate the lesson scenario sample prepared based on it. The data obtained from the vignette and the lesson plan matrix was evaluated together. For data analysis, the 0, 1, and 3.5 scoring system suggested by Vazquez-Alonso and Manassero-Mas (1999) were used.In the scoring of the data, the consistency between the first and last scores was taken into account while using Miles & Huberman (1994) formula and the agreement over 70%was calculated between the two scores.

Data anaşysis related to the association among CK, PK, TPACK and sub-dimensions of PCK

In order to examine the association among fourth-grade teachers' CK, PK, TPACK, and sub-dimensions of PCK levels, Pearson's correlation analysis was used. The values were evaluated by taking into account .01, .05, and .001 levels.

3. FINDINGS

Findings related to Content Knowledge

In order to identify participants' conceptual knowledge about a unit entitled "Electricity in Our Lives", a conceptual knowledge test was administered. The results are provided in Table 1.

Table 1. Results related to the conceptual knowledge test

		Explanation level		
Item No	Items	Scientifically sufficient explanation (3,5 point)	Partially sufficient explanation (1 point)	Unscientific explanation (0 point)
1	Basic electrical circuit and elements	16 (% 30,2)	24 (% 45,3)	13 (% 24,5)
2	Basic concepts of the electricity Unit	15 (%28,30)	6 (% 11,32)	32 (% 60,38)
3	Concepts about types of bindings	17 (% 32,08)	11 (20,75)	25 (% 47,17)
4	Differences between binding types	15 (% 28,30	10 (% 18,86)	28 (% 52,84)
5	The consequences of changes in the parallel circuit	22 (% 41,50)	1 (% 1,9)	30 (% 56,6)
6	The consequences of changes in the series circuit	24 (% 45,28)	5 (% 9,44)	24 (% 45,28)
7	Electricity generation	20 (% 37,74)	8 (% 15,09)	25 (% 47,17)
8	Distribution of electricity	14 (% 26,42)	13 (% 24,53)	26 (% 49,05)
9	Use of electrical circuits in daily life	16 (% 30,18)	8 (% 15,09)	29 (% 54,71)
10	Structure of the battery	19 (% 35,84)	7 (% 13,2)	27 (% 50,94)
11	Effect of changes in the number of batteries on the circuit	19 (% 35,84)	3 (% 5,66)	31 (% 58,5)
12	Effect of connection cable on circuit	16 (% 30,19)	8 (% 15,07)	29 (% 54,72)

As seen from the table, the fourth-grade teachers did not have sufficient knowledge about the unit “Electricity in Our Lives”

Findings related to the SUSSI

In order to identify fourth-grade teachers’ opinions about the nature of science, the SUSSI was administered. The findings are provided in Table 2.

Table 2. Findings related to the SUSSI

No	**Sub dimensions**	$\bar{X}$	**sd**	**Level**
1	Observations and Inferences	3.22-4.26	.78-1.26	From transitional or mixed to informed
2	Tentative nature of scientific theories	3.09-4.13	.78-1.06	From transitional or mixed to less informed
3	Scientific laws and theories	1.92-3.43	.89-3.43	From poor to less informed
4	Social and cultural influences on science	2.52-3.39	.98-1.04	From poor to transitional or mixed
5	Imagination and creativity in scientific investigations	3.30-3.60	.96-1.23	From transitional or mixed to less informed
6	Methodology in scientific investigations	2.77-4.28	.68-1.12	From transitional or mixed to informed

According to the findings, the participants only seemed to be informed for the observation and inferences and the methodology in scientific investigation factors. Overall, out of 24 items in the SUSSI, the participants had transitional or mixed views on ten items, less informed views on nine items, inforrmed views on two items, and poor views on three items.

Findings related to Pedagogical Content Knowledge

Pedagogical knowledge of elementary teachers includes knowledge about curriculum, knowledge of learning difficulties, knowledge about learning environment, knowledge about learning strategies and methods, and knowledge about assessment. In this analysis, the data obtained from the vignette, and the lesson plan matrix was analyzed in a holistic perspective and the results are provided in Table 3.

Table3. Results related to elementary teachers' pedagogical content knowledge

		Explanation level		
Dimensions	Items	Scientifically sufficient explanation (3.5 points)	Partially sufficient explanation (1 point)	Unscientific explanation (0 point)
Overall curriculum knowledge	General objectives of the lesson and approach	18 (% 33.96)	18 (% 33.96)	17 (% 32.08)
	Learning areas	18 (%33.96)	12 (% 22.64)	23 (% 43.40)
	Understanding of assessment in the program	12 (% 22.64)	9 (16.98)	32 (% 60.38)
Overall subject knowledge	Subject-specific objectives	14 (% 2.42)	7 (% 13.21)	32 (% 60.38)
	(Science Process Skills (SPS), Science Technology Society Environment (STSE) and Attitude and Value (AV)objectives	23 (% 4.,40)	9 (% 16.98)	21 (% 39.63)
	Goals in students' learning	21 (% 39.62)	12 (% 22.64)	20 (% 37.74)
Knowledge about learning difficulties	Misconceptions and reasons	12 (%22.64)	11 (%20.75)	30 (% 56.60)
	Limitations and difficulties encountered in teaching the subject	11 (%20.75)	6 (% 11.32)	36 (% 67.92)
	Subject-specific misconceptions, learning difficulties	13 (% 24.53)	6 (% 11.32)	34 (% 64.15)
	Reasons of learning difficulties encountered in teaching the subject	11 (%20.75)	5 (% 9.43)	37 (% 69.81)
Knowledge about teaching stratejies, methods, and techniques	Methods and techniques used in science and technology courses	12 (% 22.64)	8 (% 15.09)	33 (% 62.26)
	Subject-specific methods and techniques	14 (% 26.40)	8 (% 15.09)	31 (% 58.5)
Knowledge about assessment	Assessment tools used in science and technology courses	13 (% 24.50)	9 (% 17.00)	31 (% 58.5)
	Subject-specific assessment tools	12 (% 22.60)	8 (% 15.1)	33 (% 62.3)
	Duration	11 (% 20.75)	-	42 (%79.25)

Knowledge about learning environment	Environmental conditions	12 (% 22.64)	4 (%7.55)	37 (% 69.81)

The results revealed that elementary teachers provided insufficient explanations about curriculum and specifically about the subject, learning difficulties, teaching strategies, methods and techniques, assessment, and learning environment.

Results related to Technological Knowledge

In order to identify fourth-grade teachers' technological knowledge, avignette and a lesson plan matrix that were designed based on expert views were employed. Their technological knowledge was measured under two sub-headings: overall technological knowledge and subject-based technological knowledge. The overall technological knowledge includes information about whether they used technology. In terms of the subject-based technological knowledge, the followings were investigated: technological knowledge for the curriculum, technological knowledge for teaching strategies and methods, technological knowledge about learning difficulties, and technological knowledge about assessment. Table 4 is designed to provide the results.

Table 4. Results related to Technological Knowledge

		Explanation level		
Dimensions	Sub-dimensions	Scientifically sufficient explanation (3.5 point)	Partially sufficient explanation (1 point)	Unscientific explanation (0 point)
Technological knowledge	Overall technological knowledge	10 (% 18.90)	7 (% 13.20)	36 (% 67.90)
	Integration of technological knowledge and program knowledge	10 (%18.90)	6 (% 11.30)	37 (% 69.80)
	Integration of technological knowledge and learning difficulty knowledge	11 (% 20.70)	2 (%3.80)	40 (% 75.5)
	Integration of technological knowledge and knowledge about teaching strategies, methods and techniques	12 (% 22.60)	9 (% 17.00)	32 (% 60.38)
	Integration of technological knowledge and assesment knowledge	10 (% 18.90)	5 (% 9.40)	38 (% 71.70)

The results revealed that more than 60% of the fourth-grade teachers provided unscientific explanations to all sub-dimensions.

4. Results related to the association among CK, PCK, TPACK and among sub-dimensions of PCK

Table 5. Results related to the association among CK, PCK, TPACK

	CK	PCK	TPACK
CK	-	.353*	.240
PCK	.353	-	.924**
TPACK	.240	.924	-

***P<,05 , **P<,001**

According to the results provided in Table 5, a significant and positive association was observed between CK and PCK ($p < .05$) and between PCK and TPACK ($p < .001$).

Table6. Results related to the association among sub-dimensions of PCK

	1	**2**	**3**	**4**
Overall curriculum knowledge (1)	-	.816**	.890*	.767*
Knowledge about learning difficulties (2)	.816*	-	.954*	.897*
Knowledge about teaching stratejies, methods, and techniques (3)	.890*	.954*	-	.886*
Knowledge about assessment (4)	.767*	.897*	.886*	-

*P<,000

According to the results, significant and positive associations were found among all sub-dimensions ($p < .001$).

4. CONCLUSION, DISCUSSION VE RECOMMENDATIONS

Conclusion, Discussion and Recommendation about Content Knowledge

Conclusion, discussion and suggestions regarding the findings obtained from conceptual knowledge questions

The results revealed that the fourth-grade teachers did not have sufficient subject knowledge. Among the participants, only 13 gave correct answers to all questions in the conceptual knowledge test. On the other hand, 12 teachers did not have any correct answers. In

a similar study, Hashweh (1987) found that teachers had misconceptions about science subjects that they taught students.In another study on the structure and properties of matter, Deborah, Dante, and Kelsey (2018) concluded that elementary teachers did not have sufficient knowledge about the particulate nature of matter and they did not know why this issue was scientifically important. Also, Euphemia (2017) found that elementary teachers considered themselves inadequate in teaching science subjects and admitted that they had misconceptions about science, which were also proved through observations and lesson plans. Based on these findings, Euphemia (2017) suggested organizing in-service professional development programs focusing on science education. While Catalona, Lauren and Alana stated (2019) that elementary teachers generally have low self-efficacy in mathematics and science, Musikul (2007) reported that teachers believe that science subjects are one of the most difficult to teach. As a result of these findings and the findings of the current study, differences in undergraduate schools teachers graduated from and insufficiency in high-school and undergraduate level science courses may be considered as reasons for insufficieny in teachers' conceptual knowledge in science. Therefore, it is critical to revise science-related courses in teacher education programs and in high schools, which may result in more effective teaching and learning.

Conclusion, discussion and suggestions regarding the findings obtained from nature of science questionnaire

According to the data obtained from SUSSI, which was used to determine elementary teachers' opinions about the nature of science, the participants provided transitional or mixed views to ten items, less informed views for nine items, poor views to three items, and informed views for only two items. These results revealed that the elementary teacher did not have sufficient knowledge about the nature of science. Similar findings were found in another study conducted by Ayvacı (2007). On the other hand, Saraç and Capellaro(2012) found that although the participants had realistic views about e effect of society on science, the effect of science on society, the nature of observations, and the transience and changeability of scientific knowledge, they had insufficient knowledge about the relationship between scientific discoveries and gender, the nature of scientific models, the association among hypothesis, theory, and law, and the epistemological perspective of scientific knowledge. Since elementary teachers did not take any course directly related to the nature of science in their undergraduate education, they may not be able to build a bridge between their field and the nature of science.

It may be possible to include some science-related courses in the teacher education programs in order to ensure teacher candidates understand science and scientific studies better. In this respect, it is even more important that the concept of scientific literacy is the main target not only in the field of science and technology but also in all other fields.

Conclusion, Discussion and Suggestions Regarding Pedagogical Content Knowledge

Conclusion, discussion and suggestions regarding curriculum knowledge

According to the findings, it was observed that the teachers did not have sufficient knowledge about the science curriculum. A similar result was found by Kaya (2010). Karaman and Karaman (2016) also found a parallel result and suggested that in-service programs should be designed to increase teachers' knowledge about the science curriculum. Özcan, Oran and Arık (2018) asked teachers to evaluate the 2013-2017 science curriculum and found that they had insufficient knowledge. They also suggested that professional development programs should be designed to positively affect teachers' attittudes towards curriculum, increase their awareness, and help them to adopt the curriculum. Considering the findings of this study, it is seen that the elementary teachers did not receive sufficient instruction related to the general objectives and the content of the science curriculum in their undergraduate education. Therefore, more professional development programs related to the science curriculum and science instruction are required for teachers. Also, teacher education programs need to be revised to cover information about science curriculum.

Conclusion, discussion, and suggestions regarding learning difficulties

When the findings of the study regarding learning difficulties were examined, teachers' knowledge about learning difficulties was unsifficient. Altun and Uzuner (2016) found similar results and emphasized the importance of teacher education programs and in-service professional development programs. In another study, Yangın, Yangın, Önder, and Şavlığ (2016) examined awareness levels of elementary teacher candidates' and faculty members in Department of Elementary Education in terms of learning difficulties and found that they were unable to define terms related to learning difficulties and did not have knowledge about how to manage students' learning difficulty issues. Similar results were found by Ghimire (2017). Kaçar and Düzkantar (2019) put strong emphasis on professional development programs on learning difficulties. It is also stated that teachers and students tend to have the same scientific

misconceptions and these misconceptions affect teaching negatively (Catalona, Lauren & Alana, 2019). Considering the findings in the literature and the current study, it is concluded that one of the main reasons of such insufficient knowledge about learning difficulties may be due to the limited emphasis on learning difficulties and on the science curriculum in teacher education programs. Therefore, more emphasis should be placed on learning difficulties and misconceptions in the theoretical and practical science courses in teacher education programs.

Conclusion, discussion and suggestions regarding teaching strategies and methods

Another critical finding of the current study is related to teachers' limited knowledge in teaching strategies and methods. Heidi and Rogers (2018) and Kaya (2010) also reported elementary teachers' insufficient knowledge and beliefs about how to teach science. In order for high quality in education, content knowledge, pedagogical knowledge, and pedagogical content knowledge are the critical aspects andteachers should have content knowledge as well as knowledge about how to support students' learning (Gess-Newsome & Lederman, 1999, Sothayapetch, Lavonen and Juuti, 2013). More specifically, teachers tend to generally focus on only instruction and content with their limited pedagogical knowledge, which causes students to avoid ~~from~~ science (Sothayapetch, Lavonen, &Juuti, 2013). In addition, Zembal-Saul, Krajcik, and Blumenfeld (2002) stated that teachers are afraid of unexpected problems when teaching science. Therefore, as Kaya (2010) suggested, teacher education programs need to be revised in terms of science-related courses. Demir and Özden (2013) also found that elementary teachers had limited and incorrect knowledge about teaching strategies, methods, and techniques and suggested organization of professional development programs to support teachers' pedagogical knowledge in science education. Bardak and Karamustafaoğlu (2016) also found similar results and acknowledged schools to help teachers overcome this issue. In short, increasing the number and quality of professional development programs focusing on science instruction may help teachers learn more about various teaching methods and strategies and assessment tools.

Conclusion, discussion, and suggestions regarding learning environment

According to the results, the teachers did not provide enough scientific explanations to the item "Please tell us about the other factors that may affect your instruction about electricity", which proved their limited knowledge about learning environment. In their study, Seven and

Engin (2008) examined the factors that negatively affect instruction in schools and reported that learning environment is one of the factors and improving conditions of learning environment will affect learning positively. Considering the time determined in lesson plans may be insufficient to teach a certain topic especially in crowded classrooms, future research must consider examiningclass size and its effects on instruction and the effects of professional development programs on teachers' instruction.

Conclusion, discussion and suggestions regarding assessment

Despite assessment is considered as one of the components of pedagogical content knowledge for science teaching (Magnusson et al., 1999), it was observed that the participants of thisstudy did not have sufficient knowledge in terms of assessment. Similar results were found by Yamtim and Wongwanich (2014). In a study, Özenç and Çakır (2015) examined elementary teachers' competencies in alternative assessment methods. They found that teachers had insufficient knowledge about assessment tools and considered alternative assessment techniques complex, and as a result, they preffered traditional assessment tools for evaluation of students' performances. Roig-Vila, Mengual-Andres, and Quinto-Medrano (2015) also stated that elementary teachers are not able to adapt different teaching techniques and styles into instruction and do not know how to evaluate students' performances for different courses. Baş and Beyhan (2016) examined the self-efficacy perceptions of teachers working in primary and high schools and found a low level of assessment-related self-efficacy in both knowledge and skills dimensions. Baş and Beyhan (2016) also suggested teachers to participate in professional development programs and to seek Master's Degree in Education. Tuncer and Geçim (2019) found teachers' deficiency in developing objective assessment tools and put a strong emphasis on improving teachers' knowledge on students' learning in teacher education programs. In addition to these suggestions, the deficiencies in alternative assessment issues should be emphasized in teacher education programs through theoretical and practical courses.

Conclusion, Discussion, and Suggestions Regarding Technological Knowledge

In this study, it was observed that elementary teachers were quite insufficient in terms of general and subject-specific technological knowledge. Similar results were found by Varol (2013). In another study, Sakin and Yıldırım (2019) found that teachers' self-efficacy beliefs were low on TK, TCK, TPK, and TPACK and suggested that teacher candidates need to be

exposed to various instructional technologies during their undergraduate education and teachers should be able to easily access to different technological tools and applications including animations, simulations, and online exams related to the subjects they tend to teach. Avcı and Ateş (2018) also put strong emphasis on professional development programs to increase teachers' active and effective usage of technology and as a result, increase their TPACK levels. Zhang, Liu, and Cai (2019) stated that elementary teachers rarely use technology in their lessons, especially at lower grades, and they prefer to use storytelling and children's songs in their instruction. In their study, Topçu and Masal (2020) examined mathematics teachers' perceptions and self-evaluation skills about TPACK by considering how and to what extent they use technology in their instruction and found that teachers had the highest score for the PCK sub-dimension and the lowest score for the TK sub-dimension. Similar results were found by Roig-Vila, Mengual-Andres, and Quinto-Medrano (2015). In addition, Zhang, Liu, and Cai (2019) found that elementary teachers had lower TPACK levels compared with middle school teachers' TPACK levels. According to the researchers, this difference may be related to teachers' academic performances and professional development performances in teacher education programs. On the other hand, Heitink, Voogt, Fisser, Verplanken, Van Braak (2017) conducted a study with teachers in Netherlands and found that teachers used tools including personal computers or laptops, mobile phones, tablets, and cameras along with Microsoft Word, internet, simulation software, and assessment software in their lessons. Eliminating the physical problems of learning environments and providing sufficient technological tools and materials, presenting teaching activities and textbooks in technological environments, and making the TPACK concept an active element in every step of the curriculum will ensure the increase in teachers' TPACK levels.

According to the correlation results, a strong relationship was found between teachers' PCK and TPACK scores (r =, 924). However, there was a moderate correlation between teachers' CK and PCK scores (r =, 353), while a small correlation was found between teachers' CK and TPACK scores (r =, 240). In addition, a high level of correlation was found among the sub-dimensions of PCK (Table 5,6). In a similar study, although Chai, Koh, and Tsai (2010) found a positive correlation among technological knowledge, pedagogical knowledge, and content knowledge in their study, the strongest correlation was observed between PK and

TPACK. In another study, Lin, Tsai, Chai, and Lee (2013) found a positive correlation between PK, TK, and CK and the other factors of TPACK.

Recommendations

Considering the findings of this study, experimental studies must be conducted to increase the TPACK levels of elementary teachers.

Elementary teachers must be provided with in-service professional development programs to advance their knowledge on TPACK.

Revisions need to be considered in teacher education programs to include more and detailed TPACK activities to ensure the graduation of teacher candidates more competently.

During undergraduate education, especially practical courses must be revised within the framework of TPACK.

By examining the education systems of different countries, ideas about technology integration can be obtained.

In addition, studies should be conducted to determine and increase the TPACK competencies of prospective teachers in online environments.

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Genişletilmiş Özet

1980'li yıllarda Shullman tarafından literatüre kazandırılan Pedagojik Alan Bilgisi (PAB) öğretmenlerin kendi alanlarına ait bilginin yanı sıra pedagojinin de gerekliliğini ortaya koyan bir kavramdır. Bu bağlamda PAB, konu alan bilgisi, öğretim yöntemleri bilgisi, öğretim programı bilgisi, değerlendirme bilgisi ve öğrencileri anlama bilgisi alanlarını açıklamaktadır. Teknolojinin eğitimde kullanılmaya başlanmasıyla da pedagojik alan bilgisi kavramı teknolojik pedagojik alan bilgisi (TPAB) kavramı halini almıştır. Bu kavram ile öğretmenlerin teknoloji sayesinde öğrenme-öğretme süreçlerini daha etkili hale getirmeleri amacıyla yeterliliklerinin artırılmasını amaçlanmaktadır. TPAB, teknolojik bilgi, pedagojik bilgi ve alan bilgisinin birbirinin etkileşimini üzerine kurgulanmıştır ve bu üç yapının etkileşimiyle pedagojik alan bilgisi, teknolojik alan bilgisi, teknolojik pedagojik bilgisi ve teknolojik pedagojik alan bilgisi kavramları oluşmuştur. Bu araştırmada dördüncü sınıflarda görev yapan sınıf öğretmenlerinin elektrik ünitesi kapsamında TPAB seviyelerinin belirlenmesine çalışılmıştır. Araştırma, 2014 yılında Şanlıurfa, Elazığ ve Kayseri illerinde görev yapan 53 sınıf öğretmeni ile yürütülmüştür. Literatür incelendiğinde TPAB ile ilgili çalışmaların genellikle fen ve teknoloji, bilişim teknolojileri ya da matematik öğretmenleri veya öğretmen adaylarına yönelik olduğu sınıf öğretmeni ya da öğretmen adayları ile ilgili yapılan çalışmaların ise daha az sayıda olduğu görülmektedir. Ayrıca yapılan çalışmaların genellikle öz yeterlik, öz güveni belirlemeye çalışan ölçeklerle yürütüldüğü görülmektedir. Bu araştırmada ise çoklu veri toplama araçları kullanılarak sınıf öğretmenlerinin TPAB seviyelerinin belirlenmesine çalışılmıştır. Bu çalışmada, tarama metodu kullanılmıştır ve bilimin doğası görüş anketi, açık uçlu kavramsal bilgi testi, ders senaryo örneği ve ders planı matriksi kullanılarak veriler toplanmıştır. Sınıf öğretmenlerinin kavramsal bilgi seviyelerini ölçmek amacıyla geliştirilen on üç sorudan oluşan kavramsal bilgi soruları kullanılmıştır. Ayrıca sınıf öğretmenlerinin bilimin doğasına ilişkin görüşlerini belirlemek amacıyla "Bilimin Doğası İle İlgili Görüş Anketi" kullanılmıştır. Aynı zamanda öğretmenlerin, pedagojik bilgilerini belirlemek amacıyla ders senaryosu ve ders planı matriksleri veri toplama araçları olarak kullanılmıştır. Kavramsal bilgi soruları ile ders planı matriksi ve ders senaryo örneğinden elde edilen verilerin analizinde 0,1 ve 3,5 puanlama şablonu kullanılmıştır. Öğretmenlerin sorulara vermiş oldukları cevaplardan doğru ve eksiksiz olanlara 3,5 puan, kısmen doğru cevaplara 1 puan ve yanlış olup hiçbir bilimsel açıklaması olmayan cevaplara 0 puan verilmiştir. Sınıf öğretmenlerinin bilimin doğası görüş anketinden elde edilen verilerin değerlendirilmesinde de aritmetik ortalamalar kullanılarak kategorilendirme yapılmıştır. Sınıf öğretmenlerine ait demografik verileri belirlenirken % (yüzde) ve frekans (f) değerleri kullanılmıştır. Araştırmanın kavramsal bilgi sorularından elde edilen bulguları incelendiğinde, öğretmenlerin konu alan bilgisi seviyelerinin yeterli olmadığı belirlenmiştir. Sonuçlar incelendiğinde, kavramsal bilgiye ait tüm sorulara doğru cevap veren öğretmen sayısı 13 iken 12 öğretmen ise hiçbir soruya doğru cevap verememiştir. Sınıf öğretmenlerinin bilimin doğası ile ilgili görüşlerini belirlemek için kullanılan anketten elde edilen verilere göre, katılımcılar on maddeye geçişli veya karışık görüş, dokuz maddeye daha az bilgilendirilmiş görüş, üç maddeye zayıf görüş bildirirken sadece iki madde için bilgilendirilmiş görüş bildirmişlerdir. Bu sonuçlar, sınıf öğretmeninin bilimin doğası hakkında yeterli bilgiye sahip olmadıklarını ortaya koymuştur. Benzer biçimde sınıf öğretmenlerinin genel program bilgisi, Fen ve Teknoloji dersi öğretim programının yapısı, ilkeleri, programın amaçları, programda yer alan kazanımlar ve programın yaklaşımı ile ilgili sorulara verilen cevapları incelendiğinde yeterli düzeyde bilgiye sahip olmadıkları sonucuna ulaşılmıştır. Sınıf öğretmenlerinin öğrenme güçlüğü, ortam bilgisi, öğretim

strateji/yöntem ve değerlendirme bilgileri ile ilgili sonuçları da bu alanlarda yetersiz bilgi seviyesine sahip olduklarını göstermiştir. Aynı zamanda sınıf öğretmenlerini genel ve konuya özgü teknolojik bilgileri yönünden de oldukça yetersiz oldukları sonucuna varılmıştır. Bu sonuçlar doğrultusunda genel olarak sınıf öğretmenlerinin dördüncü sınıf Fen ve Teknoloji dersi elektrik ünitesi kapsamında teknolojik pedagojik alan bilgisi seviyelerinin yetersiz olduğu görülmüştür. Literatürde sınıf öğretmenlerinin teknolojik pedagojik alan bilgisi seviyelerini belirleyen daha farklı çalışmaların yapılmasıyla beraber bu sonuçlardan hareketle bundan sonraki çalışmalarda bu yetersizliklerin giderilmesine yönelik çalışmaların yapılması da büyük önem arz etmektedir. Bu tür çalışmaların öğretmen yetiştirme politikalarına da katkı sağlayacağına inanılmaktadır. Bununla beraber, bu tür çalışmaların sonuçları eğitim fakültelerinde öğrenim görmekte olan öğretmen adaylarına uygulanan programların şekillenmesinde de önemi bir rol oynayacaktır.