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An Inquiry into the Underlying Reasons for the Impact of Technology Enhanced Problem-Based Learning Activities on Students' Attitudes and Achievement*

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ABSTRACT

Purpose: In the constantly changing and evolving world of today, there is a need to raise individuals who are able to renew themselves, learn autonomously, and have higher order thinking skills such as critical thinking and deducing. The purpose of the present study is to investigate the effects of Technology Enhanced Problem-Based Learning Activities (TEPLA), developed with regard to the aforementioned need, on learners' attitudes towards mathematics and academic achievement in mathematics through qualitative data in order to designate the underlying causes of these effects.

Method: In the research, conducted as a case study, the analysis of the written and oral interviews were held with students using "Student Interview Form" in order to analyze the effect of TEPLA on the attitudes towards mathematics and mathematics achievements of study group students who were applied TEPLA by the first author.

Findings: The analysis revealed two main dimensions affecting the association between TEPLA and learners' attitudes towards mathematics: Affection and Usefulness, which comprised five and three distinct reasons, respectively. On the other hand, ten factors were defined to account for the impact of using TEPLA on learners' mathematics achievement.

Implications for Research and Practice: The research findings suggested that learners found TEPLA interesting and meaningful. Thus, it can be suggested that the impact of TEPLA on learner motivation can also be investigated using a motivation scale. Moreover, learners stated during interviews that they achieved retention in learning thanks to TEPLA. Thus, the finding regarding TEPLA's impact on retention can be further investigated quantitatively.

* This study is derived from a PhD dissertation and part of it was presented in 4th EJER Congress in Denizli, 11-14 May, 2017

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Introduction

Today Mathematics Education does no longer adopt the traditional function of teaching merely the equational skills and abstractions, but it is rather driven by the purpose of providing the learners with the ability to use mathematics in daily life. These new trends have brought up the issue of using different instructional methods and integrating technology into education. Cakır and Aztekin (2016) reported that authentic tasks contribute significantly to learners' motivation, as they show learners how the knowledge they have learned work in daily life. Likewise, National Council of Teachers of Mathematics (1989) emphasized the principle… "To learn mathematics is to apply mathematics".

On the other hand, in our world, which constantly change and evolve thanks to what technology brings into our lives, there is an increased need to raise individuals who are able to renew themselves, learn autonomously, and have higher order thinking skills such as critical thinking and deducing. Therefore, Problem-Based Learning (PBL) offers a method compatible with the purpose of raising individuals with those higher order thinking skills, since PBL is characterized by learning mathematics by doing, activating learners' higher order thinking skills, teaching how to learn, and enabling the learners to adapt knowledge to different situations. Furthermore, today the ease provided by technologies in instructional activities, and gradual increase in the prevalence of technology have made it necessary and inevitable to integrate technology into education (Bozkurt & Cilavdaroglu, 2011). Besides, Oberlander and Johnson (2004) stated that for students to learn better, it is necessary to integrate instructional technologies into PBL so as to create conditions that facilitate meaningful learning, enhance visuality, and provide opportunities for knowledge transfer into authentic tasks, feedback, and revision. Moreover, findings from many studies (e.g. Cheung, 1988; Erktin, 1993) indicated that learners' attitudes towards mathematics is a significant predictor of achievement, thus developing favorable attitudes among learners towards mathematics have become one of the primary objectives of mathematics education. Therefore, it is considered important in terms of mathematics education to better understand the underlying factors responsible for the impact of using PBL method and technology use in mathematics education on learners' mathematics achievements and attitudes towards mathematics classes. Likewise, Sheehan and Nillas (2010) further stress that technology integration has many benefits on learners, however, there is still a need for further studies to figure out the impact of technology on learning from all aspects. Present study is believed to contribute to the relevant literature by shedding light on this need.

Literature Review

Recently, a considerable number of studies have been conducted about the impact of technology and PBL method on learners' academic achievement and attitudes. Among them, let's first examine those investigating the impact of Geogebra software activities. For example, Baltacı, Yıldız and Kosa (2015) found that Geogebra can help learners develop positive attitudes towards mathematics, enhance their interests in mathematics, enjoy the lessons, and increase their motivation based on data obtained

from teachers' views. Likewise, Zengin (2017) concluded that Geogebra software contributed to the development of learners' mathematical communication skills through creating a learning environment with cooperation and discussions. In addition to this, Wah (2015) found positive and significant impact of Geogebra software on learners' academic achievement and motivation. Likewise, Takaci, Stankov and Milanovic (2015) inferred from interviews with students that using Geogebra software made it easy for the students to learn the topic, enabling them to communicate, cooperate and reinforce their understanding thanks to quick feedback. Moreover, Dayı (2015) argued that Geogebra software helped learners conceptually understand the definition of function better, they could easily model the real life problems with the help of Geogebra software removing any need to make symbolic definitions. As it can be understood from these research findings, using Geogebra software in mathematics education have favorable effects on learners.

Now we need to outline the findings of the studies on the effects of PBL. For example, Amalia, Surya and Syahputra (2017) reported that PBL has a positive and significant impact on learners' ability to solve mathematical problems. However, Han, et. al. (2016) suggested that while PBL has no significant impact on academic achievement, it ensured the learners to enjoy the lessons more, relieve their mathematics anxiety, and develop interest in advanced mathematics. Botty, Jaidin, Li, Shahrill and Chong (2016) found out that problem-based learning had a significant positive impact on learning mathematics, motivating learners to work in cooperation; and thus, reducing their dependence on teachers. It is understood from these studies that though different results regarding PBL's impact on student achievement have been obtained, positive effects of PBL on learners have been observed.

When we examine the studies conducted, it is evident that although there are many studies investigating the impacts of PBL and technology on students' achievement and attitudes based on students' self-report, research inquiring into the underlying reasons for their impacts on academic achievement and attitude have not been encountered. It is believed that this study will serve to better understand the impact of technology and PBL on attitude and achievement exploring the factors affecting achievement and attitude based on student views, and to develop multifaceted and content-rich instructional practices considering these factors.

Purpose

The purpose of the present study is to investigate in depth the effects of Technology Enhanced Problem-based Learning Activities (TEPLA), developed by the first author and implemented on 9th graders attending a state high school in Ankara, on learners' attitudes towards and achievement in mathematics through learners' views, and to designate the underlying reasons for these effects.

In this regard, this study will answer the following research questions:

1. How do the written and oral interviews with participants in the study group explain the effect of applied TEPLA on learners' attitudes towards mathematics?

2. How do the written and oral interviews with participants in the study group explain the effect of applied TEPLA on learners' achievement in mathematical functions topic?

Method

Research Design

Designed as a case study, which analyzes a certain process or individuals in depth (Creswell, 2014, s. 14), present study focused on and limited to the qualitative part of a large scale PhD dissertation (First Author, 2017). During the first phase of the abovementioned dissertation, using Technology Enhanced Problem-Based Learning Activities, (TEPLA) an experimental study was conducted on the treatment group while the control group was taught through Traditional Instruction (TI). This qualitative case study was conducted only on students in the treatment group. In order to analyze the impact of TEPLA on learners' attitudes and achievement regarding mathematics, qualitative data were collected using *Student Interview Form,* which included both open-ended written and oral interview questions.

It would be possible to reveal many factors affecting attitude and achievement we investigated in *the case study, which* is a qualitative research design providing the opportunity to investigate in depth the event. As a matter of fact, Yıldırım (1999) highlights that the field of education have been investigated predominantly with quantitative study, however, such studies fall short of explaining educational phenomena, and findings of these studies fail to regulate the actual practices in the field of education. Thus, we preferred to use the case study design to investigate in depth a phenomenon or an event which the researcher cannot take control of, by relying on the questions of "how" and "why" as asserted by Yıldırım and Simsek (2011).

Research Sample

Participants of the research comprised of 9th graders (25 students) attending a state high school affiliated to Provincial Directorate of National Education in Ankara during 2013-2014 school year. The school where the first author works, admits students through a selection exam and offers education on equally-weighted domain (combination of verbal and numerical skills). The group of the students, to whom the first author taught Mathematics, were selected as participants according to non-probability sampling method of convenient sampling.

Research Instrument and Procedure

In order to collect the detailed views of study group students about TEPLA used in this study, "Student Interview Form", including seven questions, was developed and used by the researcher. This form was examined by three academicians, and necessary regulations were executed.

The data were collected by using this Student Interview Form was developed by the first author in line with the views of an expert panel in order to understand the

students' detailed views about TEPLA. Using this form, students were asked to write down their views first. After the written feedbacks were analyzed, a total of twelve participants were selected from the students using the criterion sampling method based on the criteria of ability of self-expression, equal representation of both sexes, and different levels of mathematics achievement. Then, these students were interviewed in depth about their views on TEPLA. The interviews were recorded via a video camera.

First author taught mathematical functions to the participants using TEPLA. A total of twelve TEPLA were designed to help students understand the role and significance of functions in mathematics in real life through a combination of problem solving method and technology. These activities in TEPLA were aimed to ensure that students learned mathematics meaningfully by doing and experiencing with the help of technology. During these activities, learners were given examples of real life situations, and these stituations were transferred into problem situations as required by the subject matter. During the learning process, learners were expected to come to some mathematical conclusions through small and large group discussions. Participants were taught in three different formats. The first one included in-class group activities, the second one involved using smartboard and dynamic mathematics software in computer laboratory, and the third one was based on out-of-class activities and projects.

Validity and Reliability

To secure the validity of the qualitative data, following validity strategies were used as defined by Creswell (2014). First of these strategies is Peer Debriefing. Accordingly, the analysis of the participant students' views was examined by three specialized scholars, and revised duly. Moreover, these data were analyzed and approved by two peers doing their PhD in Mathematics education.

Furthermore, participant views running contrary to the general results of the research were also presented; thus, negative or discrepant information in the themes with opposite evidence were introduced. The validity of the results increases to the extent that the researcher has experiences and interactions with the participants. As a validity strategy, data were collected spending a prolonged time, a month (20 lesson hours), in the field.

Another validity strategy is to explain the researcher's bias he/she brings to the study in order to clarify the researcher's characteristics in the background in qualitative research. As a matter of fact, qualitative research is mainly characterized by reflectiveness. Therefore, all aspects of the researcher that could affect the study were defined in the "Researcher Role".

Researcher Role: All TEPLA were applied by the first author. The relevant researcher had studied the use of technology in teaching mathematics in his master's thesis, which facilitated him to teach participants the technology-based applications better. Moreover, the participant interviews were conducted by the first author, in

person. To avoid biased responses from the participants, they were encouraged to be relaxed at the beginning of the interviews, and the interviews were recorded on video.

Data Analysis

Participants' written and oral responses to the questions of Student Interview Form were coded via open coding method, and analyzed and evaluated. Participants' written and oral responses were labeled with letter "d" and "D", respectively. The analysis of the participant students' views was examined by three specialized scholars, and revised duly. Moreover, these data were analyzed and approved by two peers doing their PhD in Mathematics education.

Results

Results Regarding the First Research Question

The results about the first research problem "How do the written and oral interviews with participants in study group explain the effect of applied TEPLA on learners' attitudes towards mathematics?" were presented below. Participants' views on the underlying reasons for the impact of TEPLA on learners' attitudes towards mathematics were analyzed in terms of "Affection" and "Usefulness". Heijden (2003) defines Affection factor as one's enjoying something in its essence. Gürol (2008), on the other hand, defines Usefulness as the degree of one's belief that using a certain system will improve his/her work performance.

Affection factor: Five underlying reasons under "Affection" factor which explain the impact of TEPLA on learners' attitudes towards mathematics were listed in *Themes* column accompanied by quotations from participants in Table 1.

The first theme in Table 1, which emerged from the students' views suggested that group works made the lesson enjoyable. Data extracts from participants including D9 ("It was enjoyable that everyone tried to do something and cooperated with their classmates" and D15 ("When we do by giving hands to each other and cooperate, it becomes more intimate.") also stressed that group work made the lessons enjoyable. The second theme explaining the impact of TEPLA in terms of affection factor suggested that TEPLA facilitated learning the lessons. For example, participant D14 illustrated how they do so by saying "Since they are related with daily life, it facilitated my comprehension." The third factor was that TEPLA improved self-confidence, responsibility, communication competences, and alike. Asserting that "Out-of-class tasks enhanced our senses of responsibility." participant D16 emphasized that Out-of-class tasks enhanced their senses of responsibility, while participant D15 suggested how TEPLA strengthened their communications skills and self-confidence saying "It has strengthened our communication… I have gained confidence in this topic." Fourth factor suggested that learning how to learn among learners improves the fluency of lesson. Participant D16 indicated learning autonomously by saying "the lessons are more easygoing since we learn and produce formulas". The last factor suggested that technology made the lesson interesting. Participant D7 explained the role of technology

in making the lessons interesting by saying "More appealing the technology is (to the youth), more interesting the lessons are. "

Table 1

Participant Views on Underlying Reasons Regarding the Impact of TEPLA under Affection Factor

Themes	*Quotations*
Group work makes the lesson enjoyable	*D9- "It ensured that the lessons were not dull anymore and lessons were productive. It was enjoyable that everyone tried to do something and cooperated with their classmates. I think other lessons should be taught in this way. It makes mathematics classes more enjoyable and interesting."* *D15: When we do by giving hands to each other and cooperate, it becomes more intimate.*
TEPLA make learning easier	*D10 -"I have been afraid of functions since last year. I realized that I don't need to be afraid of them when it is taught this way. Functions are not that difficult to understand."* *D14: Since they are related with daily life, it facilitated my comprehension.* *I have learned what function means during the activities. I know its relation with the daily life. I can solve the problems more easily as I can understand them by reasoning.*
TEPLA improve self-confidence, responsibility, communication competences and alike	*D16-"Out-of-class tasks enhanced our senses of responsibility. Communication competence has improved. As we competed with our friends like in a race, I gained self-confidence, saying 'I know it, I must do it first'."* *D15: It has strengthened our communication. We become closer friends. I have gained confidence in this topic.*
Learning how to learn improves the fluency of lesson	*D16 -"While we used to yearn for the end of the lesson since the lessons were very boring and monotonous, now the lessons are more easygoing since we learn and produce formulas."* *d2: "Involving the daily life while teaching the lesson content pleased me since it enabled me to apply mathematics into life".*
Technology makes the lesson interesting	*d23 - "Technological applications contributed to us. They attracted my attention more. I listened to the teacher more and engaged to the lesson more."* *d7 - "More appealing the technology is (to the youth), The more interesting the lessons are"*

Usefulness factor: The three reasons under "*Usefulness" factor* which explained the impact of TEPLA on learners' attitudes towards mathematics were listed under *Themes* column accompanied with quotations from participants in Table 2:

Table 2

Participant Views on Underlying Reasons Regarding the Impact of TEPLA Under Usefulness Factor

Themes	*Quotations*
Increasing eagerness to learn	*D16 -"I used to find it boring. Students always ask a question: "What does Mathematics even work for us? However, when functions, which students generally find very complicated, were applied into daily tasks, we admitted that it was so connected to real life. Mathematics is something reasonable. It is necessary in daily life. Thus, I became more devoted to study. At least we didn't get bored. We used to get bored previously. We could not even understand anything from the test books."*
	D13 – I realized that mathematics can be enjoyable. We have learned that it may work in daily life, seeing that I can use it in daily life. I became more willing to learn.
Developing affection for mathematics	D20 -"*Thus, One likes mathematics much more from now on. (It becomes like a game. As we solve our own problems by working regularly on it, we also solve mathematics by working on it, too. Thus, we kind of identify mathematics with our life and consider it as something we must do."*
	D1 - "*It presented us a different point of view. It made us love mathematics. People who dislike mathematics generally do not believe in its usefulness. Actually, they are right. The practical use of mathematics is not taught in traditional education ."*
Satisfaction by students	D10 -"*When we measured the height of the school building, we both enjoyed a lot and applied mathematics directly to our lives. We didn't pretend, we really witnessed that mathematics is feasible, and we entertained while doing."*
	D9- "It ensured that the lessons were not dull anymore and lessons were more productive. It was enjoyable that everyone tried to do something and cooperated with their classmates."

It was seen in Table 2 that first factor explaining the impact of TEPLA on learners' attitudes towards mathematics in terms of usefulness was increasing learners' eagerness to learn. Regarding this factor, participant *D13* explained how TEPLA increased learners' eagerness to learn by saying *"I realized that mathematics can be enjoyable. We have seen that it can be used in daily life, and we have learned that it may work in daily life. I beca*me more willing to learn." Second factor suggested that TEPLA developed affection for mathematics. Participant D20 asserted that TEPLA helped him love mathematics by identifying himself with it by saying *"Thus, we associate mathematics with our life, and consider it as something we must do."* Third factor defined the satisfaction TEPLA gave to the learners. Learners expressed their satisfaction by saying "*It was productive, it was entertaining*".

Results Regarding the Second Research Question

The results about the second research problem "*How do the written and oral interviews with participants in study group explain the effect of applied TEPLA on learners' achievement in mathematical functions...?*" were presented below. Ten underlying reasons explaining the impact of TEPLA on learners' mathematics achievement were listed under *Themes* column accompanied with quotations from participants in Table 3.

Table 3

Participant Views on Underlying Reasons Regarding the Impact of TEPLA on Mathematics Achievement

Themes	*Quotations*
Group work	D15- "*When we do the group work, we cannot always ask you questions. But I can easily ask to my classmates. When I am solving the problems, I come to some point where I get stuck. I need someone to give me a hand and show me so that I can progress. I was able to progress myself in the following questions. I was perfect for us.*"
	D1- "*There was a pleasant competition among us during group work. Everybody concentrated better on the questions. Hence, we could understand the topic better.*"
Difficulties of group work in learning	D2-"*As I tried to involve my peers in the group, I missed the lesson.*"
	D1- "*Although our classmates explained us the difficult parts, we cannot understand as they are not expert.*"
Verbal expression	D14 - "*When it is stated, we can exactly understand how to do.*"
	D10- "*Expressing what we have learned at the end of the activity has improved our mathematical expression ability.*"
Visuality	D11- "*Because we could visualize the graphic as we see on the computer, it became easier to understand. I was able to solve the problem faster upon seeing it. I mean it made the topic more concrete. After seeing the graphic we were able to find the equation more easily.*"
	D23- "The program we used enabled me to do and understand the activity more easily as I could see the changes on the graphic."
Lack of technology acceptance	D16-"*It takes some time to get used to the technology. There was a problem with perception. I could not focus on the computer. Paper-and-pencil is better for me. There was some humming noise in the laboratory.*"
	D25- "*I am not quite good at technology and computers. I believe we can learn the content without using the technology.*"
Learning by discovering, experiencing and involving more senses via technology	D14 - "*It is more effective to learn myself with daily life activities, because in this way we open our senses and challenge ourselves more thus gaining more permanent knowledge.*"
	D20- "When I do it myself, I struggle, pay attention and spend effort. This is easier to remember."
Daily life tasks' making it easy to comprehend and associate	*D20- "In the new method we learned technological authentic tasks and this attached us to mathematics. Using mathematics in daily life and applying them by seeing… both makes us happy and let us understand and comprehend things better."*
	D8- "I think using daily life tasks is a better method, because we can understand better when we are in it."
Meaningfulness and increased speed of learning by discovering and experiencing	D16 – "*We have learned on our own by doing. We learned faster. We didn't learn stereotyped things, but we discovered the solutions by finding our own stereotypes.*"
The opportunity to spend the time to improve higher order thinking skills thanks to the ease of processing via technology	D14 -"*I think our graphic exercises in the laboratory improved our ability to read graphics. It was beneficial because we did everything with technology by seeing in daily life activities. It was both easy and we saved extra time. We didn't waste any time with calculations. The essential knowledge was produced. We could understand what actually we needed to learn. This let us understand the topic better. We understand better by concentrating on doing rather than wasting time with calculations.*"

Table 3 Continue

Themes	*Quotations*
Self-Learning	D21-*"In fact, one hardly forgets something he/she has learned by himself/herself. One remembers it in his/her own way. It would be a great desire to discover something by ourselves. We can remember better later on, since we have learned it by ourselves. It would be permanent knowledge."* D20-*"We can understand, comprehend and remember something we do, learn and apply by ourselves."*

First factor explaining the TEPLA's relationship with learners' mathematics achievement was "*Group work*". Participants suggested that one aspect of the contribution of group work was cooperation expressing their views with such sentences as "*…we cannot always ask you questions. But I can easily ask to my classmates."* Participants defined another contribution of group work as encouraging competition by saying *"There was a pleasant competition among us during group work."* Second factor was "*Difficulties of group work on learning*". Participants stressed that they had difficulty in following the lesson due to the group work, and cooperation within group was not enough at higher levels. Third factor was "*Verbal expression"*. Participants stated that TEPLA improved learners' verbal expression skills. Fourth factor emerged from participant views was "*Visuality*". Learners asserted that they were able to comprehend the content more easily and faster. The fifth factor explaining the TEPLA and mathematics achievement was "*Failure to accept technology*". Participants stated that they had difficulty in getting used to the computers and had problems in laboratory, since they were not quite good at computers. The sixth factor emerged from learners' views was "*Learning by discovering, experiencing and involving more senses via technology*." Participants explained that learning by exploring and doing enhanced their capacity to perceive, increased their interests, thus helped to achieve retention in learning outcomes. Seventh factor was "*Daily life tasks' making it easy to comprehend and associate*". Participants emphasized that daily life activities involved them in actual learning and helped them comprehend the topic better by understanding its rationale. Eighth factor that emerged from participant views was "*meaningfulness and increased speed of learning by discovering and experiencing*". Participants suggested that learning by discovering, doing and making sense was faster. Ninth factor was about "*The opportunity to spend the time to improve higher order thinking skills thanks to the ease of processing via technology*". Participants' views revealed that technology accelerated the unnecessary processes and saved time, thus provided the opportunity to improve the higher order thinking skills. The tenth and the last factor emerged was *"Self-Learning."* Participants emphasized that by learning themselves, they comprehended better and retained what they had learned. All factors explaining the underlying reasons for the impact of TEPLA on learners' attitudes towards mathematics and academic achievement are summarized in Table 4.

Table 4

All Factors Explaining the Underlying Reasons for the Impact of TEPLA *on Learner Attitudes and Academic Achievement*

Factors explaining the relationship of learner attitudes and TEPLA		**Factors explaining the relationship of academic achievement and TEPLA**
Themes explaining the affection factor	**Themes explaining the usefulness factor**	
Group work makes the lesson enjoyable	*Increasing eagerness to learn*	*Group work*
TEPLA make learning easier	*Developing affection to mathematics*	*Limitations of group work on learning*
TEPLA improve self-confidence, responsibility, communication competences and alike	*Satisfaction by students*	*Verbal expression*
Self-learn improves the fluency of lesson		*Visuality*
Technology makes the lesson interesting		*Failure to accept technology*
		Learning by discovering, experiencing and involving more senses via technology
		Daily life tasks' making it easy to comprehend and associate
		Meaningfulness and increased speed of learning by discovering and experiencing
		The opportunity to spend the time to improve higher order thinking skills thanks to the ease of calculation via technology

Discussion, Conclusion and Recommendations

The results of the present research are supported by many previous studies in the literature, which investigated using problem-based learning, technology, and dynamic mathematics software in particular. For example, investigating a software prototype to teach mathematical functions, Ceylan (2003) found based on interviews with learners that almost all learner agreed that they could learn mathematics more meaningfully and permanently thanks to the technology-aided instructional methods. Likewise, Wah (2015) reported that Geogebra software program had positive and significant effect on learners' achievement and motivation. Moreover, findings from Takaci et al. (2015) also support the results of the present study. As a result of the analysis of the participant interviews in this study, it was concluded that Geogebra applications enabled the learners to understand the topic better, to devote more time to analyze the relationship between formulas and graphics rather than the calculations,

and to enjoy an effective and enriched learning environment. Furthermore, learners stated that they had the opportunity to communicate, cooperate and get quick feedback, thus deepening their knowledge thanks to Geogebra. Sheehan and Nillas (2010) found out that learners could participate in lessons more actively, experience higher order learning, and associate different mathematical representations in case they were primary users of technology. Fies (2007) argued that technology helps many students visualize topics in mathematics, which help them learn more easily, and that using technology enhances learners' motivation and participation into lessons. In addition to this, Arbain and Shukor (2014) reported that Geogebra applications had significant and positive effects on learners, and enhanced learners' motivation, self-confidence, willingness to learn, and critical thinking skills.

The findings of many previous researches about PBL method also comply with the findings of the present study. However, the results regarding the effect of PBL on academic achievement are different to some extent. For example, Usta (2013) found out that problem-based learning method had positive effects on learners in terms of improving higher order thinking skills like problem solving, association, and deductive reasoning, and other outcomes like communication skills and self-efficacy. On the other hand, Han et al. (2016) reported that while problem-based learning method had no significant effect on the academic achievement of 9th grade students, thanks to PBL method learners found the lessons more enjoyable, their level of mathematics anxiety decreased, and their interests in advanced mathematics increased. Botty et al. (2016) reported that problem-based learning had significant positive effect on learning mathematics, motivated them to work in cooperative groups, thus decreased their dependence on teachers. Moreover, Amalia et al. (2017) found out that problem based learning had positive and significant effect on developing learners' ability to solve math problems.

An analysis of the research results above apparently reveals that there is a consensus about the positive effects of technology on academic achievement, while there are controversial results regarding the effect of problem-based learning on academic achievement. Therefore, it can be interpreted that integrating technology and problem-based learning into our TEPLA can have a positive and significant impact on academic achievement. As a matter of fact, as specified in Gestalt theory, the whole can have an effect different from the sum of its parts (Cevik, 1991). In addition to this, apart from the previous researches in the literature, results of the present study regarding TEPLA's effect might contribute to understanding the effect of TEPLA on attitude and academic achievement better, and enable future researchers and practitioners to prepare multifaceted and successful instructional activities considering these factors. However, it should be noted that the present study was limited to the 9th grade students attending a high school in Ankara and to teaching mathematical functions only.

This study investigated how students have explained the impact of TEPLA (Technology Enhanced Problem-Based Learning Activities) on learners' attitudes towards mathematics and academic achievement in mathematics through written and oral interviews.

The analysis revealed two main factors accounting for the impact of using TEPLA on learners' attitudes towards mathematics: *Affection* and *Usefulness,* which comprised five and three distinct reasons, respectively. Another aspect of the study was about the impact of TEPLA on learners' achievement in mathematics. As a result of the analysis of the participants' views, ten factors, mentioned above, were defined accounting for the impact of using TEPLA on learners' mathematics achievement.

It was found in the present study that learners found TEPLA interesting, meaningful, and entertaining. Therefore, considering that learning motivation refers to the extent learners find learning activities meaningful, interesting, and helpful in making use of the learning outcomes, whether TEPLA affect learner motivation can be investigated using a motivation scale.

Contrary to the positive results, it was also found that one of the factors explaining the relationship between TEPLA and learners' academic achievement in mathematical functions was the failure to accept technology and adapt to the practices since they were not good at technology. Therefore, learners' readiness regarding technology and their attitudes towards technology can be measured before applying TEPLA, and thus the effect of technology on learners can be investigated comparing their backgrounds.

Since present study was restricted to mathematical functions, activities like TEPLA can be used to teach different topics in mathematics at different class levels to investigate the factors affecting attitude and academic achievement in a more comprehensive manner. Besides, in the present study it was found that TEPLA were accepted and considered useful by the learners. Therefore, it can be useful to teachers, and candidate teachers can be trained about TEPLA to use them in their actual or future schools. As a matter of fact, following the present research, 15.000 mathematics teachers were trained online about dynamic mathematics software by a team of experts where the first author was also involved within a project conducted by Ministry of Education Directorate General of Innovation and Educational Technologies (YEGİTEK). Moreover, 100 mathematics teachers were given a face-to-face teacher training program about teaching mathematics with technology. In addition to this, learners stated that they could retain what they have learned by exploring, spending effort, and using what they had learned in daily life. Thus, whether TEPLA ensure retention in learning can be investigated using quantitative research methods.

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Teknolojiyle Zenginleştirilmiş Probleme Dayalı Öğrenme Uygulamalarının Öğrencilerin Tutum ve Başarılarına Etki Sebeplerinin İncelenmesi

Atıf:

Cetin, Y., Mirasyedioglu, S., & Cakiroglu, E. (2019). An inquiry into the underlying reasons for the impact of technology enhanced problem-based learning activities on students' attitudes and achievement. *Eurasian Journal of Educational Research, 79, 191-208*, DOI: 10.14689/ejer.2019.79.9

Özet

Problem Durumu: Anlamlı öğrenmeye elverişli koşullar sağlayan, görsellik, geri bildirim ve gözden geçirmeye imkân sunan öğretim teknolojisi ortamlarının öğrencilerin yeteneklerini geliştirmek üzere tasarlanmasını sağlayan teknolojinin matematiği gerçek yaşamla ilişkilendiren PDÖ'ye entegrasyonu öğrencilerin daha iyi öğrenmeleri açısından önemlidir. Fakat teknoloji ve PDÖ'nün öğrenciler üzerindeki etki veya faydalarının tüm yönleriyle derinlemesine inceleyen çalışma pek bulunmamaktadır. Dolayısıyla, matematik öğretiminde PDÖ'nün ve teknoloji kullanımının matematik başarısına ve öğrencilerin matematik dersine yönelik tutumlarına etkisinin altında yatan sebeplerin açığa çıkarılması matematik öğretimi açısından yararlı olacaktır.

Araştırmanın Amacı: Bu çalışmanın amacı Teknoloji Destekli Probleme Dayalı Öğrenme Uygulamalarının (TPU)'nun öğrencilerin matematiğe yönelik tutumları ve matematik başarıları üzerindeki etkisinin altında yatan sebepleri belirlemektir.

Araştırmanın Yöntemi: Büyük ölçekli bir doktora araştırmasının (Birinci Yazar, 2017) sadece nitel kısmına odaklanan bir durum çalışması olarak gerçekleştirilen bu araştırmada Öğrenci Görüşme Formu kullanılarak öğrencilerle gerçekleştirilen yazılı ve sözlü mülakatların analizleri yapılmıştır. Araştırmada çalışma grubu; Milli Eğitim Bakanlığına bağlı olarak birinci yazarın görev yaptığı, sınavla öğrenci alan ve eşit ağırlık alanında eğitim veren bir devlet lisesinde bulunan bir 9. Sınıfın öğrencileri seçilmiştir.

Fonksiyonlar konusunun öğretiminde teknoloji destekli probleme dayalı öğrenme uygulamaları (TPU) adı altında problem çözme ve teknolojiyi kullanarak matematiğin günlük hayattaki yerini ve anlamını görebilecekleri bir içerikte birinci yazar tarafından hazırlanan 12 etkinlik, çalışma grubu öğrencilerine birinci yazar rehberliğinde uygulanmıştır.

Çalışma grubu öğrencilerinin teknoloji destekli probleme dayalı öğrenme uygulamaları hakkında düşüncelerini ayrıntılı biçimde algılamak için birinci yazar tarafından uzman görüşleri doğrultusunda bir Öğrenci Görüşme Formu düzenlenerek 7 soru içerecek biçimde son şekli verilmiştir. Birinci yazar tarafından geliştirilen bu

form kullanılarak önce öğrencilerin yazılı görüşleri alınmıştır. Daha sonra bu yazılı görüşler incelenerek kendini ifade edebilen, kız-erkek ve matematik başarısı dengeleri gözetilerek bu öğrencilerden amaçlı örneklemeden ölçüt örnekleme yöntemi ile belirlenen 12 öğrenci ile okulda özel bir odada mülakat yolu ile TPU hakkında detaylı görüşleri alınmıştır.

Araştırmanın Bulguları: Öğrencilerin matematik dersine yönelik tutumları ile TPU'nun ilişkisi "Hoşlanma" ve "Kullanışlılık" alt boyutları bazında incelenmiştir. "Hoşlanma" boyutu ile TPU ilişkisini açıklayan sebepler aşağıda sıralanıp ilgili öğrenci görüşleri verilmiştir. TPU'nun *hoşlanma* boyutu ile ilişkisini açıklayan nedenler *Grup Çalışması, TPU'nun ders işleyişini kolaylaştırması, TPU'nun kişisel becerileri geliştirmesi, kendi kendine öğrenmenin dersi akıcı kılması ve teknolojinin dersi ilgi çekici hâle dönüştürmesi* olarak ortaya çıkmıştır. "Kullanışlılık" *boyutunun* uygulanan TPU ile ilişkisini açıklayan etmenler *dersi öğrenme isteğini artırması, matematiği sevdirmesi ve matematiğin kullanışlılığını görmenin öğrencilere verdiği memnuniyet* olarak ortaya çıkmıştır.

TPU ile matematik dersi akademik başarısı ilişkisini açıklayan on etmen aşağıdaki başlıklar altındaki öğrenci görüşleriyle belirlenmiştir. TPU ile matematik dersi başarısı ilişkisini açıklayan etmenler; *grup çalışması, grup çalışmasının öğrenme zorlukları, sözlü ifade etme, görsellik, teknolojinin kabullenilmemesi, teknolojiyle daha çok duyu organlarının kullanılması, günlük hayat uygulamalarının ilişki kurmada ve anlamada kolaylığa sebep olması, Keşfederek, uygulayarak öğrenmenin anlamlı ve hızlı olması, Teknolojinin sağladığı işleyiş kolaylığının zamanı üst seviyedeki düşünme becerilerinin geliştirilmesine kullanmaya imkân tanıması ve Kendi kendine öğrenme* olarak belirlenmiştir.

Araştırmanın Sonuçları ve Önerileri: Öncelikle çalışma grubunun öğrencileriyle yapılan yazılı ve yüz yüze görüşmeler, uygulanan TPU'nun öğrencilerin matematik dersine yönelik tutumlarına etkisini nasıl açıkladığı incelenmiştir. Öğrencilerin matematik dersine yönelik tutumları ile TPU'nun ilişkisinin incelendiği iki alt boyuttan biri olan *Hoşlanma* boyutu ile TPU ilişkisini açıklayan sebepler yukarıda belirtilen beş başlık altında, diğer alt boyut olan *Kullanışlılık* boyutunun uygulanan TPU ile ilişkisini açıklayan etmenler ise 3 başlık altında incelenmiştir. Çalışmada öğrenci görüşlerinin incelendiği diğer bir boyut; TPU ile öğrencilerin matematik başarıları arasındaki ilişkidir. İncelenen öğrenci görüşleri sonucunda TPU ile matematik dersi başarısı ilişkisini açıklayan etmenler on başlık altında incelenmiştir.

Bu çalışmada öğrencilerin TPU'yu ilgi çekici, anlamlı ve eğlenceli buldukları belirlenmişti. Dolayısıyla, öğrenme motivasyonu, öğrenen bireyin, öğrenme etkinliklerini anlamlı, ilgi çekici bulması ve bunlardan yarar sağlaması olarak düşünüldüğünde TPU'nun öğrenci motivasyonunu etkileyip etkilemediği bir motivasyon ölçeği kullanılarak nicel olarak da araştırılabilir.

Bununla birlikte, öğrencilerin matematik dersi fonksiyon konusundaki başarıları ile TPU ilişkisini açıklayan bir etmenin teknolojinin kabullenilmemesi olduğu ve öğrencilerin teknolojiye adapte olmakta güçlükler yaşadıklarından uygulamaları benimseyemedikleri belirlenmişti. Bu yüzden TPU çalışması öncesinde öğrencilerin bilgisayar hazır bulunuşluk düzeyleri veya teknolojiye yönelik tutumları belirlenip

teknolojinin öğrenciler üzerindeki etkisi teknoloji geçmişleriyle karşılaştırılarak irdelenebilir.

Bu çalışma sadece fonksiyon konusuyla sınırlı olduğundan farklı matematik konularında ve farklı seviyelerdeki sınıflarda TPU benzeri uygulamalar kullanılarak tutum ve başarıya etki eden faktörler daha geniş bir yelpazede irdelenebilir. Bunun yanı sıra, çalışmamızda TPU'nun öğrenciler tarafından benimsendiği ve faydalı görüldüğü belirlenmişti. Bu yüzden TPU öğretmenlere veya öğretmen adaylarına ders verilip bu uygulamaları görev yaptıkları okullarda uygulamaları sağlanması öğrenciler açısından faydalı olabilir.

Öğrenciler akılda kalıcılığa ilişkin görüşlerinde kendilerinin keşfederek, emek sarf ederek, günlük hayatta uygulayarak ve kullanarak kalıcı öğrenme gerçekleştirdiklerini ifade etmişlerdir. TPU'nun akılda kalıcılık sağladığı görüşü nicel olarak da araştırılabilir.

Anahtar Kelimeler: Matematik eğitimi, Geogebra, Günlük hayat uygulamaları, Durum çalışması.