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ABSTRACT
The study aims to determine the effect of using argumentation-based science learning approach (ABSL) on science achievement of the 6th grade students in teaching three different units of science lesson including biology, chemistry and physics. The study was conducted with 55 sixth grade students from three different classes. In this study, quasi-experimental research design, one of the experimental research designs was preferred. The classes were assigned randomly as two experimental groups and one control group. While ABSL approach supported by brochure production and report writing was used in the experimental groups, the current curriculum was used in the control group. Science achievement test was applied as pretest and posttest. Mixed Between-Within Subjects ANOVA was used in the analysis of the data. According to the posttest results obtained from the study; it was found out that in biology unit, the experimental group supporting ABSL with brochure was more successful than the control group, there was no difference between the group supporting ABSL with report and the control group; in chemistry unit, there was no difference between the groups and in physics unit the experimental groups were more successful than the control group. The results showed that ABSL approach supported by brochure increased 6th grade students' academic achievement in biology unit, and ABSL approach supported by both brochure and report increased their academic achievement in physics unit.

Keywords: ABSL, science achievement, brochure, report

INTRODUCTION

Writing which plays an important role in open and logical communication (Myers, 1984) is one of the frequently used learning activities (Klein, 1999). Especially in argumentation processes, writing activities undoubtedly come up as an important tool to cognitively externalize students' processes of justification (Jimenez-Aleixandre & Erduran, 2007). Argumentation-based science learning (ABSL) is based on writing. What is meant with writing here is not traditional method in which the student records information in a passive way, such as taking notes directly about the lectures given by the teachers in the lesson or what is told in the textbooks, preparing laboratory reports about the experiments (Günel, Atila & Büyükkasap, 2009), but what is meant is writing to learn, an effective teaching strategy, which focuses on written product that focuses on the process of organizing and expressing ideas (Balgopal & Wallace, 2013). Within this context, it was highlighted that the most fundamental purpose of ABSL approach in science and science teaching is to use the components of language, manifesting in the form of speaking, listening, reading and writing to explore scientific concepts, to recognize processes in the functioning of science, and to better understand science (Roth & Worthington, 2016).

Argumentation is an important cognitive capacity for handling conflicting information, viewpoints, and perspectives (Besnard et al., 2014). Argumentation is the development of an assertion or claim with supporting justifications (Dawson & Carson, 2020). According to Miller (1987), it is an effort to find a reasonable answer through a systematic organization of the logic processes carried out in the presence of a question or a claim. That is, argumentation is the expression of reasoning within the context of conflicting and controversial issues which have multiple alternative solutions (Sadler, 2006). The implementation based on ABSL approach raise students' awareness, improve their conceptual understanding, and develop their opinions about understanding science and scientific knowledge (Günel, Omar, Grimberg & Hand, 2003).

The concept of argumentation has been described in different disciplines via different dimensions throughout the historical process. Argumentation, which is fundamentally based on the concept of debate reached back to the ancient philosophers and has come to the fore with the name "scientific debate", known as argumentation, today. Toulmin developed argumentation in 1958 and the "Toulmin model" has an important place in modern argumentation process. Toulmin argued that each component in the argumentation process (claim, grounds, warrant, qualifier, rebuttal, and backing) can be used for the interpretation and judgment of the data presented in a scientific debate from a broad perspective, including both creative and logical experimental and non-experimental calculations. The basis of the argumentation process is that students develop claims about scientific events and putting forward an idea about how and why these claims must be supported. In brief, argumentation process consists of pondering a question, examining raw data, forming a claim, test the claim, and reasoning along the way (Chen, 2020).

Argumentation can also be expressed as the process of argument interdependence and argument evaluation (Simon, Erduran & Osborne, 2006; Walton, 2006). Toulmin defined argument as the coordination of theories and evidence put forward to confirm, support or refute a decision or prediction (Toulmin, 1958). Thus, arguments could be considered as sets of interrelated components (Scheuer et al., 2010). Nielsen (2011) associates the situation between argumentation and argument as follows: while argumentation is an activity, the argument is a distilled product from this activity. That is, argumentation is a set of arguments used to explain something or to persuade people (Cambridge advanced learner's dictionary, 2013).

Science education based on argumentation is an area that has increasingly gained importance with different studies in the literature (Bogar, 2019; Choden & Kijkuakul, 2020; Evagorou, Nicolaou & Lymbouridou, 2020; Walker, Van Duzor & Lower, 2019; Yeşildağ-Hasançebi & Günel, 2013; Zhu et al., 2017). Many disciplines, including science education have revealed with many studies that argumentation-based science learning environments, which are the leading student-centred teaching methods, have an important effect on the permanence of learning and learning. In science, argumentation serves to reveal inconsistencies between claims and grounds (Berland & Hammer, 2012), and thus, it is used to determine the relationship between events and opinions rather than finding the winner, the loser, and the truest (Keçeci, Kırılmazkaya & Kırbağ-Zengin, 2011). Therefore, argumentation in science education has become an important research topic at the end of the twentieth century and construction of scientific arguments has become one of the aims of science education (Driver, Newton & Osborne, 2000). Thus, teaching science with scientific practices that include problem solving, confirmatory and supportive communication has been facilitated (Driver, Asoko, Leach, Mortimer & Scott, 1994).

There are studies which determine that ABSL approach has a positive effect on students' academic achievement (e.g., Greenbowe, Poock, Burke & Hand, 2007; Kana, 2013; Uluay, 2012). In addition to this, it is frequently emphasized that argumentation-based learning has positive effects regarding different perspectives such as high-order thinking skills (e.g., Hsieh, 2005; Kunsch, Schnarr & van Tyle, 2014; Lawson, 2003; von Aufschnaiter, Erduran, Osborne & Simon, 2008), students' argument skills (e.g., Chen & She, 2012; Fan, Wang & Wang, 2020; Knight & McNeill, 2015; Oh, 2004; Sampson, Grooms, & Walker, 2011; Torun, Açıkgül & Fırat, 2020), willings to debate skills (e.g., Arık, 2016; Kuhn, 1991; Zohar & Nemet, 2002), students' science literacy skills (e.g., Aslan, 2014; Tonus, 2012; Tümay, 2008), and social skills (e.g., Kuhn & Udell, 2003).

In Işıker and Emre (2021)'s study examined that argumentation-based instruction had a positive impact on academic achievements, attitudes towards the science course and scientific process skills of 4th grade primary school students. As to Kıngır (2011) demonstrated that the effect of ABSL approach on 9^{th} grade students' understanding levels of chemical concepts and their chemistry achievements in the units of Chemical Change (or Reaction) and Mixtures in comparison with the traditional chemistry teaching method. The results of the study determined that when compared to the traditional method, ABSL approach was more effective on 9^{th} grade students' understanding of chemical change (or reactions) and mixtures. Moreover, the study carried out by Kırbağ-Zengin, Kırılmazkaya and Keçeci (2012) with 7^{th} grade students was conducted via one-group pre-test post-test experimental design. In the study of elementary school students' learning the socio-scientific issue of nuclear energy with online argumentation method, the aim was to measure and increase the awareness of students about the risks and benefits of nuclear power plants and to improve their sensitivity to the environment. As a result of the study, it was determined that there was a significant difference between the pre-test and post-test results of the students.

The point that science has reached and the emerging needs have brought about the search for new pedagogies (Hung, 2015). The studies revealed that there were many benefits of using the ABSL approach in learning environments. According to MEB (2018); In the learning environments based on the student in the Science Curriculum; It is envisaged that the lessons will be carried out with problem, project, argumentation, cooperative learning. The learning process includes exploring, questioning, making arguments, and designing products. In addition, by expressing themselves in writing, verbally and visually; It is expected that opportunities will be provided that enable the development of communication and innovative thinking skills. It is envisaged to provide environments where students can discuss the benefit-harm relationship towards scientific phenomena so that they can freely express their ideas, support their thoughts with different justifications, and develop opposing arguments to refute the claims of their friends (MEB, 2018). There is a need for longer-term use of the ABSL approach, which is a current issue in national and international literature. At this point this study is important in terms of the use of ABSL which is a rare situation in the literature, in both physics, chemistry and biology units and their association. Thus, in the same study, the interactive examination of ABSL which is applied in all science fields between units constitutes the original and functional aspect of the study. In addition, considering the studies carried out in literature, it was found that ABSL approach was not supported with different writing genres but usually supported with reports (e.g., Arlı, 2014; Demirbağ & Günel, 2014; Kabataş-Memiş, 2011; Kana, 2013; Yeşildağ-Hasançebi & Günel, 2013). It is considered that the integration of ABSL with writing to learn activities and the design and development authentic activities in line with the learning outcomes will make contributions to the literature. The purpose of this study which aims at filling all these gaps and bringing innovations to the literature is to examine whether there is a difference among the units "Animal and Plant Reproduction", "Matter and Heat", and "Electrical Conduction" considering the effects of ABSL approach supported with brochures, ABSL approach supported with reports, and existing curriculum on science achievement.

METHOD

The information about the research design, participants, examining the equivalence of experimental and control groups, the role of the researcher, data collection tools, research process, and data analysis was given under this title.

Research Design

In this study, quasi-experimental research design, one of the experimental research designs was preferred. In experimental research, it can be argued that any difference in the variable is due to the experimental procedure (Keppel & Wickens, 2003). In the study, quasi-experimental design with pre-test post-test control group was used. In the quasi-experimental method used in the research, "Academic Science Achievement Test" (ASAT) was administered to two experimental and one control group students as a pre-test and a post-test for each unit of biology, chemistry, and physics (Reproduction, Growth, Development in Plants and Animals, ASAT1; Matter and Heat, ASAT2 and Electrical Conduction ASAT3). 19 activities in accordance with ABSL approach were developed for the experimental groups. In the research, the ABSL method was administered with the experimental group 1 with preparing a brochure and the experimental group 2 with report writing. On the other hand, the control group was taught with the activities and methods included in the Science Course Teacher's Guide and the existing curriculum. The research design was presented in Table 1.

Table 1: Research Design

Study Group	Pre-test	Method	Post-test
Experimental Group 1	Academic Science Achievement Test (I-II-III)	Teaching with ABSL Approach (Preparing a brochure)	Academic Science Achievement Test (I-II-III)
Experimental Group 2	Academic Science Achievement Test (I-II-III)	Teaching with ABSL Approach (Using reports)	Academic Science Achievement Test (I-II-III)
Control Group	Academic Science Achievement Test (I-II-III)	Teaching in accordance with the existing curriculum	Academic Science Achievement Test (I-II-III)

Participants

The sample of the research consists of 55 students in the 6th grade of a state school. Among the 6th grades having the same academic achievement level and with moderate level of achievement, two classes were assigned objectively as experimental groups (Experimental Group 1, EG1; Female: 7, Male:11) (Experimental Group 2, EG2; Female: 9 Male:10) and one class was assigned objectively as a control group (Control Group, CG; Female:6, Male:12). In the research, while ABSL method was carried out by preparing brochures for application group 1 (EG1) and ABSL method was carried out by preparing reports for application group 2 (EG2); in the control group (CG), the activities and methods in the Science Lesson Teacher's Guide book and the courses in accordance with the current curriculum were taught. "Typical case sampling" was used in the study. Here, among a series of phenomena in which the implementation is made and there is innovation, it is possible to work by choosing one or more typical ones. The main purpose is to have an idea about a particular area by studying what is average or usual and then share this phenomenon (Patton, 2014; Yıldırım & Şimşek, 2011).

Examining the equivalence of experimental and control groups

Examining the equivalence of experimental and control groups, students' "5th grade science mean scores" were discussed as a criterion. One-way Anova test was administered for statistical analysis; as a result of this, it was found that there was not a significant difference between the mean scores of the students in EG1, EG2, and CG from the 6 written exams administered in the 5th grade science course *($F_{(2,52)}$=0.22, p= .80).* Examining the equivalence of experimental and control groups, another criterion considered is to analyse the pre-test results of ASATs administered to students. Academic science achievement test (ASAT) was administered to experimental and control groups as pre-test for each one of the units. It was found that there was not a significant difference between the pre-test scores (ASAT1-pre $F_{(2,52)}$=0.20, p= .82; ASAT2-pre $F_{(2,52)}$=.40, p= 0.67; ASAT3-re $F_{(2,52)}$=1.47, p=.24). These results reveal that both control and experimental students are like one another in terms of readiness to science course before the study.

Researcher's Role

The researcher in the study paid attention to be objective in the administration of each stage and carried out the process herself. Against the danger of restricting the ecological external validity with the researcher being in the process (McMillan & Schumacher, 2014), the researcher attended the classes with another instructor working on the same subject, and the instructor took notes as an observer. In addition, the events that the researcher experienced and observed throughout the process were recorded daily by the researcher.

Data Collection Tools

Five different data collection tools were used in the study. These include the following: the academic science achievement test prepared for each unit, the brochures and reports prepared by the students for the ABSL implementation for the experimental groups.

Academic Science Achievement Test (ASAT) and Reliability and Validity of ASAT

Academic achievement tests are the data collection tools mostly used to measure the dependent variable in experimental studies (Fraenkel et al., 2012). Academic science achievement test (ASAT) was applied to the experimental and control groups as pre-test and post-test. Before starting the study, informal interviews were carried out with the teachers to determine which concepts, facts, and events they touched on in the units and the subjects the students had difficulty in understanding. ASAT was developed by thoroughly reviewing the literature within the framework of these interviews for each unit in the study and by reviewing all science questions developed by the researcher and published by the Ministry of National Education as well as all science books available in the market. For the content validity of the questions, a table of specifications was developed by considering the learning outcomes in the units. In addition, the questions prepared within the framework of the learning outcomes in the units were developed by considering the Bloom's taxonomy of cognitive domain levels. The draft ASATs prepared were submitted to expert opinions and necessary corrections were made. After the corrections made, the draft ASAT was administered to 180 6th grade students studying in two different secondary schools. Considering the factors such as expert feedback, the status of similar questions measuring the same outcome, and the results of item analysis procedures, ASAT was finalized with 20 multiple choice standard items in each unit.

If the item difficulty index ranges 0, it means that the item is difficult, and if it ranges 1, that item is easy (Tekin, 2000). For all three units, the questions were found to be close to 50, that is, moderate difficulty. Accordingly, the item difficulty index of the items in the tests meets the desired situation. Item discrimination index refers to the ability of an item to differentiate among individuals based on how well they know the material tested. It is stated that if the item discrimination index value is below 0.30, then these items should be removed from the scale (Büyüköztürk, 2012). It was also found that the items for all three units consisted of values above .30 and around .50. The result here is that the test differentiates different success levels, that is, it meets the desired condition.

Since ASAT consisted of two parts, multiple choice and open-ended, the reliability coefficients were calculated separately. The reliability coefficient for the multiple-choice questions of ASATs was calculated using KR-20 and the coefficient was .81 for the unit "Reproduction, growth and development in plants and animals"; .84 for the unit "Matter and Heat" and .79 for the unit "Electrical Conduction", respectively. A KR-20 reliability coefficient of .70 and above is required for educational studies (Fraenkel et al., 2012). In reliability analysis for open-ended questions, (0, 1, 2, 3, 4, 5) was measures considered as valuable. For these values, the researcher prepared answer keys for open-ended questions and detailed scoring was performed. An expert opinion was taken for scoring and answer key from the expert who works in Science Education Department. Necessary corrections were made within the framework of the suggested feedback. To ensure the scorer reliability, 10 randomly selected papers were evaluated by an instructor and a researcher working in the Science Education Department. Two raters independently created a data set by answering 8 open-ended questions for each unit. To calculate the reliability coefficient, the following formula was used: Reliability = Total number of agreements + disagreements (Miles & Huberman, 2016). The scoring of the researcher and the lecturer (2 raters) were compared, and the agreement was over 70% for each unit. Cronbach alpha was used in the reliability analysis of the multi-valued (0, 1, 2…) items (Büyüköztürk, 2012). Cronbach alpha value was found to be high in open-ended questions for each unit. In the last case, the Cronbach alpha values were respectively .80 for the unit

"Reproduction, growth and development in plants and animals, .87 for the "Matter and Heat unit, and .84 for the unit "Electrical Conduction". The scale is considered reliable when the Cronbach alpha value is .70 and above (Creswell, 2012).
Thus, the finalized ASATs were evaluated over 100 points in total, that is, multiple-choice with 20 questions worth 3 points each, and 8 open-ended questions worth 5 points each.

Brochure
The brochure report was filled in by EG1 at the end of the activities. In the brochure, the students are asked to answer the following sections: my question, my preliminary opinions, what I have done, what I found, my claims, my arguments, how to compare my opinions with the others' opinions, preliminary opinion-finding-evidence, question-claim-evidence and reflections. When the brochure report was given to EG1 students, they were informed about how to fill in the report both verbally and with instructions distributed to them.

Report
The report was filled in by EG2 at the end of the activities. Instead of traditional laboratory reports, in research and inquiry-based ABSL activities, the report format, which is a kind of writing to learn activity, was used. This report was developed by Keys, Hand, Prain & Collins (1999). This report form consists of the following sections: my question, my preliminary opinions, what I have done, what I found, my claims, my arguments, how to compare my opinions with the others' opinions, preliminary opinion-finding-evidence, question-claim-evidence and reflections. The report was assigned as homework to the students in EG2 and they were informed about how to fill in the report both verbally and with instructions distributed to them.

Activities
While preparing the activities, the learning outcomes of science curriculum published by the Ministry of National Education were taken into consideration. Considering each unit's learning outcomes, a total of 19 activities were developed including 5 activities from the unit reproduction, growth and development in plants and animals, 7 activities from the unit matter and heat unit and 7 activities from the unit electrical conduction. The activities were prepared using variety of resources such as 6th grade coursebooks, scientific journals, articles, daily events, science teachers, and the internet. The activities were presented to the opinion of two teaching staffs in science and three experienced science teachers who are experts in their fields and after making necessary corrections with the feedback from the experts, they were finalized by making corrections with the needful feedback. Examples of activities for each unit are given in Figure 1, Figure 2, Figure 3.

Research Process
Implementation Process
Implementation consisted of three stages: preliminary preparations before implementation, pilot implementation and actual implementation. The summary of preliminary preparations were presented in Figure 4.

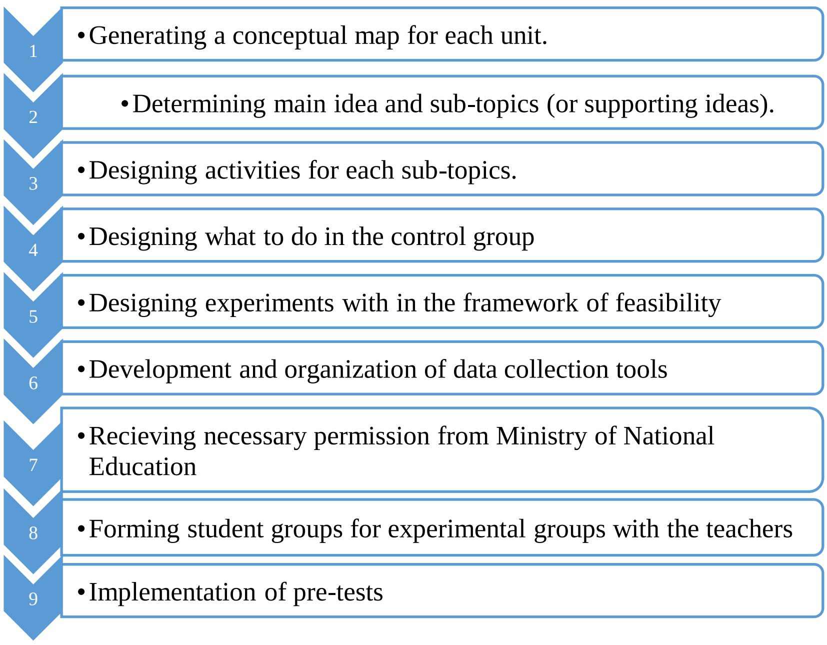

Fig.4: Preparations before the Implementation

Pilot Implementation

Before the implementation within the context of preliminary preparations, the piloting was carried out with the 6th graders in a different school before the actual implementation. It was planned that the pilot study was administered in this school with the units chosen for the actual implementation. The only difference is that a sampling different from the sampling of the actual implementation was chosen. After getting necessary permission from the school administration for the pilot study, the teacher who would carry out the pilot study was decided. The implementer teacher was someone who has master's degree in educational sciences and knows ABSL method. The pilot study is an essential trial stage to test activities and implementations before the main study.

Actual Implementation

The actual implementation of the study was carried out with 55 students studying in three different classrooms in a middle school in Yakutiye district of Erzurum, Turkey. The actual implementation was 4 lesson hours per week and lasted 13 weeks to complete. While lessons were executed via ABSL approach in the experimental groups, lessons in the control group were conducted with the existing (traditional) teaching method. The implementation stages of ABSL were the same with EG1 and EG2. The only difference between them was the writing genre that supports ABSL at the end of the implementation.

Experimental groups course process

In EG1 and EG2, the researcher got prepared before attending the lesson considering such things as creating a concept, determining the main and sub-points of the unit, and developing activities for each sub-opinion and thus provided the groundwork for students to establish a question-claim-evidence triangle and form arguments with their active participation. A total of 19 activities developed for all units within the framework of the ABSL approach were implemented sequentially. While one activity was performed for some learning outcomes, two activities were done with some of the learning outcomes.

Each activity was done between 2 and 4 lessons hours. All groups in EG1 (6 groups) and EG2 (6 groups) discussed their preliminary ideas for each activity as a class and among themselves (in the presence of classmates and each group among themselves). As a result of the discussions, they determined the variables and formed the research questions using these variables. After EG1 and EG2 students determined the questions they wanted to investigate about the activity, each group wrote their questions on the board with the joint decision of all group members. Each group's questions were revised with the researcher (teacher) and classmates so that they could be clear and understandable. Since the research questions of the groups were preferred to be different from each other, the choices were made by considering the alternative questions of the groups. In addition, attention was paid not to shift the questions from the axis of sub-idea and main idea. Until the next lesson, the students conducted research from the sources (textbook, supplementary books, journals, internet) under the supervision of the researcher to find the answers to the questions, collected data with observations, and conducted experiments when necessary. The students always consulted the researcher while collecting the data; the researcher always involved in the process. In addition, the researcher participated in the discussion between the students by asking what they found and what they thought.

Students had small group discussions until the next lesson with the data they gathered through experiments, observations, and research. At the end of this, they made a claim that would answer the questions they investigated from the data in the form of experiments, observations, and research during the claim stage. Later, the students provided evidence to support their claims. These proofs they put forward are based on the results of the data they obtained from their experiments. The groups checked the research questions, the claims they made in response to these questions, the evidence they put forward to support these claims, and the accuracy of their explanations by conducting resource searches under the supervision of the researcher. They benefited from the textbooks, supplementary resources, and internet outputs. In the next lesson, each group went to the board one by one and tried to persuade their other classmates of the accuracy of their research questions, claims, and evidence through discussions in the classroom under the guidance of the researcher; thus, they held a large group discussion. Discussion took shape with the questions of other students in the class. The researcher also participated in the discussion and ensured the realization of the subject in the axis of sub-point and main point and thus contributed to the formation of student-student interaction. In addition, the teacher tried to attract attention by intervening secretly to the missing points during the discussion.

Throughout the process, EG1 students completed the brochures by keeping them individually. Throughout the process, EG2 students completed the reports individually. As a result, in the EG1 and EG2 classrooms, the researcher (teacher) determined the main idea of the activity throughout the implementations, the students formed arguments in the question-claim-evidence triangle, did activities by sticking to the sub-point and main point and discussions were made by collecting data with experiments and observations. Thus, they completed their brochures and reports.

Control group course process.

In the control group, the units of “Reproduction, Growth, Development in Plants and Animals", “Matter and Heat” and “Electrical Conduction” were studied in accordance with the current curriculum. More than one method and technique were used in each course. During the lessons, the students were made to take short notes about the subject by the teacher. After lecturing of the subject was completed, the students were asked if there was anything they did not understand about the subject and the necessary explanations were made. At the end of the lesson, the questions were solved, and they were asked to write a summary of the topic.

Data Analysis

In this part of the research, there is information about the techniques used in the analysis of data obtained from the data collection tools.

- Frequency (f) and percentages (%) were used for the statistics related to the demographic characteristics of students in the experimental and control groups in the study,
- Mixed Between-Within Subjects ANOVA is used to determine whether or not there is any difference between experimental and control groups in terms of academic science achievement the and to compare the differences between them.

RESULTS AND DISCUSSION

In this study, in order to determine the 6th grade students’ academic achievement with ABSL instruction, one academic science achievement test for each unit of “Reproduction, Growth, Development in Plants and Animals”, “Matter and Heat” and “Electrical Conduction” (ASAT 1, ASAT 2, ASAT 3) was implemented as pre-test and post-test to the students in the experimental and control groups.

Accordingly, with the intention of determining whether or not instruction with ABSL has a significant effect on students’ academic achievement, mixed between-within subjects analysis of variance (Mixed Between-Within Subject ANOVA) test results for each unit were included in order to observe the development depending on time within the groups, to see the differences between the groups, to test whether or not the interaction between two independent variables is significant, and to reduce the growing error with separate analyses.

Descriptive Data related to the Academic Science Achievement Tests (ASAT 1- ASAT 2- ASAT 3)

Academic science achievement test given as pre-test and post-test to the students in the experimental and control groups in the study was implemented with the units of “Reproduction, Growth, Development in Plants and Animals” (ASAT1), “Matter and Heat” (ASAT2), and “Electrical Conduction” (ASAT3). A total score obtained from each ASAT is 100. The pre-test and post-test findings of each unit of each of the three groups are presented in Table 2.

Table 2: ASAT’s Average and Standard Deviation Values

Değişkenler	Groups	N	$\overline{X}$	sd.
ASAT 1 Pre-Test	EG1	18	12.50	6.913
	EG2	19	13.42	6.02
	CG	18	12.22	4.91
	Total	55	12.72	5.91
ASAT 1 Post-Test	EG1	18	55.38	18.69
	EG2	19	48.78	18.76
	CG	18	38.94	18.70
	Total	55	47.72	19.57
ASAT 2 Pre-Test	EG1	18	17.50	6.91
	EG2	19	18.15	4.47
	CG	18	19.16	5.21
	Total	55	18.27	5.54
ASAT 2 Post-Test	EG1	18	51.11	15.98
	EG2	19	48.47	16.93
	CG	18	61.88	19.48
	Total	55	53.72	18.16
ASAT 3 Pre-Test	EG1	18	13.05	5.72
	EG2	19	16.31	6.63
	CG	18	13.33	6.85
	Total	55	14.27	6.48
ASAT 3 Post-Test	EG1	18	64.66	21.33
	EG2	19	62.94	18.57

	CG	18	47.55	24.67
	Total	55	58.12	22.51

As presented in Table 2, while ASAT 1 pre-test total mean score was $\overline{X}$ =12.72 (*SS=5.91*), this value was $\overline{X}$ =47.72 (*SS=19.57*) in the post-test. While ASAT 2 pre-test total mean score was $\overline{X}$ =18.27 (*SS=5.54*), this value in the post-test was $\overline{X}$ =53.72 (*SS=18.16*), and finally while ASAT 3 pre-test total mean score was $\overline{X}$ =14.27 (*SS=6.48*), this score in the post-test became $\overline{X}$ =58.12 (*SS=22.51*). According to this, it was observed that after the in all group implementations of the units "Reproduction, Growth, Development in Plants and Animals", "Matter and Heat" and "Electrical Conduction", there was an increase with the academic achievement levels.
The experimental group students' post-test mean scores from the unit "Reproduction, Growth, Development in Plants and Animals" EG1 ($\overline{X}$ *=55.38, SS=18.69*) and EG2 *(* $\overline{X}$ *=48.78, SS=18.76)* were higher than the mean scores the students in CG got from the ASAT *(* $\overline{X}$ *=38.94, SS=18.70)*. Moreover, it was reported that the experimental group students' post-test mean scores from the unit "Electrical Conduction" EG1 *(* $\overline{X}$ *=64.66, SS=21.33)* and EG2 *(* $\overline{X}$ *=62.94, SS=18.57)* were higher than the mean scores the students in CG got from the ASAT CG *(* $\overline{X}$ *=47.55, SS=24.67)*.

Assumptions of Mixed Between-Within-Subject Analysis of Variance
In the study, in order to determine the effect of instruction with ABSL on academic achievement, mixed between-within subject analysis of variance test was applied. All assumptions were provided for mixed between-within subject analysis of variance. As the first assumption, the univariate normality of the distribution of variables related to the achievement scale was revealed by examining the skewness and kurtosis values. Cooper-Cutting (2010) stated that a skewness value of ± 2 in a data set is acceptable for normal distribution. In the study, it was determined that the variables took values between the determined values and showed normal distribution (skewness: 0.34 for ASAT 1, kurtosis: -0.30; skewness: 0.17 for ASAT 2, kurtosis: -1.34 for ASAT 3: -0.28, kurtosis: 0.06). Thus, the assumption of normality required for the analysis was provided. The homogeneity of group variances was examined as another assumption. Levene's test was used for homogeneity of group variances. It was found that the group variance of the variables was equal (p>0.05). Thus, it was determined that this assumption was met. Then, Mauchly's Test of Sphericity was performed to understand whether or not the assumption of sphericity is violated (Gamst, Meyers & Guarino, 2008) and this result revealed that the assumption of sphericity was met (p=0.57 for ASAT1, p=0.61 for ASAT 2 , p=0.55 for ASAT 2 ; p>0.05).

Results of Mixed Between-Within-Subject Analysis of Variance
Mixed between-within-subject analysis of variance for the unit of reproduction, growth, development in plants and animals
ASAT1 was administered to three groups as pre-test and post-test for the unit "Reproduction, Growth, Development in Plants and Animals". Mixed between -within subject analysis of variance was used for the pre-test and post-test data of three groups. All assumptions were provided for this. The findings of mixed between -within-subject analysis of variance were presented in Table 3.

Table 3: Analysis of Variance Findings Between-Within Mixed Groups

Effect	Wilks' Lambda	F	SD	p	Effect Size
Group	0.86	27.42	2	0.02	0.08
Time	0.83	59.94	2	0.01	0.13
Group*Time	0.94	3.26	4	0.39	0.03

α =0.05
First, the Sphericity Assumption result was examined to understand whether or not there was a significant interaction between groups and time; it was found that there was no significant interaction between the group and time *($F_{(4,104)}$=3.26, p= .39)* (Table 3). Figure 5 exhibits that there is no interaction between EG1, EG2 and CG.

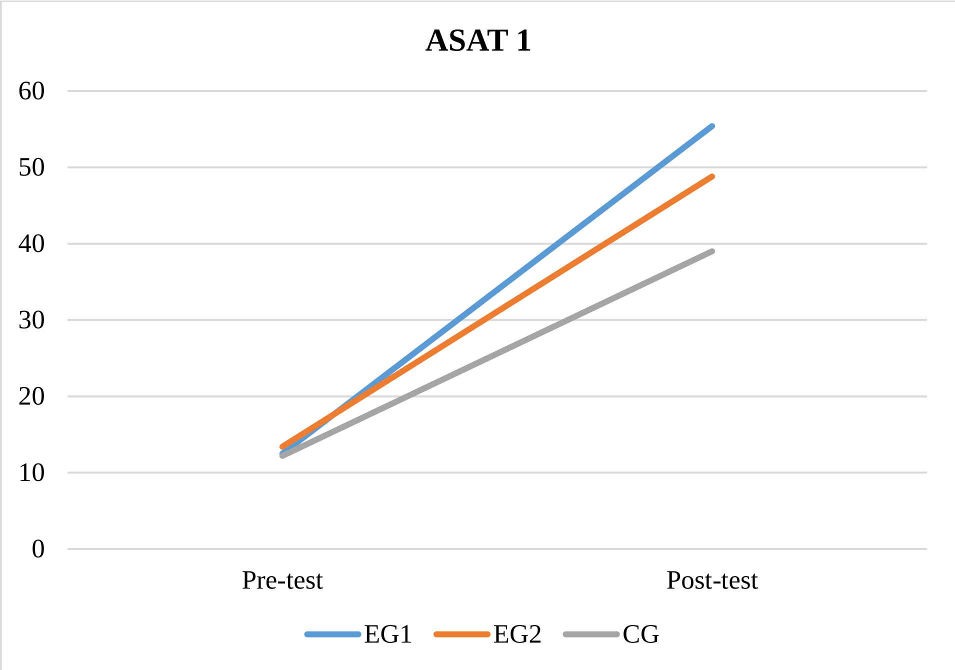

Fig.5: Pre-test and post-test achievement mean scores of EG1, EG2 and CG in ASAT1

Then, the p value of Sphericity Assumption was checked to determine whether or not there was a statistical difference depending on time between the groups. According to the Mixed Variance Analysis performed, it was observed that there was a significant difference between the groups according to time (F (2,52) = 59.94, p = .02) (Table 3). The effect size of this significant difference has a medium effect with 0.08 (Cohen, 1988). Cohen suggested that 0.01 is considered a small effect size, 0.06 represents a medium effect size and 0.14 a large effect size (Pallant, 2016)

Bonferroni test was used to determine between which groups there was a significant difference. Bonferroni test results between the groups were given in Table 4. According to the Bonferroni test, there is a significant difference between EG1 and CG in favour of EG1 (p = 0.04) considering AFBT 1 post-test; however, there was no significant difference between EG2 and CG (p = 0.12) and between EG1 and EG2 (p = 0.76) (Table 4).

Table 4: Time-dependent Bonferroni Test Results Between Group in ASAT1

Time/Group	Groups (I)/Times(J)	Groups (I)/Times(J)	Mean Difference(I-J)	Standard Error	Significance level
	EG1	CG	0.38	0.76	0.62
		EG2	-0.92	0.72	1.00
	EG2	EG1	0.92	0.72	1.00
Pre-test		CG	1.2	0.72	1.00
	CG	EG1	-0.38	0.76	0.62
		EG2	-1.2	0.72	1.00
	EG1	CG	16.39	0.83	0.04
		EG2	6.6	0.41	0.76
	EG2	EG1	-6.6	0.41	0.76
Post-test		CG	9.79	0.55	0.12
	CG	EG1	-16.39	0.83	0.04
		EG2	-9.79	0.55	0.12

Finally, the p value of Sphericity Assumption was examined to determine whether or not there was a statistical difference depending on time within the groups. It was observed that there was a significant difference in terms of time within the group (F (2,104) = 59.94, p = 0.01). The effect size of this significant difference has a medium effect with 0.13. (Table 3)

The Bonferroni test was used to determine when the significant difference occurred with respect to time. Time-dependent Bonferroni test results within the group were presented in Table 5. According to the Bonferroni test within the groups, while there was a significant difference in favour of the post-test between the pre-test and the post-test with respect to time in EG1 (p = 0.00) and EG2 (p = 0.00), there was no significant difference between the pre-test and post-test in CG (p = 0.09) (Table 5).

Table 5: Time-dependent Bonferroni Test Results Within Group in ASAT1

Time/Group	Groups (I)/Times(J)	Groups (I)/Times(J)	Mean Difference(I-J)	Standard Error	Significance level
EG1	Pre-test	Post-test	-42.89	0.42	0.00
EG2	Pre-test	Post-test	-35.37	0.60	0.00
CG	Pre-test	Post-test	-26.72	0.54	0.09

Mixed between-within-subject analysis of variance for the unit of matter and heat
ASAT2 was administered to three groups as pre-test and post-test for the unit "Matter and Heat". Mixed between -within-subject analysis of variance was used the pre-test and post-test data of three groups. All assumptions were provided for this. The findings of mixed between -within-subject analysis of variance were presented in Table 6.

Table 6: Analysis of Variance Findings Between-Within Mixed Groups

Effect	Wilks' Lambda	F	SD	p	Effect Size
Group	0.86	42.17	2	0.06	0.04
Time	0.84	51.23	2	0.02	0.12
Group*Time	0.92	7.42	2	0.28	0.03

α =0.05
First, the Sphericity Assumption result was examined to understand whether or not there was a significant interaction between groups and time and it was found that there was no significant interaction between the group and time *($F_{(4,104)}=7.42$, $p=0.28$)* (Table 6). Figure 6 exhibits that there is no interaction between EG1, EG2 and CG.

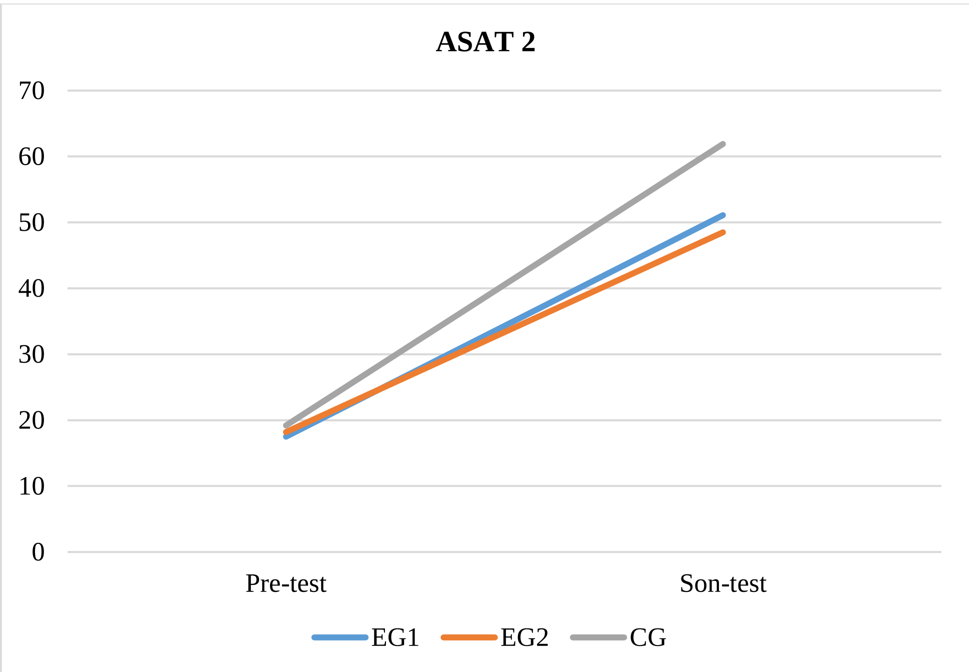

Fig.6: Pre-test and post-test achievement mean scores of EG1, EG2 and CG in ASAT2

Then, the p value of Sphericity Assumption was checked to determine whether there was a statistical difference depending on time between the groups. According to the Mixed Analysis of Variance, it was observed that there was not a significant difference between the groups depending on time *($F_{(2,52)}$=42.17, p= .06)* (Table 6). The Bonferroni test was not administered, because there was no difference.

Finally, the p value of Sphericity Assumption was examined to determine whether there was a statistical difference depending on time within the groups. It was observed that there was a significant difference in terms of time within the group *($F_{(2,104)}$=51.23, p= .02)*. The effect size of this significant difference has a medium effect with 0.12 (Table 6).

The Bonferroni test was used to determine when the significant difference occurred with respect to time. Time-dependent Bonferroni test results within the group were presented in Table 7. According to the Bonferroni test within the groups, there was a significant difference in favour of the post-test between the pre-test and the post-test with respect to time for all groups (p=0.00 for EG1, p=0.00 for EG2 and p=0.00 for CG) (Table 7)

Table 7: Time-dependent Bonferroni Test Results Within Group in ASAT2

Time/Group	Groups (I)/Times(J)	Groups (I)/Times(J)	Mean Difference(I-J)	Standard Error	Significance level
EG1	Pre-test	Post-test	-33.61	0.21	0.00
EG2	Pre-test	Post-test	-30.32	0.21	0.00
CG	Pre-test	Post-test	-42.71	0.29	0.00

Mixed between-within-subject analysis of variance for the unit of Electrical Conduction.

ASAT2 was administered to three groups as pre-test and post-test for the unit "Electrical Conduction". Mixed between -within-subject analysis of variance was used for three groups' pre-test and post-test data. All assumptions were met for this. The findings of mixed between -within-subject analysis of variance were presented in Table 8.

Table 8: Analysis of Variance Findings Between-Within Mixed Groups

Effect	Wilks' Lambda	F	SD	p	Effect Size
Group	0.72	26.18	2	0.01	0.17
Time	0.75	37.12	2	0.00	0.53
Group*Time	0.89	5.18	4	0.21	0.08

First, the Sphericity Assumption result was examined to understand whether or not there was a significant interaction between groups and time and it was found that there was no significant interaction between the groups and time *($F_{(4,104)}$=5.18, p= .21* (Table 8). Figure 7 exhibits that there is no interaction between EG1, EG2 and CG.

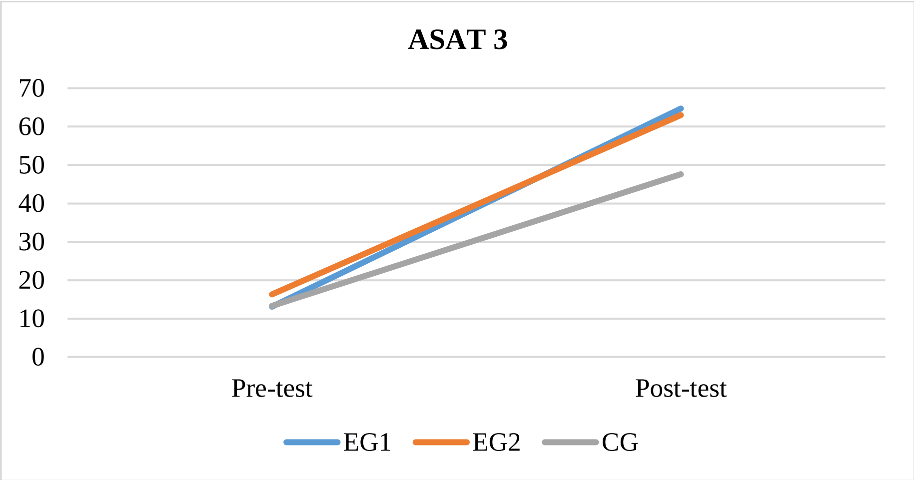

Fig.7: Pre-test and post-test achievement mean scores of EG1, EG2 and CG in ASAT3

Then, the p value of Sphericity Assumption was checked to determine whether there was a statistical difference depending on time between the groups. According to the Mixed Analysis of Variance performed, it was found

that there was a significant difference between the groups depending on time *($F_{(2,52)}$=26.18, p= .01)* (Table 8). The effect size of this significant difference has a high effect with 0.17.
Bonferroni test was used to determine between which groups there was a significant difference. Bonferroni test results between the groups were given in Table 9. According to the Bonferroni test, there is a significant difference between EG1 and CG in favour of EG1 (p = 0.00); however, there was no significant difference between EG1 and EG2 (p = 0.11) (Table 9).

Table 9: Time- Dependent Bonferroni Test Results Between Groups in ASAT3

Time/Group	Groups (I)/Times(J)	Groups (I)/Times(J)	Mean Difference(I-J)	Standard Error	Significance level
	EG1	CG	-0.27	0.56	0.74
		EG2	-3.26	0.71	0.52
	EG2	EG1	3.26	0.71	0.52
Pre-test		CG	2.99	0.68	0.60
	CG	EG1	0.27	0.56	0.74
		EG2	-2.99	0.68	0.60
	EG1	CG	17.11	0.26	0.00
		EG2	1.72	0.22	0.74
	EG2	EG1	-1.72	0.22	0.74
Post-test		CG	15.39	0.21	0.04
	CG	EG1	17.11	0.26	0.00
		EG2	-15.39	0.21	0.04

Finally, the p value of Sphericity Assumption was examined to determine whether or not there was a statistical difference depending on time within the groups. It was observed that there was a significant difference in terms of time within the group *($F_{(2,104)}$=37.12, p= .00)* (Table 8). The effect size of this significant difference has a large effect with 0.53.
The Bonferroni test was used to determine when the significant difference occurred with respect to time. Time-dependent Bonferroni test results within the group were presented in Table 10. According to the Bonferroni test within the groups, there was a significant difference in favour of the post-test between the pre-test and the post-test with respect to time for all groups (p=0.00 for EG1, p=0.00 for EG2 and p=0.00 for CG) (Table 10).

Table 10: Time-dependent Bonferroni Test Results Within Group in ASAT3

Time/Group	Groups (I)/Times(J)	Groups (I)/Times(J)	Mean Difference(I-J)	Standard Error	Significance level
EG1	Pre-test	Post-test	-51.61	0.32	0.00
EG2	Pre-test	Post-test	-46.63	0.36	0.00
CG	Pre-test	Post-test	-34.23	0.27	0.00

CONCLUSION

In this study, no significant difference was found between the groups according to the pre-test results performed at the beginning of each unit. The absence of a significant difference between the pre-test scores is important for students to start the implementation under equal conditions.
First of all, according to the post-test results performed at the end of the unit “Reproduction, Growth and Development in Plants and Animals”, there was no significant difference between EG1 and EG2 and EG2 and CG in the students’ science achievement in this unit while a significant difference between EG1 and CG was in favour of EG1. Although ABSL was applied in both experimental groups, EG1 completed their reports by writing a brochure and EG2 completed by writing a report. In other words, it can be said that the reason why there is a difference in one of the experimental groups and but not in the other one is due to the type of writing, that is, the effect of the brochure. This situation can be explained with the fact that the brochure is a semi-structured writing activity, whereas the report is a relatively more structured type of report. As a matter of fact, in the study conducted by Hasançebi (2014), there was not significant difference between the experimental

group and control group, both of which completed the ABSL implementation in the middle school level biology unit (human and environment) by writing a report (the same report format used in the study) in terms of science achievement and this result shows parallelism with the research result. Knowing that the first page of the brochure should convey an effective message, the students prepared the brochure as attractive as possible. Especially, the brochure, which tries to bring visual elements to the foreground due to its structure is thought to have eliminated the problem of rendering biology less visual, which is considered to be one of the reasons of failure (Kırpık & Engin, 2009) Since the biology lesson is considered as a verbal lesson (Kırpık & Engin, 2009), the information that students will write is expected to have richer content and thus, brochure writing serves this purpose due to its format. In addition, information in the field of biology is mostly invisible abstract information (Ekici, 2016). Concretizing the concepts of biology could be made possible by brochure writing in which students will be able to work with different types of representations (graphics, tables, figures, pictures). Indeed, Koçak and Seven (2016) concluded in their study that the brochure increased visuality. In addition, it has been revealed that different types of representations could be used both as arguments and evidence in the construction of argumentation process (Namdar & Shen, 2016). Therefore, it can be said that students increase their interest in biology lesson and provide meaningful learning by structuring them in their minds instead of memorizing the concepts (Saygın, Atılboz & Salman, 2006) by brochure writing.

According to the results of the post-test conducted at the end of the second ABSL implementation in chemistry unit “Matter and Heat” with the students, no significant difference was found between the experimental groups and the control group in students’ science achievement in this unit. When the reason for this situation was explored, it was understood from the brochures and reports that the students could not find enough claims about this issue. In addition, thanks to student-teacher communication, students stated that the easiest unit in the discussions was the “Matter and Heat” unit, and that there was not much to discuss when compared to other units. Generally, the most intense communication is experienced between students and teachers in classrooms (Demiray, 2012). Thus, it is possible to carry out situation analysis through student-teacher communication. Although this result in the research contradicts with the fact that there is a significant difference in favour of the experimental group between the experimental and control groups that perform ABSL implementations in the “Matter and Heat” unit, the result is in line with the findings that there is not significant difference between the experimental groups and control groups during the ABSL implementations (Kabataş-Memiş, 2011; Okumuş, 2012); Acar et al. (2016), Tola (2016) in “Matter and Heat” unit and Çınar (2013) in the “Change and Recognition of Matter” unit.

The last ABSL implementation carried out with the students was the physics unit “Electrical Conduction”. According to the post-test results at the end of the unit, the significant difference was in favour of experimental groups regarding students’ science achievement in this unit. It was determined that both EG1 and EG2 were academically more successful than CG in the unit of “Electrical Conduction”. The fact that the experimental groups’ performance in ABSL activities was more successful than the control group reveals the positive effect of ABSL activities on academic achievement. In addition, it can be said that writing to learn activities used together with ABSL activities have a positive effect because the written products created by the students are completely individual efforts and they are not pieces of writing which are directly quoted from the board or book (Choi, Notebaert, Diaz & Hand, 2010). This situation reveals that ABSL implementations increase academic achievement for the physics unit. There are many studies in the literature that support this situation (Akkuş Günel & Hand, 2007; Aktaş, 2017; Doğru, 2016; Driver *et al.*, 2000; Gençdoğan, 2017; Gültepe, Çelik & Kılıç, 2010; Günel & Tanrıverdi, 2012; Hand, Prain & Wallace, 2002; Hohenshell & Hand, 2006; Kaya & Kılıç, 2008; Kıngır, 2011; Okumuş, 2012; Ulu & Bayram, 2015).

Recommendations

It was found in the study that the unit in which the difference regarding ABSL implementations occurred in terms of science achievement on group basis was the physics unit. This situation can be explained by the study in which Namdar and Tuskan (2018) took opinions of science teachers about argumentation. According to the findings of the study, the teachers stated that the argumentation was the most suitable for physics subjects. The reason why physics topics are considered the most suitable for argumentation is that physics is the area where individuals establish the connection mostly between science and life, and it is due to the fact that physics issues are more consistent with everyday life (Ayaz & Söylemez, 2015; Bağ & Çalık, 2017; Namdar & Tuskan, 2018).

Some suggestions are made based on result of the research. It was found that ABSL provided effective and efficient learning in science lessons, especially in the physics unit. Since both the opinions of science teachers at the secondary school level and the studies carried out in the literature reveal that because physics subjects are the most closely related to everyday life (Ayaz & Söylemez, 2015), they are the most suitable for argumentation (Bağ & Çalık, 2017; Namdar & Tuskan, 2018). For this reason, it is recommended that ABSL practitioners who will design ABSL activities in different science disciplines should develop them mostly in relation to everyday life. In addition, the writing process was completed in one of the experimental groups by using a brochure, one of the writing to learn activities. Different writing to learn activities such as writing letters, writing poems, keeping a journal (or diary) and preparing posters were studied in the literature (Bozat, 2014; Yeşildağ, 2009). However, it was found that ABSL implementations were only conducted with report writing but with no other forms of writing to learn activities (letter, poem, poster, diary, story). In future research, different writing to learn activities can be integrated with ABSL and thus, new studies can be conducted.

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