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The effect of probability instruction through argumentation approach on the achievement of pre-service teachers and the permanence of their knowledge#

Ömer Sinan Can[1]* and Tevfik İşleyen[2]

[1]Vocational School, Ağrı İbrahim Çeçen University, Ağrı, Turkey.
[2]Kazım Karabekir Faculty of Education, Atatürk University, Erzurum, Turkey.

ABSTRACT

The purpose of this study is to investigate the effect of probability teaching with the argumentation approach on the academic achievement of pre-service mathematics teachers and the permanence of probability knowledge. Quantitative research method was adopted in the study and quasi-experimental design was used. The study group consisted of 44 pre-service teachers studying in the third grade of Elementary Mathematics Education at a state university. The Probability Achievement Test (PAT), which was developed by the researchers, was used to measure the academic achievement and permanence of probability knowledge of pre-service teachers. PAT was applied to pre-service teachers as pre-test, post-test and retention test. According to the findings, it was found that there was a statistically significant difference between the PAT posttest scores of the groups in favor of the experimental group. As a result of the analysis of the PAT retention scores of the groups, it was concluded that there was no statistically significant difference between the PAT retention scores. As a result of the research, it has been seen that the argumentation approach increases the pre-service teachers' success in probability more than the traditional method. On the other hand, the argumentation approach had no effect on the permanence of the knowledge of the pre-service teachers.

Keywords: Argumentation approach, probability instruction, probability success.

*Corresponding author. E-mail: omersinancan@gmail.com.

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INTRODUCTION

The use of mathematics in daily life and various disciplines shows that mathematics is an important part of human life. While mathematics has an important effect on obtaining the technologies we use, it is also important for the development of new technologies. The development of new technologies necessitates the development of mathematics in a way. Therefore, the development of mathematics requires the education of people who do mathematics as well as those who know mathematics. In order to overcome this necessity, it is aimed to give better mathematics education to students by using many teaching methods and techniques from traditional methods to constructivist methods. In order to train individuals who do and create mathematics, they should be provided to think and discuss as scientists. In order to make students think like scientists, they need to be trained as individuals who think, question and create new ideas (Hacıoğlu, 2011). Students should be provided with real science practices in order to understand how science, which is a social practice, is formed, developed and progressed (Driver et al., 2000).

Research on mathematics education in the eighties carried social learning to the agenda in mathematics education (Lerman, 2000). This tendency in mathematics education is to consider mathematics as a product of social activity consisting of reasoning, thinking, discussion and meaningful actions (Lerman, 2000). Krummheuer (2000) argues that the information learned in the social environment is more logical and consistent to the students. The National Council of Teachers of Mathematics (NCTM), 2000) stated that communication has an important role in improving students' mathematical understanding. Therefore, the teaching environment should be arranged in such a way that students can share their ideas, evaluate and analyze the ideas of others. The discussion of individuals in a social environment will enable them to better understand their knowledge, to think deeply about their existing knowledge and to access new information by reasoning from this information. In addition, students will have the opportunity to present their ideas, defend, listen to other students' ideas, and reflect on the emerging ideas. With scientific discussions, students think like scientists and try to structure the concepts themselves. Therefore, it will be useful to use argumentation approach, which is one of the learning approaches that will enable students to learn mathematics and think like a scientist in a social environment, in mathematics classes.

Argumentation is defined as scientific thinking as a social activity (Kuhn, 2010). Akkuş et al. (2007) defined the argumentation as “an approach in which ideas are put forward, criticized, evaluated, question-claim and evidence processes are carried out, arguments are formed, and reconciliation and negotiation processes are formed (p. 1748).” Argumentation approach is based on inquiry-based activities, group work, group discussions, exchange of ideas, evaluation of ideas and making inferences (Burke et al., 2005). Krummheuer (2000) argued that argumentation is a kind of social phenomenon in which students try to express their thinking in relation to their own ideas and actions, and that argumentation cannot consist of one participant because other participants cannot contribute. Berland and Reiser (2009) argue that argumentation is a social activity that helps an individual to interpret information. According to Van Eeremen and Grootendorst (2004), argumentation is a verbal, social and logical activity. In the argumentation approach, the students try to prove their ideas by using their prior knowledge and refute the opposing ideas (Uluçınar-Sağır, 2008). Scientists make sense of events in nature through arguments (Ford, 2012). In the argumentation process, students experience the same process that scientists construct information (Aymen, Apaydın and Taş, 2012). In the argumentation approach, individuals play an active role in social activities within the group and experience reasoning processes (Van Eeremen and Grootendorst 2004). In this way, students understand how scientists work by modeling the scientific process experienced in reaching information and think and work as a scientist. During the argumentation process, students talk about informational activities and see the model of professional scientists closely (Erduran, 2007). With the argumentation approach, students understand the nature and epistemology of science and develop a positive attitude towards science (Osborne et al., 2004). In this way, instead of taking ready knowledge and memorizing, the students produce knowledge like scientists themselves. Argumentation approach includes high thinking skills beyond knowledge transfer (Erduran, 2007).

The Common Core State Standards for Mathematics (CCSSM, 2010) states that students need to develop skills to form viable arguments and criticize reasoning of others. The National Council of Teachers of Mathematics (NCTM, 2000) emphasized the importance of mathematical communication and stated that the teaching environment should be designed to enable students to share their ideas and to evaluate and analyze the ideas of other students. In primary and secondary school mathematics curriculum implemented in Turkey, among the special aims of mathematics teaching are the students' ability to conduct research, produce and use knowledge, express their mathematical thoughts and reasoning in a logical way easily, and develop to see the deficiencies in mathematical thinking and reasoning of others (MoNE, 2018). These mentioned skills will increase students' success in mathematics and contribute to the learning and development of mathematics. Bringing these skills into the students can be achieved by using argumentation approach in mathematics courses.

Argumentation approach is a learning model based on constructivist approach. Argumentation approach is an interdisciplinary method involving discussion techniques in which people make inferences by reasoning and making arguments (Karışan, 2011). It is mainly based on logic and inferences. Individuals try to persuade others by expressing and defending their own ideas. Individuals use expressions to support or refute their solution while solving a problem. This is an indication that individuals do argumentation. Argumentation is a process that enables the emergence of the advantages and disadvantages of the results of the opinions discussed by individuals (Mason and Scirica, 2006). Scientists obtain information by making claims from the data obtained and supporting these claims with evidence (Erduran et al., 2004; Günel et al., 2012). This process used by scientists is the process of argumentation. Therefore, argumentation is an effective tool in the development of scientific knowledge (Erduran et al., 2004). In the argumentation process, claims are made, and then they are discussed. The claimants defend and try to prove their claims. If there is a mistake in the claims, these mistakes will be refuted. Individuals do not blindly accept a claim in argumentation. As a lawyer defends his client's right, students should defend their ideas. In argumentation, students gain the ability to produce ideas, to interpret and present their ideas. This ensures that students are actively involved and responsible for their own learning.

Toulmin used the arguments, data, justification, qualifier, supportive and rebuttal components and the relationship among them in the analysis of the discussions (Aldağ, 2006; Toulmin, 2003). Toulmin has created a model (Figure 1) that illustrates the basic elements of argumentation and the relationships among these elements in order to explain the discussions (Toulmin, 2003). Toulmin argued that there are 6 basic components of an argument. According to Toulmin, these components are claim, grounds, warrant, backing, qualifier, and rebuttal.

An argument is a co-ordination of ideas and justifications for supporting or refuting a claim (Toulmin, 2003). In order for the argument structure to be formed, students are requested to make their own claims based on the data, establish valid and acceptable warrant between this claim and the data, and support (backing) them with more formal information when objections (rebuttal) are received during the argumentation process (Aladag, 2006). Argumentation is the process of generating arguments. Arguments are elements of scientific discussion. There must be the data, claim and warrant for the establishment of an argument. Backing, rebuttal and qualifier increase the validity of the argument (Ceylan, 2012; Kaya and Kılıç, 2008). According to Toulmin, data, claim, justification, backing, qualifier and rebuttal from the argument elements in a discussion are independent of the field, which means these argument elements are also available in different fields. However, field-dependent and field-specific argument elements are also available. In other words, different argument elements can be used in discussions in different fields (Toulmin, 2003).

Toulmin defines the elements of an argument as follows:

- Data: These are the collections that provide the claim.
- Claim: It is the suggested-statement based on data.
- Warrant: Principles and rules that explain the relationship between data and claims.
- Backing: It is the statements that support the warrant.
- Qualifier: It is the boundary to which the claim is true (including words like 'most', 'usually', 'always' or 'sometimes').
- Rebuttal: The statements used in cases where the claims are not correct.

In argumentation-based courses, students use scientific theories, data and evidence to defend or refute their claims about a topic (Kaya et al., 2014). In a course in which the argumentation approach is used, students should defend their claims on the grounds that they themselves form, and teachers should guide the students in this process and lead the discussion. In this process, the teachers should direct the students to discussions and to think about the arguments by asking questions like "why do you think like that?", "how do you convince your friends that your thoughts are true?", "why do you think that your friends' thoughts are not true?" In order to discuss different ideas in a course in which the argumentation approach is applied, teachers should guide the students with questions that will give rise to these different ideas (Simon et al., 2006).

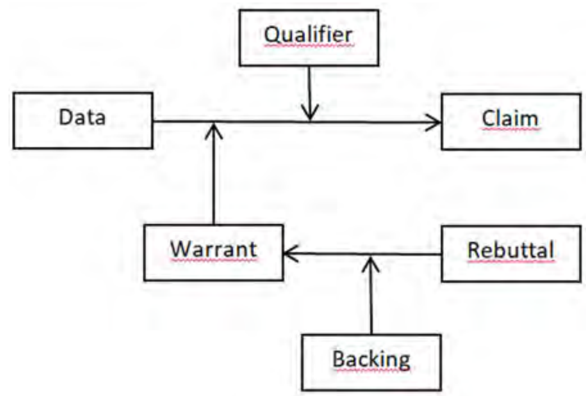

Figure 1. Toulmin's argumentation model (Toulmin, 1958, p.103).

Research on the use of argumentation approach in mathematics teaching has also been conducted. Sanchez and Uriza (2008) conducted the teaching of the integral subject with the argumentation approach. It was seen that the arguments were developed by the students without teacher's intervention. In the study conducted by Brown and Reeves (2009), it was observed that the argumentation approach encouraged students to participate in mathematics courses. With the argumentation approach, it was observed that students' mathematical skills, mathematical problem-solving skills and their ability to produce new approaches in problem solving were increased.

Most of the research on the use of argumentation in mathematics education is about the relationship between argumentation and proof process. The researchers compared the proof process to the argumentation process. According to these studies, proof is a special type of argumentation. Furthermore, according to the research, the argumentation experiences of the students positively affect the proof process of the students. These students were more successful in proving. Some of the studies on the relationship between argumentation and proof have been made in the field of geometry (Boero et al., 2017; Mariotti et al., 1997; Pedemonte, 2003, 2007) and some of them were made in the field of algebra (Douek, 1999; Pedemonte, 2008).

In the study conducted by Küçük-Demir (2014), the teaching of the function subject to the 9th grade students were made with the argumentation approach. As a result of the study, students' creative thinking skills and their success in function were positively affected. In addition, students expressed positive opinions about the use of argumentation approach in their courses. In the study conducted by Mercan (2015), the teaching of the subject of function to experimental group students was done with argumentation approach. The control group was taught the subject of function using the existing teaching methods. As a result of the study, it was seen that the achievement scores of the experimental group students were higher than those of the control group. In addition, the use of the argumentation approach has improved the experimental group students' scientific process skills and attitudes towards mathematics more than the control group. In the same study, the demands of the experimental group students for discussion increased as a result of the application. The students stated that their knowledge was more permanent with argumentation approach, their willingness to discuss increased and they wanted it to be used in other courses. In the study conducted by Fırat et al. (2016), probabilistic predictions of secondary school students in computer-aided argumentation environment were examined. In the study conducted with 6 students, it was found that students' probabilistic thinking skills increased misconceptions about probability decreased and correct predicting skills developed. In the study conducted by Doruk (2016), proof and argumentation skills were analyzed in Analysis courses. The rationales produced by the pre-service teachers were categorized as external, non-reference, experimental and deductive. In addition, it was found that the structural gap between the argumentation and proof process prevented pre-service teachers from making proof and the structural continuity made it easier for them to make proof. In the study conducted by Duran et al. (2017), probability education was given to secondary school students with an argumentation approach. The mathematics achievement of the students increased more with the argumentation approach than the current teaching method. There was no significant difference in the math anxiety of the experimental and control group students. The students expressed positive opinions about the argumentation approach.

The mathematical subjects in which the argumentation approach will be used must have certain characteristics arising from the nature of the argumentation approach. Argumentation approach may not be used in teaching each subject. The subjects taught with argumentation approach should provide the possibility of more than one opinion, be suitable for group work, and allow different views to be evaluated by the students (Driver et al., 2000). In the subject of probability, there are questions that have solutions in different ways that allow for the formation of arguments. In addition, students need to have prior knowledge and level of readiness to discuss a topic. Since the subject of probability is one of the mathematics subjects that the pre-service teachers have come across since secondary school years, it is thought that the pre-service teachers have readiness about probability. Therefore, it was thought that argumentation approach could be used in probability in this study.

Probability is an important subject of mathematics. It is frequently used in daily life, games of chance, genetics, meteorology, physics, biology and many other areas. According to Borovenick and Peard (1996), the subject of probability is a very important tool for developing independent creative thinking and probability-based thinking which is one of the most important aims of mathematics (Gürbüz, 2008). Individuals use probability with or without awareness in making decisions about certain events (Dereli, 2009; Gürbüz et al., 2010; Veda, 2008).

Probability takes place in primary and secondary education curriculums due to its usage areas and its importance in mathematics. Probability has been included in the primary and secondary education programs with the recommendations in the NCTM School Mathematics Curriculum and Evaluation Standards (NCTM, 1989), while it has been included in the education programs including the secondary education program since the pre-school program with School Mathematics Principles and Standards (NCTM, 2000). Probability began to be included in high school curriculums after the 1960s in Turkey. As a result of the changes made in the mathematics curriculum in 1990 and 1992, the scope of probability was expanded (Bulut et al., 1999). With innovation in the primary school curriculum in Turkey, it started to be included in mathematics curriculum from 8th grade 8. 8th grade students are expected to determine the probable states of a fact and events with different probabilities, examine the probabilistic events and calculate the probability of simple events (MEB, 2018).

In probability, teachers and students in Turkey and many other countries experience difficulties for various reasons. These difficulties are caused by teacher-centered education in the classroom environment, lack of materials (Gürbüz, 2006), students' misconceptions (Fischbein and Schnarch, 1997), and the lack of pedagogical and field knowledge of teachers (Bulut et al., 2002).

Reasons for difficulties in probability teaching in studies on probability teaching are lack of appropriate teaching material, teacher-centered teaching, lack of sufficient knowledge of teachers, lack of teachers' field knowledge, teachers' pedagogical deficiencies, students' readiness level, students' age, students' negative attitude and misconceptions caused by various reasons (Batanero and Serrano, 1999; Fast, 1997; Fischbein and Schnarch, 1997; Garfield and Ahlgren, 1988; Kahneman and Tversky, 1972; Shaughnessy, 1977). Bulut (2001) observed in his study conducted with pre-service mathematics teachers that they didn't have enough information and had misconceptions about probability concepts and stated that pre-service teachers should get a better education about probability.

In the subject of probability, which is very important for daily life and mathematics education, it is of great importance to increase student achievement. Providing students to learn in a social environment and thinking of them as a scientist will increase student achievement. Therefore, it is important to use the argumentation approach in the teaching of probability. In this study, pre-service teachers were taught probability by using argumentation approach. On this wise, it was aimed to increase the probability success of pre-service teachers. Increasing the probability success of the pre-service teachers will contribute to the elimination of the lack of knowledge of the teacher, which is one of the reasons of the difficulties encountered in the teaching of probability.

Purpose of the study

The purpose of this study is to investigate the effect of probability teaching with the argumentation approach on the probability success of pre-service mathematics teachers and the permanence of probability knowledge.

In this study, answers to the following research problems were sought:

1. What is the effect of probability teaching with the argumentation approach on the probability success of pre-service primary school mathematics teacher?
2. What is the effect of probability teaching with the argumentation approach on the permanence of probability achievement of pre-service primary mathematics teacher?

METHODOLOGY

Research design

In the study, quantitative research method was adopted, and quasi-experimental research design was used (Fraenkel, Wallen and Hyun, 2012). Probability Achievement Test (PAT) developed by the researchers was used as pre-test, post-test and retention test. PAT was applied on both experimental and control groups as pre-test, post-test and post-test as a retention test three months after the application. Tests were applied to the experimental and control groups simultaneously so that the experimental and control groups were not affected from each other.

Study group

The sample of the study consisted of 44 third grade pre-service teachers studying at the Department of Elementary Mathematics Education in a public university. Pre-service teachers are taught in two groups that are pre-determined by the institution. Pre-service teachers in the sample are taking Probability and Statistics course for the first time at university level. The PAT was applied as a pre-test to the pre-service teachers in both groups and no significant difference was found between the groups as a result of the analysis of the pre-test scores. Therefore, the group was divided into two, and one of the groups was randomly selected as the experimental group and the other as the control group. The experimental group consisted of 23 pre-service teachers (12 females and 11 males) and the control group consisted of 21 pre-service teachers (9 females and 12 males).

Data collection tools

Probability Achievement Test (PAT) developed by the researcher was used as a data collection tool. In the development of PAT, the probability achievement test for pre-service teachers, which consisted of 28 open-ended questions, was prepared by taking the opinions of two faculty members who previously taught Probability and Statistics to pre-service teachers. In determining the acquisitions for pre-service teachers, the acquisitions determined by the Ministry of National Education for students at primary and secondary level and the acquisitions determined by the ECTS (European Credit Transfer System) were taken into consideration. The interviewed experts and researchers agreed that the questions included in the test were consistent with the outcomes identified.

In the scoring of the questions in the PAT; scores below are used:

● 0 Points:
○ If no work has been done to solve the problem
○ If only the wrong result is written without any work done
○ If some data in the question has been copied but no work has been done to solve the problem

● 1 Points:
○ Beyond copying the data, a study has been conducted to solve the problem, but this does not lead to the correct solution of the problem.
○ If the right result is achieved with a wrong approach
○ One or more incorrect approaches have been applied or explained

● 2 Points:
○ If there are some important shortcomings, although some of the appropriate strategy is used to solve the problem
○ If an appropriate strategy was used to solve the problem, but it was applied incorrectly
○ If there are possible feasible facts related to the case, but not all
○ If the possible and all facts related to the case are incorrectly proportioned
○ Possible fact is proportioned correctly to all the facts but if there are significant deficiencies in the calculation of the possible case

● 3 Points:

○ If the correct strategy has not been achieved due to a processing error or other errors, even though the appropriate strategy is fully implemented
○If only the correct result is given without any explanation or study done

● 4 Points:
○ If an appropriate strategy is used to solve the problem and the correct result is obtained

These scoring criteria were determined by the researchers by making use of some examples in the literature (Küçük-Demir, 2014; Mercan, 2015).

The achievement test was applied to 100 prospective fourth grade pre-service mathematics teachers who took probability course before and succeeded in order to conduct a pilot study. Pre-service teachers were given 120 minutes to answer the test. As a result of the pilot application of the test, the Cronbach Alpha value of the test scores was calculated as 0.774.

In order to determine inter-rater reliability, PAT was scored by two independent researchers and Cohen Kappa coefficient was calculated for each question. The Cohen Kappa coefficient was developed by Cohen (1960) to determine the degree of agreement between the two raters (as cited in Bilgen and Doğan, 2017). The Kappa coefficient is between -1 and +1 (Bilgen and Doğan, 2017). The values given in the following table (Table 1) were used for the interpretation of the Kappa coefficient (Bilgen and Doğan, 2017).

The inter-rater agreement power was found to be very high for each question. Therefore, the PAT, which was then applied as pre-test, post-test and retention test, was scored by the researcher.

Table 1. Value ranges for interpretation of Kappa coefficient.

Kappa coefficient	The power of agreement
<0.00	Weak
0.00-0.20	Insignificant
0.21-0.40	Low
0.41-0,60	Medium
0.61-0.80	Significant
0.81-1.00	Very High

Source: Bilgen and Doğan (2017).

Data analysis

A statistical analysis software was used in the analyses. In the analysis of the achievement test, the pre-test and post-test scores of the experimental and control groups were compared. In addition, pre-test scores of experimental group and control group and post-test scores of experimental group and control group were compared. The tests used in these comparisons are given in Table 2. When deciding to use these tests, it was decided whether the scores were suitable for normal distribution.

Whether the score distributions show normal distribution was investigated by Shapiro-Wilk Test as the sample was less than 50 (Büyüköztürk et al., 2011). According to the results of Shapiro-Wilk Test, parametric tests were used in cases in which normal distribution was seen and non-parametric tests, which corresponded to parametric tests, were used in cases in which normal distribution was not seen.

Table 2. Tests used in quantitative data analysis.

	Normal Distribution	Test used
Experimental and Control Group pre-test comparison	Non-normal	Mann-Whitney U Test
Experimental group pre-test and post-test comparison	Non-normal	Wilcoxon Signed Ranks Test
Control group pre-test and post-test comparison	Normal	Dependent Samples T Test
Experimental and Control Group post-test comparison	Normal	Independent Samples T Test
Comparison of Experimental and Control Group Retention Test	Normal	Independent Samples T Test

Application

In the control group, traditional teacher-centered methods such as direct instruction, question and answer were used in the study of probability. In the introduction of the subject, firstly the necessary definitions were given and then the related samples were solved by the researcher. In the experimental group, the same sample problems were solved by using argumentation approach.

In the experimental group, pre-service teachers were informed about argumentation approach and elements of argumentation at the beginning of the first lesson. It was stated that argumentation approach will be used in the courses. It was stated that the pre-service teachers should make arguments for the solution of the problems presented in the course in the argumentation process and defend their claims with reasons. In the experimental group, the following conditions, which were determined by Mueller (2009) and required for the provision of the argumentation environment, were considered in the application of the argumentation approach.

● A safe learning environment should be provided for cooperative learning.
● Students are given open-ended tasks, allowed to research, discuss and return to task.
● Students are encouraged to form their own representation.
● Models can be created with accessible tools.
● Students are invited to explain their own defense.
● Behind the scenes of the case is highlighted.
● Teacher interventions should be carefully planned.
● Mathematical discourse is encouraged.

In the experimental group, pre-service teachers were expected to make claims for solutions based on the data in the problems, to establish reasons between the claims and the data, and to support their claims against the objections. Since the use of cooperative argumentation increased the students' desire to learn mathematics (Brown and Redmod, 2007; Mueller, 2009), group work was used in practice. The students were first asked to form groups of 4-5 people among themselves. The students formed groups with friends that they could get along with and were close with. Giving a certain period of time, it was expected that the groups would make claims for the solution of the sample problem written on the blackboard. The length of time to solve, the complexity of the sample problem and the discussions within the group were decided to determine the given time. The students were asked to formulate arguments for the solution of the problems with the participation of all students in the group and to determine the reasons for their claims. It was tried to be ensured that pre-service teachers expressed their thoughts freely and listened carefully and respectfully to the pre-service teachers who presented their thoughts. Because, in order to apply the argumentation approach effectively, students should participate in the argumentation activities within the group, express their thoughts freely and listen respectfully to the counter claims (Simon et al., 2006). Students who claimed to have a solution to the problem solved it on the board. The student who solved the problem was expected to persuade other groups to his claim. Other groups were asked to state whether they objected to the claims and were expected to refute or support the claims. Thus, a discussion environment between groups was created. The researcher asked questions such as “Do you agree with the solution of your friend? Why?”, “Do you think your friend's solution is right? Why?”, “Does anyone object to a solution? Why?” in setting up a discussion environment. At the end of the discussion, the agreed solution or the solutions of the problem was summarized by the researcher and the solution for a problem was ended.

Since the lessons given to the control group were based on the traditional methods, the problems were solved by the researcher. In the experimental group, the pre-service teachers reached a solution by arguing on the problem since the lessons were based on argumentation approach. Therefore, the lessons taught in the experimental group took longer than the lessons taught in the control group. In the control group, the lessons were completed within the normal period. The extra time required for the courses with the experimental group was solved by extending the normal course time by a joint decision of the pre-service teachers considering that the argumentation process should not be interrupted. Control and experimental groups were taught 18 hours of lessons in 5 weeks.

As a result of the application, PAT was applied on both groups as a posttest without prior notice. In order to compare the persistence of pre-service teachers' knowledge 3 months after the application, both experimental and control groups were applied simultaneously as PAT retention test without prior notice.

RESULTS

In this section, the findings of the research are presented. The findings of the sub-problems are given respectively. Findings related to the first sub-problem include the pre-test and post-test scores of the pre-service teachers. In the findings related to the second sub-problem, the results obtained from the pre-service teachers' retention test scores were included.

Findings related to first sub-problem

The arithmetic mean, standard deviation, highest and lowest scores and median values of the pre-test and post-test scores of pre-service teachers in the experimental and control group are presented in Table 3.

According to the data in Table 3, the arithmetic mean of the post-test scores of the control group increased compared to the arithmetic mean of their pre-test scores. The standard deviation of the pre-test scores of the control group was higher than the standard deviation of the post-test scores. The deviations of the pre-test scores from the arithmetic mean are less than the deviations of the post-test scores from the arithmetic mean. In the control group, the highest score from the pre-test was 49 while the highest score from the posttest was 87. Similarly, the lowest score from the pre-test was 13 while the lowest score from the post-test was 25. In the control group, the pre-test median value was 28. The median value is the exact value when the scores are placed in order of magnitude. Therefore, half of the pre-test scores of pre-service teachers were lower than 28 and half of them were higher than 28. The median value of the post-test was calculated as 53. Half of the pre-service teachers' post-test scores are less than 53, and half are

Table 3. Descriptive statistical findings of pre-test and post-test scores.

	Test	N	$\bar{X}$	SS	Highest score	Lowest score	Median
Control Group	Pre-test	21	29.5714	10.67507	49	13	28
	Post-test	21	52.0952	17.46111	87	25	53
Experimental Group	Pre-test	23	27.2609	11.76751	48	9	22
	Post-test	23	78.6087	16.02197	108	39	80

higher than 53.

According to Table 3, the arithmetic means of the post-test scores of the pre-service teachers' in the experimental group also increased compared to the arithmetic mean of the pre-test scores. In the experimental group, the standard deviation of the pre-test scores is lower than the standard deviation of the post-test scores. Accordingly, it can be said pre-test scores are closer to each other than post-test scores. In the experimental group, the highest score from the pre-test was 48 while the highest score from the post-test was 108. Similarly, the lowest score obtained from the pre-test in the experimental group was 9 and the lowest score in the post-test was 39. The median value of the pre-test scores of the experimental group was calculated as 22, while the median value of the post-test scores was calculated as 80. In the experimental group, half of the pre-test scores were lower than 22 and half of them were higher than 22. The median value of the post-test scores of the experimental group was calculated as 80. Half of the experimental group's post-test scores were lower than 80 and half of them were higher than 80.

The lowest score of the experimental group in the pre-test was lower than the lowest score of the control group in the pre-test. According to the post-test at the end of the application, the lowest score of the experimental group was higher than the lowest score of the control group. Similarly, the highest score of the experimental group in the pre-test was lower than the lowest score of the control group in the pre-test, while the highest score of the experimental group in the post-test was higher than the highest score of the control group in the post-test. This shows that the probability of success in the experimental group increased more than the control group.

In the experimental group, the standard deviation of the post-test scores increased compared to the standard deviation of the pre-test scores. In the control group, the standard deviation of the post-test scores increased compared to the standard deviation of the pre-test scores. This increase was higher in the control group than in the experimental group. A low standard deviation indicates that the scores are close to each other, whereas a high standard deviation indicates that the scores differ from each other. Therefore, the post-test scores of the experimental group are closer to each other than the post-test scores of the control group.

Comparison of pre-test scores of experimental and control groups

The pre-test scores of the experimental and control groups were compared. According to the Shapiro-Wilk test, the pre-test scores of the experimental group did not show normal distribution ($p_{experimental} < .05$, $p_{control} > .05$). The results obtained from the Shapiro-Wilk test are presented in Table 4.

Since the pretest scores of the experimental group did not show normal distribution, Mann-Whitney U test was used to compare the pretest scores of the experimental and control groups. Mann-Whitney U test results are given in Table 5. Accordingly, there was no significant difference between the pretest scores of the experimental and control groups ($u = 203.00$, $p > .05$).

The fact that there is no difference between the pre-test scores indicates that pre-service teachers' knowledge of probability from previous years is similar for the experimental and control groups. Using this, the groups were randomly assigned as experimental and control groups.

Comparison of pre-test and post-test scores of the experimental group

PAT pretest and posttest mean scores applied to the experimental group were compared. Since pre-test scores did not show a normal distribution ($p_{pretest} < .05$, $p_{posttest} > .05$) according to the Shapiro-Wilk test (Table 6), Wilcoxon Signed Ranks Test was used to compare the pretest and posttest mean scores of the experimental group.

The results of the Wilcoxon Signed Ranks Test are given in Table 7. Accordingly, there was a significant difference in favor of posttest among the experimental group PAT mean scores of pre-test and post-test ($z = -4.198$, $p < .05$). It was seen that PAT scores of all students increased.

This finding shows that the achievement scores of the experimental group pre-service teachers increased with the argumentation approach. The success of all pre-service teachers in the experimental group on probability was increased.

Table 4. Shapiro-Wilk test results for experimental and control groups PAT pre-test scores.

Group	N	t	p
Control group	21	.952	.367
Experimental group	23	.907	.035

Table 5. Mann-Whitney U test results for PAT pre-test scores of experimental and control groups.

Group	N	Mean Rank	Rank Sum	u	p
Experimental Group	23	20.83	479.00	203.00	.365
Control Group	21	24.33	511.00		

Table 6. Shapiro-Wilk test results for PAT pre-test and post-test scores of experimental group.

Test	N	t	p
Pre-test	23	.907	.035
Post-test	23	.969	.671

Table 7. Wilcoxon signed ranks test results for PAT pre-test and post-test scores of experimental group.

Posttest-Pretest	N	Rank Mean	Rank Sum	z	p
Negative rank	0	.000	.000		
Positive rank	23	12.00	276.00	-4.198	.000
Equal	0				

Comparison of pre-test and post-test scores of the control group

PAT pretest and posttest mean scores of the control group were compared. According to the Shapiro-Wilk Test (Table 8), the pre-test and post-test mean scores of the control group were compared with the Dependent Sample T Test since the pre-test and post-test scores showed normal distribution ($p_{pretest} > .05$, $p_{posttest} > .05$)

Table 8. Shapiro-Wilk test results for PAT pre-test and post-test scores of control group.

Test	N	t	p
Pre-test	21	.952	.367
Post-test	21	.959	.496

Dependent Sample T Test results are given in Table 9. Accordingly, there was a significant difference in favor of the posttest among the mean PAT pretest and posttest scores of the control group (t = -6.9880, p <.05). It was seen that PAT scores of all students increased.

According to this finding, it can be said that pre-service teachers in the control group increased their success in probability. Teaching with teacher-centered traditional methods applied in the control group increased the pre-service teachers' achievement in probability.

Comparison of posttest scores of experimental and control groups

The mean post-test scores of the experimental and control groups were compared. Since the posttest scores of the experimental and control groups showed normal distribution according to Shapiro-Wilk Test (Table 10) ($p_{experimental} > .05$, $p_{control} > .05$), the Independent Samples T Test was used in the comparison of the posttest mean scores of the experimental and control groups. According to Levene Test, the variances of posttest scores were homogeneous (p = .448> .05). According to the results of the Independent Samples T Test evaluated by taking Levene test into consideration, there is a significant difference between the post-test mean scores of the experimental and control groups in favor of the experimental group (t = -5.253; p <.05). Independent Sample T Test results are given in Table 11.

According to findings obtained, although the success of experimental and control groups on probability increased, this increase was statistically significantly higher in the

Table 9. Dependent sample t test results for PAT pre-test and post-test scores of control group.

Measurement	N	$\bar{X}$	SS	sd	t	p
Pre-test	21	29.5714	10.67507	20	-6.9880	.000
Post-test	21	52.0952	17.46111			

Table 10. Shapiro-Wilk test results for posttest scores of experimental and control groups.

Group	N	t	p
Control Group	21	.959	.496
Experimental Group	23	.969	.671

Table 11. Independent sample t test results for PAT posttest scores of experimental and control groups.

Group	N	$\bar{X}$	SS	sd	t	p
Control group	21	52.0952	17.46111	42	-5.253	.000
Experimental group	23	78.6087	16.02197			

experimental group compared to the control group. This difference is due to the teaching method applied to the experimental and control groups. The argumentation approach applied to the experimental group increased the pre-service teachers' success more than the pre-service teachers to whom the traditional teaching methods applied in the control group.

Findings related to second sub-problem

PAT was applied to pre-service teachers as retention test 3 months after the PAT was applied to pre-service teachers as post-test. As 4 teachers from the experimental group and 4 from the control group were transferred to a different university by lateral transfer, the number of the sample was decreased by 8. 3 female and 1 male pre-service teachers were missing from the experimental group, while 2 female and 2 male pre-service teachers were missing from the control group. 19 pre-service teachers in the experimental group and 17 pre-service teachers in the control group participated in the retention test. The table below contains the arithmetic mean, standard deviation, highest and lowest scores, and median values of the pre-service teachers' retention test scores (Table 12).

According to Table 12, the retention test arithmetic mean of the pre-service teachers in the experimental group is higher than those of the pre-service teachers in the control group. The standard deviation of the retention test of the experimental group and the standard deviation of the retention test of the control group are approximately of the same value. The highest score in the experimental group was 99 while the highest score in the control group was 91. While the lowest score in the experimental group was 28, the lowest score in the control group was 27. The median values were 74 in the experimental group and 60 in the control group. When these values are examined, it can be said that the pre-service teachers in the experimental group are more successful in the retention test than the pre-service teachers in the control group. However, there was no statistically significant difference between the retention test scores of the experimental and control groups according to the results of the Independent Samples T test conducted to compare the mean values.

The Shapiro-Wilk test was used to determine whether the retention test scores showed normal distribution. According to Shapiro-Wilk Test results (Table 13), the retention test scores show normal distribution ($p_{experimental} > .05$, $p_{control} > .05$).

Since the retention test scores of the pre-service teachers showed normal distribution for both groups, Independent Samples T Test was used when comparing the retention test scores of the experimental and control groups. According to Levene Test results, the retention test variances of the experimental and control groups were homogeneous ($p > .05$). Considering this result of Levene Test, it was determined that there was no statistically significant difference between experimental and control group retention test scores according to the Independent Samples T Test results ($t = -1.845$; $p > .05$). The Independent Samples T Test results for the retention test scores of the experimental and control groups are given in Table 14.

When the table is examined, it is seen that there is no

Table 12. Retention test descriptive statistical data.

	N	$\bar{X}$	SS	Highest score	Lowest score	Median
Control group	17	61.2941	17.88772	91	27	60
Experimental group	19	72.1579	17.41093	99	28	74

Table 13. Shapiro-Wilk test results for retention test scores of experiment and control groups.

Group	N	t	p
Control group	17	.968	.782
Experimental group	19	.936	.225

Table 14. Independent samples t test results for retention test scores of experimental and control groups.

Group	N	$\bar{X}$	SS	sd	t	p
Control group	17	61.2941	17.88772	34	-1.845	.074
Experimental group	19	72.1579	17.41093			

statistically significant difference between the permanence of the knowledge of the pre-service teachers in experimental and control group. The situations that may cause non-differences are discussed in the Conclusion and Discussion section of the test.

DISCUSSION AND CONCLUSION

This section includes the results and discussions obtained by interpreting the findings gathered as a result of the study according to the sub-problems. Findings obtained from the study were evaluated and their relationship with other studies in the literature was mentioned.

Results related to the first sub-problem

In this study, PAT was applied to pre-service teachers in experimental and control groups as a pre-test, and pre-test scores of pre-service teachers were analyzed with Mann-Whitney U Test. According to the results of Mann-Whitney U Test analysis, there was no statistically significant difference between the pre-test scores of the pre-service teachers. As a result of the study, argumentation was applied as a post-test to the pre-service teachers in the experimental and control groups. Pre-test scores and post-test scores of pre-service teachers were analyzed with Dependent Sample T Test. According to the results of the Dependent Sample T Test analysis, there was a statistically significant difference between the pre-test and post-test scores of the pre-service teachers. This shows that pre-service teachers in control group increased their probability success as a result of the application. Similarly, pre-test scores and post-test scores of the pre-service teachers were analyzed with Wilcoxon Signed Ranks Test. According to the results of Wilcoxon Signed Ranks Test, there was a statistically significant difference between the pre-test and post-test scores of the pre-service teachers. This shows that pre-service teachers' probability success was increased as a result of the application. The post-test scores of the pre-service teachers in experimental and control group were analyzed with Independent Samples T Test. According to Independent Samples T Test analysis scores, there was a statistically significant difference between the scores of the pre-service teachers in experimental and control group in favor of the experimental group. It can be said that this difference arises from the fact that the teaching of probability to the experimental group was done with argumentation approach. The conclusions that the argumentation approach increases academic achievement are also reached by Küçük-Demir (2014), Demirci (2008), Deveci (2009), Duran et al. (2017), Hand and Keys (1999), Kaya (2005), Okumuş (2012), Özkara (2011) and Uluçınar Sağır (2008). The studies conducted by Karakuş and Yalçın (2016) on the application of the argumentation approach were included in the meta-analysis process. As a result of the research, it is concluded that argumentation has a positive and broad effect on academic achievement and scientific process skills.

Results related to the second sub-problem

In the study, 3 months after the application of PAT as a post-test, it was re-applied to the experimental and control groups to compare the permanence of the probability knowledge of pre-service teachers. Independent Samples T Test was used to compare the retention test scores. According to the Independent Samples T Test results, there was no statistically significant difference between the retention test scores of the experimental and control groups. However, the mean score of the experimental group was 72.16 and the mean of the control group was 61.3. In addition, $p = .074$ value is very close to $p=.05$ significance value. This shows that the retention scores of the pre-service teachers in the experimental group are higher than the retention scores of the pre-service teachers in the control group. However, there was no statistically significant difference between these two means. However, in the studies conducted by Duran et al. (2017), Hiğde and Aktamış (2017), Kabataş-Memiş (2014), the participants stated that the argumentation approach increases the permanence of knowledge. Kabataş-Memiş (2011), in his study, taught the subject of "Electricity in Our Life" and "Matter and Heat" units with the argumentation approach and after 8 months applied a retention test for both units. The retention test total scores showed a statistically significant difference between the experimental and control groups in favor of the experimental group. Özkara (2011) taught the subject of pressure to 8th grade students using argumentation approach and applied retention test after 6 weeks. The retention test scores showed a statistically significant difference in favor of the experimental group.

In this study, there may be various reasons why there is no difference between the permanence of the probability knowledge of the experimental and control groups. Subject characteristics may be the reason and conducting retention test after a while may also be a reason. In addition, the pre-service teachers met the argumentation approach for the first time. Increasing the time spent by pre-service teachers with argumentation approach may increase the permanence of their academic success and knowledge.

RECOMMENDATIONS

As a result of this research, it has been observed that the use of argumentation approach in the teaching of probability subject increases the academic achievement of prospective teachers' more than traditional methods. Therefore, the use of argumentation approach in different subjects of mathematics may increase student achievement more. This research is limited to 18 hours of course in 5 weeks. In this study, pre-service teachers met argumentation approach for the first time. Being unfamiliar with the approach and their application for the first time can be seen as a lack of this research. Letting the students to encounter the argumentation approach more and longer can increase their success more. Because the time spent with the argumentation approach will allow full application of the argumentation approach and increase the level of argumentation (Osborne et al., 2004). The widespread use of the argumentation approach can improve the pre-service teachers' scientific thinking skills and make their success and knowledge more permanent. Only verbal argumentation was used in this study. Therefore, it may have negatively affected the hesitant students' participation in the lectures and expressing their opinions. The use of written argumentation approach is important in terms of the fact that it allows shy students to write their ideas. In this research, the argumentation approach was used only in the classroom environment. The use of activities that enable pre-service teachers to conduct research and form arguments outside the classroom may increase the effect of the argumentation approach.

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