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The Effects of Problem Based Mathematics Teaching Through Mobile Applications on Success

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Abstract

The purpose of this study is to determine the effects of problem based mathematics teaching through mobile based applications which are used as assistive technology. It has been designed in a mixed method model that integrates research results. The participants of the experimental group were chosen from the students who continue to take mathematics courses within the traditional curriculum and were included in the process of problem based learning via mobile applications. Quantitative dimension of the study was designed using quasi-experimental design with pretest-posttest control group and it was seen that the success of the students in two different environments showed significant difference before and after the experiment. In other words, it has been found that the common effects of successive measurement factors on the success of different learning environments are significant. Within the light of these findings, it has been determined that both learning environments have different effects in increasing the success of the students and that the environment created for the experimental group is more effective in increase of the success. As a result of the qualitative analysis of the data collected by the researcher through the open-ended questionnaire, it was seen that the students reported positive opinions towards the environment (mobile technology, WhatsApp or virtual stock exchange application) and problem based teaching process. Based on these results, it can be asserted that the problem based learning process in which mobile based applications are used as an assistive technology is effective both in the increase of students' success in maths and their positive attitudes.

Keywords

Instant messaging
Mathematics education
Problem based learning
Technology assisted learning
Academic success

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Introduction

Mathematics, which is a tool used by many disciplines, helps individuals develop their ability to think objectively and freely, increase their self-reliance, and explain cause-effect relationships in the problems they encounter (Alkan & Altun, 1998). Mathematics (Altun, 2008), which is more of a combination of abstract concepts, should be taken out from this abstract structure and transformed into a concrete structure which is needed by the students (Goldin, 2002). The goals identified for teaching mathematics can be achieved by students' learning to solve problems (Baykul, 2014). In mathematics education in which students have to understand in order to learn (Jung, 2002), mathematical predisposition should be given to students (Altun, 2015). The mathematics which is described as a human activity (Freudenthal, 1968, 1973, 1991) should be learned in connection with real life (Bintaş, Altun, & Arslan, 2003). For this, mathematics should be as concrete as possible and students should be able to relate mathematics to their everyday lives.

Vos and Kuiper (2005) note that since students do not meet real-life questions, their success has fallen in international exams such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS). The World PISA and TIMSS reports of general multi-purpose and student assessment programs at the international level carried out by large organizations, indicate that students do not have the required mathematics achievement in Turkey and that they are below the national average (see. Mullis, Martin, Foyer, & Hooper, 2016; Mullis, Martin, & Loveless, 2016; OECD, 2016). However, this can be solved by first seeing problem solving as the heart of mathematics (Wilson, Fernandez, & Hadaway 1993) and the actual cause of mathematics education (The National Council of Supervisors of Mathematics [NCSM], 1978).

Problem solving skills, which are one of the most important learning skills that can be gained in school and in life (Jonassen, 2002), are seen as one of the basic learning outcomes of contemporary teaching environments and education (Jonassen & Kwon, 2001). Problem-based learning - defined as the attempt to solve complex real life problems by experiencing complex real life problems - PBL (Torp & Sage, 2002) provides students active participation in the process by allowing task-oriented study within a specific problem framework (ChanLin & Chan, 2004). This method, which is defined as the process of applying knowledge by self-learning, is based on real life problems (De Grave, Schmidt, & Boshuizen, 2001), focusing on analysing the problem and learning by doing-living and solving the existing confusion (Torp & Sage, 1998). While solving real life problems, PBL provides problem solving skills as a teaching strategy that provides understanding of underlying issues, principles and laws (Spencer & Jordan, 1999), while at the same time it provides a way of learning from different subject areas and disciplines through individual and team work (Barrows, 2002). Within this framework, process management is a very important skill in problem solving and this skill also needs to be gained to the students in a way that covers all the lessons.

As an approach that allows students to learn lifelong, PBL (Schmidt, van der Molen, te Winkel, & Wijnen, 2009) is one of the basic skills that students have to take with them when they leave the classes and step into the real world (Krulik & Rudnick, 1996). There are two different types of problems that are well structured and not well structured, depending on the context of real-life associations. Problems that are not well structured are associated with more real-life problems where personal thoughts and judgments are held in the foreground provided that the necessary information is not already given (Gallagher, 1997; Jonassen, 1997; Stepien & Pyke, 1997). At this point, we are dealing with more well-structured problems in our lives, while in real life we face with unstructured problems (Jonassen, 1997). However, it is known that the education should be related to real life and the learning environment be organized accordingly. With these real and well-structured problems, it is necessary to create the closest scenarios to the real life and these scenarios should be applied with active participation in the educational environments. By providing sufficient opportunities, students can be good learners (Weinstein & Mayer, 1986), and technology at this point can provide us with this opportunity.

Developing mobile technologies and applications can provide environment to support this active participation and enable individuals to develop collaborative problem solving skills. The basic element here is to ensure that the right technology and applications are selected in accordance with the purpose and target audience. Hence, Smartphones, which almost every student has, and social networks that are becoming fixed applications of these phones can be seen as an opportunity. Research on educational use of these structures has shown that the features such as encouraging collaborative learning that contributes to the learning process, learning anytime anywhere, active participation in lessons and informal communication are common to all platforms (Arteaga Sánchez, Cortijo, & Javed, 2014).

Recently, new applications are being developed that can be defined as different social networks specific to mobile technologies, especially smartphones, and among them instant messaging applications are rapidly spreading (see SimilarWeb, 2017; Statista, 2017). Research findings show that WhatsApp, one of the most preferred instant messaging applications, provides an unstructured learning environment that contributes positively to learning, supports collaboration and content sharing in educational environments (Arteaga Sánchez et al., 2014; Bouhnik & Deshen, 2014; Church & De Oliveira, 2013; Çetinkaya, 2017a, 2017b; Çetinkaya & Sütçü, 2018; Nguyen & Fussell, 2016; Rambe & Bere, 2013; Rambe & Chipunza, 2013). The potential of WhatsApp, which Çetinkaya (2017a) defines as one of these structures accepted within the needs of individuals, in educational environments that enable cooperative synchronous and asynchronous communication with multimedia support and cover a wide range of social networking features should not be ignored.

Many studies have been carried out on the use of PBL, technology and accompanying applications in education, and their results have shown that they have different contributions to the process. Olkun and Toluk (2003) pointed out that mental activities rather than memorization should take place and that students should be encouraged to solve various problem situations in lessons such as mathematics which abstract concepts are predominant. At this point, it is necessary to evaluate the design and effects of the interactive PBL process in which students can learn in a way that they can contribute to the learning process as well as establish a relationship with the real life. The aim of this study is to determine the effects of the problem based learning process on students' mathematics success and their views on the process. For this purpose, answers to the following questions are sought:

1. Is there a meaningful difference between the success scores of the students who are taught with the mobile assisted problem based application and the success scores of the students who are educated in the traditional environment?
2. What are the opinions of the students towards the effectiveness of study process?

Method

Research Model

The study which aimed at determining the effects of problem based learning process on students' mathematics success and their opinions is designed in a mixed method model that integrates research results. This model which uses both methodologies in order to utilize the strengths of qualitative and quantitative research methodologies and to resist their limitations (Creswell, 2003; Creswell & Plano Clark, 2007; Johnson & Christensen, 2008; Tashakkori & Teddlie, 2003), contributes to the refinement and best understanding of the complexity of social phenomena by different methods (Creswell, Plano Clark, Gutmann, & Hanson, 2003). In the study, explanatory mixed method design was adopted which is one of the mixed method, in which first quantitative data and then qualitative data is collected. In this framework, quasi-experimental design with pretest-posttest control group was used in the quantitative dimension of the study to determine the effects of problem based learning process on mathematics success in which mobile based applications were used as assistive technology. The quasi-experimental design, which is applied after the pre-test and in the last stage to determine the effect on the dependent variable, is defined as the research design that best explains the cause-effect

relationships between the variables (Fraenkel & Wallen, 2011). The quasi-experimental design pattern of the research whose experimental and control groups were selected according to some preliminary measurements is given in Table 1.

Table 1. Quasi-Experimental Design of the Research

Group	Before Experiment	Experiment	After Experiment
Experimental Group	Pre Test (AST)	PBL environment	Post Test (AST)
Control Group	Post Test (AST)	Traditional environment	Post Test (AST)

AST: Academic Success Test
Independent variable: Learning environment (1. The environment in which assistive technologies are used besides traditional environment as part of PBL.
Dependent variable: Academic Success

In addition to the traditional curriculum in which all the study group were involved in the quantitative dimension of the study, the effect of the problem based learning process on the mathematics success of the students in the experimental group who used mobile based applications were compared. In the qualitative dimension of the research, student opinions about the application process were taken through open-ended question form.

Study Group

While the participants of the study which was conducted with the participation of 9th grade students in the secondary school (between the ages of 14-15) were determined, criterion sampling which is one of the purposeful sampling methods was used. In the selection of the study group, the criteria for accessibility to the subjects, the proximity of the preliminary information to the lesson, the technological infrastructure required to ensure the continuity and implementation of the experimental procedures were taken into consideration. So 2 branches (X and Y) out of 4 branches of 9th grade students which the same teacher gave the mathematics lesson were chosen. Pre-test was applied to the students to determine the prior knowledge of the two branches and to check the homogeneity of the distribution. As a result of the analysis of the data obtained after the pre-test, it was determined that there was homogeneity (Levene Test $F = .023$, $p > .01$) between the classes and the arithmetic average scores of the students in both groups did not have any meaningful difference ($t(60) = .942$, $p > .01$). Moreover, the same analysis was performed on the exam scores attained from the exam taken by the students before the mathematics lesson, and the difference between the homogeneity (Levene Test $F = .001$, $p > .01$) and success of both groups was examined ($t(60) = .314$, $p > .01$), and it was found that the results confirmed the results of the tests developed by experts. Thus, whether the success test predicts the groups correctly was tested and its validity and reliability was confirmed. Within the light of these results, it has been decided that the branches should be evaluated under two different groups as experiment and control. Thus, there was no differences between the practices in the same branches and the influence of the individuals by each other was eliminated. Following the decision of the experts who contributed to the research, the branches were divided into the experimental and control groups and during this phase together with whether the students owned a smart phone, their use of WhatsApp application and internet access were also considered. It has been determined that all students in both branches have smartphone, internet access and WhatsApp application. After taking opinions of the teacher who taught mathematics to both branches, branch X was informed about the research process. Moreover, at the end of this stage where information about the mobile applications to be used in the process is given, all the 31 students in the branch stated that they wanted to participate in the study and they could use the mentioned mobile applications. After receiving the approval of all the students, the parents have also given their written consent for the study. After this stage, it was decided to designate X-branch as experimental group, Y-branch as control group.

Table 2. Gender Distribution of the Study Groups

Study Groups	Gender				Total	
	Female		Male			
	f	%	*f*	%	*f*	%
Experimental Group	16	51.6	15	48.4	**31**	**50.0**
Control Group	17	54.8	14	46.2	**31**	**50.0**
Total	**33**	**53.2**	**29**	**46.8**	**62**	**100.0**

As detailed in Table 2, the quantitative dimension of the study with a total of 62 students (16 girls and 15 boys in the experimental group and 17 girls and 14 boys in the control group) was terminated with the participation of all students in the posttest application. The qualitative dimension of the study was completed after the application of the open-ended question form which was performed after the application of posttest to 31 students of the experimental group.

Implementation Phase

The face-to-face education processes of the study group members were conducted by the same teacher within the framework of the common curriculum. For the experimental group, no intervention was done at the beginning of the study except for the task given in the direction of the aim of the study. The students shared weekly profit and loss situations within the group together with the transactions they have performed through the stock market application.

Designing the Study According to the Subject Area Content

In the research, which aimed to determine the contribution of problem-based learning approach using WhatsApp instant messaging application and virtual stock market application to the teaching of mathematics, the topics included in the content of the task consist of the topics which are not covered in their previous curriculums.

The knowability of the terms and concepts in the subject matter detailed in Table 3 is related to the differences in their previous education processes of the students and their current learning outcomes was determined by pretest.

Table 3. Subtopics of Secondary Education 9th Grade Data Topic, Learning Gains, And Distribution of Course Hours With Terms and Concepts Used in the Subject

Subtopic and Learning Gains	Learning Gain No	Course Hours
1. Central Tendency and Disperse Measures	1	8
1.1. Calculates the central tendency and disperse measures of the data and interprets them. *Terms and concepts:* data, discrete data, continuous data, arithmetic mean, median, mode, interval, maximum value, minimum value, lower quartile, upper quartile, interquartile range, standard deviation		
2. Displaying Data in Graphs	2	8
2.1. Creates a histogram for a data set **2.2.** Represents groups of data that reflect real-life situations with appropriate chart types *Terms and concepts:* line chart, bar chart, pie chart, histogram, group count, group width		

Experts expressed their opinions that the task given within the scope of PBL covers to a large extent the gains of the subject in the curriculum and almost completely the terms and concepts.

Creation of the Success Test

The success test, sub-topics and learning gains used in the study, as detailed in Table 3 were formed by a group of five experts; one faculty member at the department of mathematics education, four mathematics teacher at the school where the study was conducted. During the creation of the success test, the terms and concepts included in the subject together with the learning gains of the

subject matter have been taken into consideration. The questions of the study in which the distribution of the course hours were taken into consideration along with the learning gains, were selected from the questions that would determine the level of comprehension of the success at national level examinations. In the question selection phase during which the statistical data on the test published after the national examinations were also taken into account, all five expert groups were involved and a pool of 124 questions was created in the first stage. The questions were re-evaluated according to their degree of difficulty which would be close to the normal distribution in the question pool, and the success test including 80 multiple choice questions with five choices (10 very easy, 15 easy, 30 normal, 15 difficult and 10 very difficult) was formed.

The item analysis of the 80 questions, which were selected for pre and posttest evaluations and had content validity, were carried out by the participation of the 112 10th grade students from the same school. The answers were collected optical forms and 1 point was given for each correct answer and 0 point was given for the wrong or blank answers. Kuder Richardson-20 (KR-20) was used to examine the internal consistency of the scores, and the relationship between the total score of the test and item scores was calculated by item total score correlation. It is stated that the test reliability coefficient .70 and higher is generally sufficient for the reliability of the test scores, while the item total correlation .30 and higher, the items distinguish the individuals well (Fraenkel & Wallen, 2011; Nunnally & Bernstein, 1994). According to the results of the analyses, the item total correlation is .37, while the reliability of the success test is KR-20 .89.

The Technical Background of the Study and the Applications Used

Prior to the study, students that would participate in the study were required to have a smartphone, internet connection, and WhatsApp application, and then they were required to sign up for a virtual stock exchange application that was compatible with all smartphones and free of charge. Detailed information on the applications used in the study are presented below.

WhatsApp application: With its multi-platform capability, multi-media support, allowing interaction between individuals and groups, WhatsApp is an instant messaging application which has a number of useful features that have become default application of all smartphones (Çetinkaya, 2017a, 2017b; Çetinkaya & Sütçü, 2018).

Virtual stock exchange application: After installing the game application to the smartphone, users can buy and sell virtual shares and foreign currencies by using their virtual money worth 50.000 TL which is granted to all accounts. By following the stock market Istanbul data instantly, all data can be monitored graphically through the application which enables the purchase and sale at the instant prices at the same time, and technical analyses of the products can be reached.

The Steps of the Process

After meeting all the technical requirements, the application process started with the participation of all the students who made up the experimental group to study on the first Monday. In the study, after the students did the task of buying and selling products like shares, foreign currencies, gold, no interventions to the process have been made and students were asked to share their profit and loss and hence the attendance of the all students together with the one who had the most profit could be monitored at the end of the each week of total 6 weeks. Furthermore, all the participants could see the strategies followed by the winners and losers of the week and made comments, which increased their active participation. The screenshots of WhatsApp and Virtual stock exchange applications in relation to the process are given in Figure 1.

(a) Virtual stock exchange application (b) WhatsApp screenshot

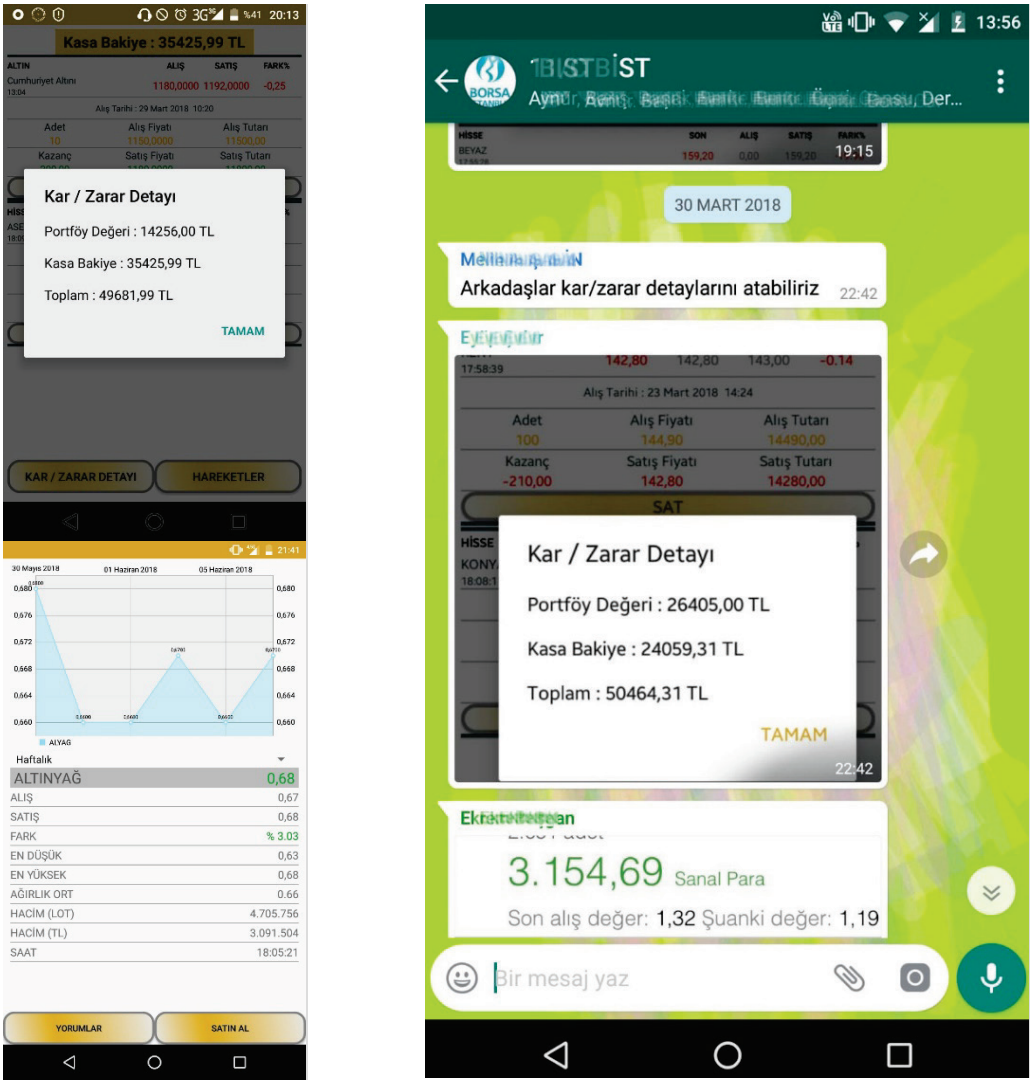

Figure 1. The Screenshots of WhatsApp and Virtual Stock Exchange Applications in Relation to the Process

In Figure 1, examples from the students' posts which are obtained from the screenshots of the students' smartphones. As seen in the pictures, students could see their profit-loss by graphics and analysis reports (a), and shared (b) their weekly situation via WhatsApp.

Data Collection

The quantitative data of the study were collected through the 80-item success test to make pre and post-test evaluations. After determining that the test had reliability and distinctiveness at appropriate levels, it was used both in pre and posttests by making changes only in the order of the questions and choices to increase the test reliability. The 80 minutes was allocated for 80 questions and it was administered one week before after the implementation phase which lasted 4 weeks. The quantitative data collection process of the study ended after the pre-test and post-test in two different classes under the supervision of teachers. Qualitative data were collected through open-ended questionnaire one day after the post-test. Prior to the application of the open-ended questions, which was the last phase of the study, the students were informed and told to write their views on the process and their suggestions, if any. The question posed to determine their views on the implementation process has been given to get their views in black and white in a classroom environment and under the supervision of the researcher in order to enable the students to express themselves freely and in detail.

Data Analysis

The success test applied simultaneously to experimental and control groups at the beginning and end of the study period. 1 point was given for each correct answer and 0 point was given for the wrong or blank answers. The questions in both pre- and post-tests which were performed at approximately 10-week interval, were exactly the same. Because there was homogeneity between the classes in which the study was conducted, a 2X2 split plot design was used to test the effectiveness of the implementation, and two-factor variance analysis was performed for the mixed measures for the analysis of this research question, since the distribution fulfilled the normality assumption and there were two groups. The significance of the difference between the average scores of the groups was .01 and SPSS program was utilized in the analysis of the data.

In the application of the open-ended question form, which constituted the qualitative dimension of the study, the data from the students of the experimental group were analysed by using categorical analysis and frequency analysis techniques. Together with the categorical analysis during which (1) the coding of the data, (2) the creation of the categories, (3) the organization of the categories, (4) the identification and interpretation of the findings were done respectively (Corbin & Strauss, 2007), frequency analysis revealed the frequency of quantitative viewing of the data, and the intensity and significance of a particular item was determined (Ryan & Bernard, 2000; Tavşancıl & Aslan, 2001). In addition, together with the untreated data from the students, the findings of the analysis of the data were sent to experts who contributed to the study with the final findings, and this dimension of the research was finalized in line with the feedback received from them.

Results

Findings obtained after the analysis are presented below in order of sub-problem and research methodologies

Findings Related to Student Success Scores

A 2X2 split plot pattern was used to test the effectiveness of the study groups' environments. The first factor in the design refers to 2 separate experimental environments (traditional environment - conventional environment designed for PBL) and the second factor represents pre- and post-experiment (pretest-posttest) measurements. The pre-test and post-test mean scores and standard deviation values of the students' learning environments are given in Table 4. For the analysis of the research questionnaire, a two-factor variance analysis for mixed measures was conducted.

Table 4. Mean and Standard Deviation Values of Groups

Group		Pretest		Posttest	
	n	$\bar{x}$	Ss	$\bar{x}$	Ss
Control	31	24.06	5.98	51.19	7.47
Experiment	31	22.61	6.14	65.03	9.53

As a result of the analysis, while the mean scores of pretest were 24.06, the scores of posttest were 51.19 for the control group. The average success scores of the students in the experimental group where the technology-supported PBL was used were 22.61, while the posttest success scores were 65.03. The results show that there is an increase in the average success scores of the students in both environments. A two-factor ANOVA test was conducted to determine whether the changes in the success scores of both groups showed a significant difference, and the results are given in Table 5.

Table 5. Results of ANOVA on Pretest-Posttest scores of Learning Environments

Source of Variance	Sum of Squares	sd	Mean Squares	F	p
Between subjects	5367.589	61			
Group (Individual/Group)	1134.073	1	1134.073	16.073	.000
Error	4233.516	60	70.599		

Table 5. Continued

Source of Variance	Sum of Squares	sd	Mean Squares	F	p
Within subjects	41454.5	62			
Measurement (Pretest-Posttest)	37174.266	1	37174.266	879.350	.000
Group*Measurement	**1743.750**	**1**	**1743.750**	**41.248**	**.000***
Error	2536.484	60	42.275		
Total	46822.089	123			

*p<.01

According to the results, it was found that the success of the students who studied in two different environments differed from the pre-experiment to the post-experiment meaningfully ($F_{(1-60)}$=41.248, p<.01). This finding suggests that both learning environments have different effects in increasing students' success. It was found that the environment created for the experimental group, which showed more increase in the success scores than before the experiment, was more effective in increasing the students' success. As a result of the calculations made to determine the size of this effect, it is determined that the effect value on success, which is the dependent variable, was great (Cohen's d=1.62, r=.63). The magnitude of effect (Cohen, 1988, 1994), which indicates a significant difference between the averages, indicates that the significant difference between the increments achieved by the groups is due to the experimental process and that this process has a great effect on success.

Findings Related to the Evaluations of the Students towards the Effectiveness of the Study Process

Findings obtained from the analysis of students' opinions on PBL process by content analysis types; categorical analysis and frequency analysis techniques are presented in Table 6. In addition to the ratios formed by one or more opinions of the students, this section also includes the students' own expressions of the students in the experimental group (Gender + Student code). A significant portion of the data obtained is related to the use of mobile technology and applications in education, and these largely overlap with the findings of research conducted by Çetinkaya (2017a) on the use of mobile instant messaging WhatsApp for education. At this point, the results of the researcher's work are taken into account, and the use of WhatsApp with the mobile device in the process is covered under a heading. Since the purpose of this research is to evaluate the process within the scope of the PBL, the student opinions and recommendations evaluated in this context are evaluated under a separate heading.

Table 6. Students' Views on the Process of Sending Information Messages via WhatsApp Application

Mobile Device and WhatsApp Application	*f*	%
Willingness to use similar technologies in other courses	30	96.7
Technical advantages (ease of use, no cost, easy accessibility, fast and secure communication)	28	90.3
Educational-Academic advantages (Learning anytime anywhere, resource and material sharing, organizing activities for academic purposes)	26	83.8
PBL Process		
Willingness to do similar studies in other courses	30	96.7
Relation to real life	21	64.5
The realization of the learning (conscious and unconscious)	20	61.2
Nice, Pleasant, Tasteful, Fun	20	61.2
Competition environment	13	41.2

It has been determined that students had highly positive opinions on the use of Instant Messaging Application WhatsApp together with mobile technology. 96.7% of the students stated that using mobile technology and WhatsApp in this study is the right approach and that it would be beneficial to use similar technologies and applications in other courses. As seen in the expressions of the students K3 "*Especially for physics would be very nice if we could use such applications that we could use over the phone*" and E15 "*…in other lessons I wish to use such applications from mobile phones.*" the implementation of the study via mobile technology and WhatsApp application is reflected in the desire of students to use in other courses. It has been determined that students have positive opinions regarding their technical advantages as well as their educational-academic purposes. It was observed that students emphasized factors such as ease of use, lack of cost, ease of accessibility, fast and secure communication, and 90% of the students used expressions that can be evaluated in this context. As seen in the statements of the students; E17 "*The use of WhatsApp, which all my friends use, was good. We were able to send messages easily without paying any fee." and K28 "When my phone was with me, I could keep up with. … I also communicated quickly and securely with my friends in the group."* realization of the study with instant messaging application via mobile technology provides technical advantages for students.

Also within the scope of educational advantages under this category; it has been emphasized that the elements such as learning anytime anywhere, resource and material sharing, organizing activities for academic purposes are emphasized and about 84% of the students express such statements which can be evaluated within this context. In their expressions such as; K7 "When I encountered problems in the process, my friends supported me." …my friends helped me when I had difficulty." and E31 "*…sometimes when I had difficulties and I could not understand, I shared the screen view and got help from my friends. I could reach them at any time and place I wanted. It would be nice if we could have a group with such friends in … class.* Students have mentioned that using instant messaging application through mobile technology provided educational-academic advantages. The majority (% 96.7) of the students expressed their willingness to have similar studies for their other courses as well within the scope of PBL. E4 stated "*We could continue as a group. I think similar practices should be done in other courses. … I feel like I'm winning in real environment*" which show that the student has related the process to the real life as well as the continuity of the study. Similarly, the ratio of those who link the process to real life is high as stated by K29 "*I followed the process like it was the real thing, and during the time I read the technical analysis and examined the exchange rates and graphs. … after a while I could now interpret the graphics.*" Similarly, the number of those who link the process with real life is also high. K29 "*I followed the process as if it was real, and during the time I read the technical analysis and examined the change rates and graphs. … after a while I could now interpret the graphics." is an indication that the process has contributed positively to the learning outcomes of the course.* Again in parallel to this, it is seen that the students frequently use expressions about the realization of learning (61.2%). K13 "*I learned many concepts that I often hear in real life during the process.*" E26 "*I have learned for what purpose the terms in the lesson are actually used. … I did not even realize what I learned while writing to my friends on WhatsApp.* As stated in these expressions, learning can take place without being aware of it. Especially when it comes to establishing a relationship with real life and the realization of learning, E22 "*I learned how the people who have money can manage it. … I learned what it means to win and lose.*" and K9 "*… besides, I learned many concepts related to stock exchange and money.*" all indicate that the practice contribute in terms of financial literacy at the same time. Again, it was seen that students used positive affective expressions towards the process (61.2%) as nice, fun, pleasant and enjoyable. E5 "*I have not only earned money :) … I also learned many concepts related to the lesson. It was nice to compete with my friends."* in fact, sincerely summarizes what is happening in the process. Moreover, it was also noted that a large number of students (41.2%) have already started to use the concepts such as being in competition. As can be understood from K21 "*I felt like I was competing, so I followed what my friends were investing in. They were not my rivals, it was me but I was better than most of them."* a natural competition environment has emerged in the process.

Conclusion

Student Success Scores

It has been observed that the average success scores of pre-test of the students in the experimental group who used PBL supported by technology increased at a higher rate than those of the control group receiving only traditional instruction. The results show that there is an increase in the average success scores of the students in both environments. According to the results of the two-factor ANOVA test conducted to determine whether there is a meaningful difference between the success of the students in both groups, it was determined that the success of the students in two different environments differed from the pre-experiment to the post-experiment. These results show that both environments have different effects in increasing the success of the students, and the environment created for the experimental group, which is higher than the experiment before, is more effective in increasing the success of the students. As a result of the calculations made to determine the size of this effect, the significant difference between groups' average success scores arises from the experimental process which had great effect on success. In the light of these results, it has been determined that both learning environments have different effects in increasing the success of the students and that the support of the traditional environment with the technology-supported PBL is more effective in increasing the success of the students.

When literature is examined, there is also a lot of evidence that PBL is an effective method in teaching mathematics. For example, Riasat, Hukamdad, Akhter, and Khan (2010) determined that the use of PBL supports the mathematics lesson successfully and creates statistically significant difference. In their study which they developed a model based on problem solving Cotic and Zulijan (2009) concluded that students in this course model are more successful than the students in traditional models which rely on teacher-centered lessons when solving difficult mathematics problems. On the other hand, collaborative learning environment was enabled through the WhatsApp application as well as the PBL method. In this direction, Eisenhard (2012) determined that the students who participated in the process by carrying out the mathematical activities in the collaborative PBL process improved their skills to understand mathematics and success. Similar results were obtained in the study carried out by Tarmizi and Bayat (2012) and it was concluded that the students in the PBL environment based on cooperation in mathematics education were more successful. Again, it can be said from the qualitative data obtained from the students that relating mathematics to real life is influential on success in learning. A number of studies support that when the PBL process is associated with real life, it contributes to the teaching of mathematics (Altun, 2002; Aydın Ünal, 2008; Bıldırcın, 2012; Çakır, 2011; Çilingir & Dinç Artut, 2016; De Corte, 2004; Pramudiani, 2011; Van Reeuwijk, 2001; Verschaffel, Corte, & Borghart; Üzel, 2007).

The Evaluations of the Students towards the Effectiveness of the Study Process

As a result of the analyses performed on the data collected through the open-ended question form from the students, the opinions of the students regarding the process are collected under two headings as *mobile device and WhatsApp application* and *PBL process*. Students have expressed quite positive views on the use of mobile technology and instant messaging application WhatsApp. Almost all of the students pointed out that using mobile technology and WhatsApp is the right approach and that they want to use similar technologies and applications in their other courses as well. Within the scope of technical advantages, students have emphasized factors such as; ease of use, lack of cost, being easily accessible, being fast and secure in communication, and the expressions that can be included within this context are used by 90% of the students. Also within the scope of educational advantages under this category; the elements such as learning anytime anywhere, resource and material sharing,

enabling to organize activities for academic purposes are emphasized by the students and about 84% of them use such expressions which can be evaluated in this context. According to the findings, the vast majority of the students believe that using mobile technology in the study provided technical, educational and academic advantages. The results obtained largely overlap with the results of the study carried out by Çetinkaya (2017a) and other studies on instant messaging applications (Arteaga Sánchez et al., 2014; Bouhnik & Deshen, 2014; Church & De Oliveira, 2013; Çetinkaya, 2017b; Çetinkaya, & Sütçü, 2018; Nguyen & Fussell, 2016; Rambe & Bere, 2013; Rambe & Chipunza, 2013).

The vast majority of pupils in PBL stated their willingness to have similar studies in their other courses as well. It can be seen that the PBL process can be associated with real life and this is reflected positively on the learning process. In the related researches, it is seen that the learning process, which is associated with the real life, is effective in the students' positive attitude towards mathematics and their behavioural developments. (ex., Abu-Elwan, 2002; Aydın Ünal, 2008; Barnes, 2004; Bonotto, 2009; Çakır, 2011; Kwon, 2002; Pramudiani, 2011; Van Reeuwijk, 2001). It is once again seen that, besides evaluating the success test, students' expressions have also been effective in the acquisition of the course outcomes and the realization of the learning. What stands out here is the expressions by students such as; "I didn't realize" or "I realized that I learned unconsciously. As Fer and Cırık (2007) have stated, while the meaning is structured in the social environment, the individual affect other people's thoughts by sharing the meaning that they created and they are also influenced by other individuals because they are also in interact with the environment. Students as cognitive apprentices who learn by sharing information among practice groups within specific academic fields (Wenger, 1998) support each other's learning processes. Although the students' individual learning and success during the research process is mostly emphasized, it is also noted that the collaborative learning is supported by the technology and accompanying applications used during the PBL process. Here, it can be argued that learning can take place by observing others' efforts and communication (Çetinkaya, 2017b; Leonardi, 2014) and students could support each other accordingly (Slavin, 1996; Stacey, 2007; Symeonides & Childs, 2015; Wang, Ke, Wu, & Hsu, 2012). Moreover, students use positive affective expressions such as; nice, fun, pleasant and enjoyable towards the process.

Apart from the above reasons, besides smartphones and its application WhatsApp which students already use in their everyday lives, the virtual stock market application used in the study may also be effective in the development of these positive attitudes towards the process. However, although this view on virtual stock exchange application is not fully supported, it is seen that the students mostly do evaluations that they have more realistic sense of reality and include activities related to real life. However, as Botturi and Loh (2008) have stated, children perceive the real life as a game, so the virtual stock market application or the whole education process may have been perceived as a game by some of them. Though the students did not use expressions related to the game directly, this perception could be effective in the formation of concepts such as; enjoy, take pleasure or have fun. Studies often support that mathematics education designed in the form of a game lead to a positive change towards mathematics (ex., Abrams, 2008; Bai, Pan, Hirumi, & Kebritchi, 2012; Bragg, 2007; Coştu, Aydın, & Filiz, 2009; Divjak & Tomić, 2011; Estapa & Nadolny, 2015; Ke, 2008; Kebritchi, 2008; Kula, 2005; Neimeyer, 2006; Öztürk, 2007; Yang & Tsai, 2010). Students also have made statements that this situation created positive reflections. It can argued that students' sharing their comments on the process together with their weekly profit-loss situations through WhatsApp application could be effective in the creation of such a competitive environment. This also shows that a natural competition environment was formed during the process when students' interaction with the real life and each other are concerned.

Discussion and Suggestions

Individuals who differ according to their cognitive structures and thinking styles also differ in the process steps they follow during the process of problem solving as well as the way they use knowledge (Jonassen & Grabowski, 1993). Another aim of mathematics teaching is to help students to develop self-regulation skills by enabling them to believe that they can do mathematics (Pesen, 2008). At this point, learning environments in which individuals can meet their needs and where they can achieve expected outcome behaviours are required to be designed or planned. The study has the advantages of collaborative learning as well as problem-based learning together with the use of inter-group interaction technologies. Inclusion of support and suggestions within the process has allowed the group members to benefit from this cooperation, even if not the group.

It seems possible to say that PBL includes almost all of the parameters of cooperative learning, linking to real life and technology use. This is supported by the analysis of qualitative data from students as well as the success achieved. On the other hand, the main source of the success of the experiment group as compared with the control group could be the medium (mobile technology, WhatsApp or Virtual Stock Exchange applications) or the teaching method. Though it is quite difficult to give a clear answer to this situation, which is seen as one of the limitations of the study, it is still possible to state that all elements of the implementation process have a potent influence on the success according to the findings. Based on the results obtained from this research

- The use of WhatsApp and similar applications in mathematics education that allow interaction between individuals together with mobile devices should be encouraged,
- Connections between mathematical subjects and real life by using appropriate methods and techniques be established,
- The use of the technologies that students already use and their accompanying applications should be encouraged in a way that they contribute to the teaching of mathematics,
- The technologies and applications that are used in the research should be used in other courses and their effectiveness be determined as well.
- Similar studies should be done in other stages of education and other mathematical topics
- Experimental studies should be conducted to confirm the qualitative data obtained from student opinions,
- Similar studies within the framework of new literacy concepts (Digital, Media, Financial, etc.) should be done,
- Educators' views on the use of WhatsApp and similar application in education to support learning environments should be examined.

Limitations and Future Implications

This study is a quasi-experimental study to explore the effects of problem based teaching method supported by mobile applications on mathematical success. There are some limitations of the study which presents a theoretical framework and empirical evaluations in the direction of the findings obtained. The reason for these limitations is that the study is carried out on a limited number of students due to the fact that it is a quasi-experimental study. Although all statistical results in the study give positive results on the suitability of the group, this may limit the generalizability of the results of the study. The second limitation is that the mobile applications are handled within the framework of a specific topic, and suitable ones are preferred. While this is the right approach, the suitability and process management of the preferred mobile application in future studies may lead to different results. At this point it is suggested that the researchers should make a good planning considering factors such as characteristics of the working group, the outcomes to be given, the determination of appropriate mobile applications, and process management.

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