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Teaching Probability to Pre-Service Teachers with Argumentation Based Science Learning Approach

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Abstract
The aim of this study is to explore the effects of the argumentation based science learning (ABSL) approach on the teaching probability to pre-service teachers. The sample of the study included 41 students studying at the Department of Elementary School Mathematics Education in a public university during the 2014-2015 academic years. The study is a quasi-experimental study. The experimental group consisted of 20 students, and the control group consisted of 21 pre-service teachers. While the teaching probability argumentation based science learning approach was applied to the teacher candidates in the experimental group, traditional methods were applied to the control group. As a data collection tool, the Probability Achievement Test with 15 open-ended questions, which was prepared by the researcher himself, was used. As a result of the application, statistical significant differences were found between the probability successes of the experimental group and control group in favor of the experimental group.
Keywords: probability, argumentation based science learning

1. Introduction

Probability is one of the most important areas in mathematics. Probability is used in our daily life, in chance games, genetics, meteorology, physics, biology, and many other areas. Probability is a very important tool in terms of developing the ability for independent creative thinking skill, which is one of the most important aims of mathematics, and the ability of probabilistic thinking as a type of basic thinking (Borovenick & Peard, 1996). Probability takes part in primary and secondary programs due to both its importance and its widespread use in mathematics. The National Council for Teachers of Mathematics (NCTM) gave a place to probability in the published School Mathematics Program and the Evaluation Standards Recommendations, and in elementary and secondary school programs (NCTM, 1989). Also, NCTM gave place to probability in instructional programs including; the pre-school education program and the secondary program with recommendations in the Principles and Standards of School Mathematics, which was published later (NCTM, 2000). In our country, the subject of probability began to be a part of the high school program after the 1960s. The scope of the subject of probability was extended as a result of the changes in the mathematics program between the years of 1990 and 1992. Together with the innovations in the primary school curriculum, the subject of probability has been involved in the education program of mathematics from the fourth grade of primary education with the following objective, "Students use the words that indicate probability in proper sentences" (Ministry of National Education [MNE], 2009, p. 194).

Probability is one of the most challenging areas in mathematics that both teacher and students have difficulty understanding (Bulut, Ekici, & Iseri, 1999). The main causes of these difficulties that both teachers and students have been the teacher-centered classroom environment, the lack of material (Gurbuz, 2006), and the misconceptions students have due to a variety of reasons (Fischbein & Schnarch, 1997). Among these reasons is that teachers do not have the necessary qualifications for teaching the subject of probability (Bulut, Yetkin, & Kazak, 2002).

Teachers who are practitioners have an important role in teaching probability. Therefore, teachers and teacher candidates must have the required content knowledge (Bulut et al., 2002). In the Ishikawa diagram, which was prepared by Memnun (2008a), it can be seen that the insufficiency in teachers' knowledge is among the reasons for the inability to learn about probability.

There are studies on the probability achievements of pre-service teachers. Bulut and Sahin (2003) found no statistical significant differences between the class averages of the 11th grade of the students in Secondary Education and the fourth year students studying at the Department of Mathematics in their research about students' probability achievements. In the same study, it was found that Secondary Education students and pre-service mathematics teachers did not know a large majority of probability concepts. However, mathematics teachers of the future must be superior to the secondary education students in terms of success. In a study by Kutluca and Baki (2009), probability was found among the math topics that pre-service teachers and tenth grade students had difficulty in learning. In terms of conceptual knowledge, pre-service teachers have insufficient ability to explain basic probability concepts, permutations and combinations concepts, and the types of event and probability. Also, they fail at the geometry-based calculus of probability in terms of transactional information (Ata, 2013; Bulut, 2001). To ensure the students' success in probability, it is necessary to improve the pre-

service teachers' performance and resolve the lack of pre-service teachers' knowledge. Therefore, different methods and techniques should be used for teacher training. Since it is well-known that it is difficult to understand the subject of probability, this reveals the need for the use of a method which contributes to students' active participation and cognitive development apart from the traditional methods such as traditional didactic method and question and answer method.

One of the methods that allows the students' active participation, configuration of information, and cognitive development, is the Argumentation Based Science Learning Approach (ABSL). The original name of this approach was Science Writing Heuristic, and in this country, some researchers still call this approach Science Writing Heuristic (SWH) (Gunel, Memis, & Buyukkasap, 2010) or the Argumentation Based Science Learning Approach (ABSL) (Gunel, Akkus, & Ozer, 2010; Gunel, Kıngır, & Geban, 2012).

There are different definitions of the Argumentation Based Science Learning Approach according to different researchers. Below are a few of these definitions:

- The Argumentation Based Science Learning Approach (ABSL) is a method where students determine their research questions themselves, design laboratory activities which help them to find the answers to these questions, develop their claims that are a part of the scientific process according to the results of the experiment, support their claims with evidence, and defend their results in small and large group discussions (Keys et al., 1999).
- With the ABSL approach, students suggest ideas based on questioning and research, advance the argument by analyzing the questions, claim and evidence processes, and perform reconciliation and discussion processes (Akkus, Gunel, & Hand, 2007).
- The Science Writing Heuristic, SWH, is a process that has been devised to encourage students to use hands-on guided inquiry laboratory activities and collaborative group work to actively negotiate meaning and construct conceptual knowledge (Burke, Greenbowe, & Hand, 2005).
- The Argumentation Based Science Learning approach is an interdisciplinary method where people make inferences by reasoning and setting up claims. It is basically based on logic and inferences. Individuals try to convince others by expressing and arguing their own ideas. It includes discussion and debate techniques (Karısan, 2011).

The components that make up the structure of argumentation are identified in the following figure (Figure 1) by Toulmin (Toulmin, 2003). For the formation of the structure of argumentation, students are asked to make their claims depending on the data, set up valid and acceptable warrants between this claim and data, and to support their claims with general formal information when people object to these claims in the process of argumentation (Aladag, 2006).

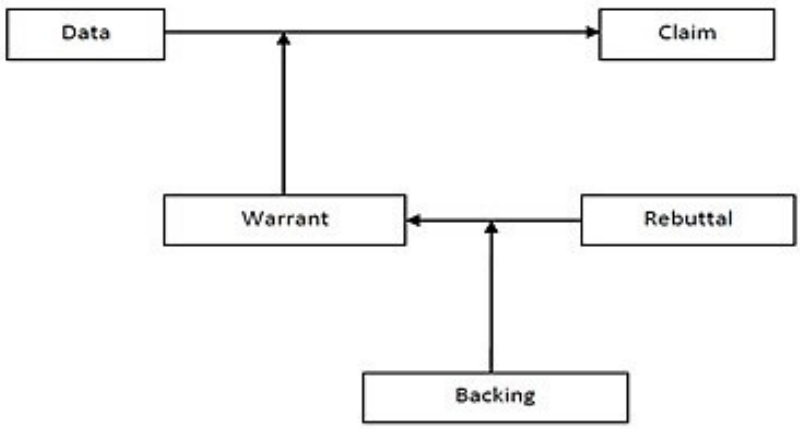

Figure 1. The Toulmin Model of Argumentation

Argument is a coordination of theories and evidence, which has been put forward to support or refute explicative a result, and model an appraisal (Toulmin, 2003). Arguments are the elements of the scientific debate. For the establishment of an argument; data, claims, and warrants are certainly mandatory. The backing, rebuttals, and qualifier increase the validity of the argument (Ceylan, 2012).

The Argumentation Based Science Learning Approach (ABSL) is built on the basis of the constructivist learning theory (Burke et al., 2005). Using ABSL is part of the instructional sequences. The format requires; guided inquiry activities, interactive group work, meaning via a collective negotiated exchange of ideas and argumentation, and reflective writing (Burke et al., 2005). In the ABSL approach, where reading, writing, and speaking, are used in an effective manner, students configure the information in an inquiry-based research

learning environment where they ask questions, make claims, and support them with evidence (Gunel, Kıngır, & Geban, 2012). With the ABSL approach, students suggest ideas based on questioning and research, advance the argument by analyzing the question, claim and evidence processes, and perform reconciliation and discussion processes. Therefore, it is important for students to expand their ideas regarding scientific issues (Akkus et al., 2007).

The ABSL approach is used in science education and there has been a lot of research conducted on it. Ceylan (2010) investigated the use of the ABSL approach in science laboratory activities. While teaching probability, the argumentation based science learning approach was applied to pre-service teachers in the experimental group, and traditional methods were applied to the control group. As a result of the experiment, the teacher candidates in the experimental group were observed to be more successful than the control group. Additionally, the teacher candidates indicated that they understood the subject matter better with the applications which were based on the ABSL approach because this approach allows for their active participation in the course, and is effective in the development of scientific process skills. The ABSL approach positively impacts on students' success. In a research conducted on 5th grade elementary students, the ABSL approach-oriented materials were used in the learning domain of the world and universe, and it concluded that teaching is more effective by using this approach (Ceylan, 2012). In a study conducted by Memis (2011), the group to which the ABSL approach was applied and who were self-assessed were was more successful than the group who applied traditional methods. The teacher candidates stated that teaching chemistry with argumentation improves the ability of scientific thinking and inquiry skills, supports conceptual change and meaningful learning, develops understanding the nature of science, increases interest in the courses, and supports the students' active participation in the learning process (Tumay & Koseoglu, 2010). The ABSL approach develops students' critical thinking skills (Tonus, 2012). In a study conducted by Celik (2010), it was concluded that while teaching with the Argumentation Based Science Learning Approach was applied to teacher candidates in the experimental group, traditional methods were applied to the control group and as a result of the application, statistical significant differences were found between the students' conceptual perceptions, and their attitudes towards the chemistry course in favor of the experimental group.

There are also studies about the use of this approach in teaching mathematics. Sanchez and Uriza (2008) performed integral teaching using the ABSL approach. It was found that the arguments were developed directly by students without any teacher interaction. In another study, the application was carried out with 20 teachers who used cooperative argumentation. The teachers indicated that the use of Collective Argumentation increases students' desire to learn mathematics, and increases professional development in the areas of math learning, and Collective Argumentation studies should be applied against the abolition of test books and structured math lessons (Brown & Redmod, 2007).

The aim of this study was to explore the effects of the argumentation based science learning (ABSL) approach on teaching probability to pre-service teachers. In the research, the answer was sought for the following question, "Is there any statistical significant difference between the probability successes of the experimental group and the control group?".

2. Method

2.1 Research Design

The study adopted a quasi-experimental research design using a quantitative method (Fraenkel, Wallen, & Hyun, 2012). This design is given in Table 1. The Probability Achievement Test, which was used both as a pre-test and post-test in the research design, was developed by the researcher.

Table 1. Research Design

Group	Pre-test	Application	Post-test
Experimental group	PAT	Teaching probability with ABSL approach	PAT
Control Group	PAT	Teaching probability with traditional methods	PAT

PAT: The Probability Achievement Test

2.2 Participants

The convenience sampling method was used in the selection of the sample. The convenience sampling method was a sampling method which aimed to prevent the loss of time, money, and labor (Buyukozturk et al., 2010). The sample of the study included a total of 41 third- year students studying at the Department of Elementary School Mathematics Education in a public university located in the eastern region of Turkey. The teacher candidates studied in two groups designated by the institution. Because there was no statistical significant difference between the groups based on the results of the pre-test, the experimental and control groups were identified through a random assignment.

2.3 Data Collection Tool

The Probability Achievement Test for the test pre-service teachers consisted of 15 questions which were prepared from the ideas of a faculty member who lectured in Probability and Statistics course for teacher candidates. The distribution of the questions is given in Table 2 according to the sub-topics of probability. The achievement test was applied to 87 fourth grade pre-service teachers who took the probability course and succeeded in it for the purpose of conducting the pilot study. The Cronbach's alpha value of the test was found to be 0.724. A sixty minute period was found to be sufficient time for the implementation of the test.

Table 2. The Distribution of Questions According to Sub-Topics of Probability

Sub Topics of Probability	The Number of Questions
The Determination of Sample Space	1
Counting Methods	2
Permutation	4
Combination	4
Probability	4
Total	**15**

2.4 Implementation Procedure

While teaching probability, the traditional method was applied to the control group. The definitions that were required for the entry of the subject were given, and then the examples which were relevant to this definition were solved by the researcher. The same sample questions were solved by the experimental group. For teaching probability, the argumentation based science learning approach was applied to the experimental group pre-service teachers. It was thought that the students would be able to suggest their own claims depending on the data in the same sample questions, to build up a valid connection between their claims and data, and to support their claims with the applicable information when people opposed these claims. First of all, the students were asked to form groups of 4-6 people between themselves. The students formed groups with the people with whom they got along with. There was no intervention by the researcher during the creation of the groups. The groups were expected to suggest their own claims for the solution to the sample question written on the blackboard during the given time. When determining the time, it was decided by taking into consideration the length of the solution of the sample question, the complexity of the sample question, and the group discussions. The students were asked to solve the questions by agreeing and discussing it with each other within the group. When the groups claimed to have solved the question, the solution was written on the blackboard by the group spokesman. While doing this, the student was asked to support claims with applicable information. The student who solved the question was expected to convince the other groups. The other groups were expected to support or invalidate the claim with solid evidence.

Thus, the formation of the negotiation process between the groups was provided. The researcher contributed to the formation of the negotiation process between the groups with questions such as "Do you agree with your friend's solution? Why?", "Do you think your friend's solution is correct? Why?", "Is there anyone who has any objection to the solution? Why?" As a result of the discussion, the solution for an example was ended by summarizing the agreed solution to the question by the researcher. While 18 lessons, where the average duration of each lesson was 45 minutes were taught in the control group, 20 lessons were taught in the experimental group. In courses that uses the Argumentation Based Science Learning (ABSL) approach, the number of lessons in the experimental group was much more than the control group due to the long duration of the debate between the groups. The implementation took five weeks. As a result of the implementation, the Probability Achievement Test was applied to both groups without notice.

3. Findings

The findings from the research are given below. The pre-test scores of the experimental and control groups, the pre-test and post-test scores of the experimental group, the pre-test and post-test scores of the control group, and the post-test results of the experimental and control groups, were compared. The SPSS 20 program (Statistical Package for the Social Sciences) was used to analyze the data. Because the sample size was under 50, the distributions were investigated with the Shapiro-Wilk Test in order to find out whether the distributions showed a normal distribution or not (Buyukozturk, Cokluk, & Koklu, 2011).

3.1 Comparison of Pre-Test Results of the Probability Achievement Test of the Experimental and Control Groups

The Probability Achievement Test was applied to the teacher candidates who studied in the two groups. Whether there was a statistical significant difference between the probability achievements of two groups or not was investigated. Therefore, the SPSS 20 program (Statistical Package for the Social Sciences) was used. Because the sample size was under 50, the Shapiro-Wilk Test was used in order to determine whether the pre-

test scores showed a normal distribution or not (Buyukozturk, Cokluk, & Koklu, 2011). The results are given in Table 3. As a result of the Shapiro-Wilk Test, it was understood that the pre-test scores did not show a normal distribution (p=.000<.050 was for the Group 1 and p=.034<.050 was for the Group 2).

Table 3. The Shapiro-Wilk Test Results for the Pre-Test Scores of the Experimental and Control Groups

Group	N	t	p
Group 1	20	.704	.000
Group 2	21	.899	.034

Because the pre-test scores of the groups did not show a normal distribution, the Mann-Whitney U Test was used in order to investigate the differences between the pre-test score averages. The Mann-Whitney U Test results of the Probability Achievement pre-test are given in Table 4. According to Table 4, statistical significant differences were not found between the probability achievements of the two groups (U=182.50, p=.468>.050). By taking into consideration this comparison, the first group was defined as the experimental group and the second group was defined as the control group randomly.

Table 4. Mann Whitney U-Test Results of the Probability Achievement Pre-test Score Averages

Group	N	Mean Rank	Rank Sum	U	p
Group 1	20	22.38	447.50	182.50	.468
Group 2	21	19.69	413.50		

3.2 Comparison of Pre-Test and Post-Test Results of the Probability Achievement Test of the Experimental Group

The Probability Achievement Pre-test and Post-test score averages of the experimental group were compared. As a result of the Shapiro-Wilk Test, it was understood that the pre-test scores did not show a normal distribution (p=.000<.050 was for the pre-test and p=.095>.050 was for the post-test). The Shapiro-Wilk test results are given in Table 5.

Table 5. The Shapiro-Wilk Test Results for the Pre-test and Post-test Scores of the Experimental Group

Test	N	t	p
Pre-Test	20	.704	.000
Post-Test	20	.919	.095

The Wilcoxon Signed Rank Test was used to determine the differences between the pre-test and post-test scores of the experimental group because the pre-test scores did not show a normal distribution (Buyukozturk, Cokluk, & Koklu, 2011). The results of the test are given in Table 6.

Table 6. The Wilcoxon Signed Rank Test Results for the Experimental Group

Post-test Pre-test	N	Mean Rank	Rank Sum	z	p
Negative rank	0	.000	.000	-3.923	.000
Positive rank	20	10.50	210.00		
Equal	0				

According to the findings shown in Table 6, statistical significant differences were found between the pre-test and post-test scores of the experimental group (z=-3.923, p=.000<.050). As a result of the teaching probability with the Argumentation Based Science Learning Approach, the pre-service teachers' achievements on the subject of probability increased.

3.3 Comparison of Pre-Test and Post-Test Results of the Probability Achievement Test of the Control Group

After implementing the Probability Achievement Test, the pre-test and post-test score averages of the control group were compared. As a result of the Shapiro-Wilk Test, it was understood that the pre-test scores did not show a normal distribution (p=.034<.050 was for the pre-test and p=.409>.050 was for the post-test). The Shapiro-Wilk test results are given in Table 7.

Table 7. The Shapiro-Wilk Test Results for the Pre-test and Post-test Scores of the Control Group

Test	N	t	p
Pre-Test	21	.899	.034
Post-Test	21	.954	.409

The Wilcoxon Signed Rank Test was used to determine the differences between the pre-test and post-test scores of the control group because the pre-test scores did not show a normal distribution (Buyukozturk, Cokluk, & Koklu, 2011). The Wilcoxon Signed Rank Test results are given in Table 8.

Table 8. The Wilcoxon Signed Rank Test Results for the Control Group

Post-test Pre-test	N	Mean Rank	Rank Sum	z	p
Negative rank	0	.000	.000	-4.021	.000
Positive rank	21	11.00	231.00		
Equal	0				

According to Table 8, statistical significant differences were found between the Probability Achievement pre-test and post-test scores of the control group (z=-4.021, p=.000<.050). As a result of the teaching probability with the traditional method, the achievements of all the pre-service teachers on the subject of probability increased.

3.4 Comparison of Post-Test Results of the Experimental and Control Groups

The Post-test scores of the experimental and the control group were compared. According to the results of the Shapiro-Wilk Test, the post-test scores of the experimental and the control group showed a normal distribution (p=.095>.050 was for the experimental group and p=.409>.050 was for the control group). The Shapiro-Wilk test results are given in Table 9.

Table 9. The Shapiro-Wilk Test Results for the Post-test Scores of the Experimental and Control Group

Group	N	t	p
The Experimental Group	20	.919	.095
The Control Group	21	.954	.409

The Independent Sample t-Test was used to investigate the differences between the post-test score averages because the post-test scores of the experimental and control group show a normal distribution (Buyukozturk, Cokluk, & Koklu, 2011). The Independent Samples t-test results are given in Table 10.

Table 10. Independent Samples t-Test Results for the Post-Test Scores of the Experimental and Control Group

Group	N	X	sd	t	p
The Experimental Group	20	16.950	4.489	4.929	.000
The Control Group	21	10.238	4.230		

The Levene's Test statistic (F) was found to be 0.114, and the p-value was found to be 0.737. These results show that the variances of the groups were not statistically different (p>.050). Also, by looking at the values given in Table 10, a statistical significant difference was found between the post-test score averages of the experimental group and control group in favor of the experimental group ($X_{experimental}$=16.950> $X_{control}$=10.238) and this difference is statistical significant (t=4.929, p=.000<.050). It can be understood from these results that there was a statistical significant difference between the probability achievements of the experimental group and control group in favor of the experimental group (t=4.929, p=.000<.050).

4. Conclusion

According to the findings obtained from the study, it was observed that all the pre-service teachers' achievement scores increased in the experimental and control group. Also, the achievements of the experimental and control group were compared, and as a result of this comparison, it was seen that while statistical significant differences were not found between the probability achievement mean scores of the groups before the research, after the implementation, statistical significant differences were found between the probability achievement mean scores of the groups, and pre-service teachers in the experimental group were observed as being more successful than in the control group. This statistical significant difference was due to the teaching probability with the Argumentation Based Science Learning Approach, and it was concluded that the Argumentation Based Science Learning (ABSL) approach has more positive effects on teaching probability than the traditional method.

The Argumentation Based Science Learning (ABSL) approach is based on the constructivist learning theory, and has increased probability achievements when compared to the traditional method. In similar studies on probability achievements, the use of the methods which are based on the constructivist approach increased the probability achievements when compared to the traditional teaching method (Besler, 2009; Ozdemir, 2012; Yazıcı, 2002; Memnun, 2008b; Gurbuz et al., 2010; Gurbuz, 2009; Akkaya, 2010).

In a research conducted with secondary school students by Demir (2014), the Argumentation Based Science Learning (ABSL) approach increased the achievements of the students on the subject of functions. According to this research and the study conducted by Demir (2014), the ABSL approach is a constructivist-based approach that can be used to increase students' achievements.

5. Recommendations

It is expected that the teaching method using the ABSL approach would increase the probability achievements of the teacher candidates, and would solve the lack of pre-service teachers' knowledge, which is among one of the reasons for the inability to learn probability.

The investigation into the effect of the ABSL approach in the process of mathematics teacher training in different subjects, and the comparison with other teaching methods, would give information regarding the positive effects of this approach regarding increasing students' success in different subjects. The use of this approach in topics in which the ABSL approach has a positive effect, can help to solve the possible lack of pre-service teachers' knowledge in different subject areas. Also, the use of the ABSL approach by pre-service teachers in their lessons would help to increase their students' success.

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