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Improvement of Students' Scientific Epistemological Beliefs and Metacognitive Awareness through Argumentation-Based Inquiry Teaching

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Abstract. The main aim of the study is to obtain a more detailed understanding on how teaching argumentation-based inquiry helps develop students' scientific epistemological beliefs and metacognitive awareness. Argumentation-based inquiry was used as the teaching method in this research. In research done up to now in science education, this method has not been used to determine the scientific epistemological beliefs and metacognitive awareness of middle school students. Consequently, this study is important in terms of filling this vacancy in the area. In this study, whole-class teaching experiment method was used in the teaching period. In this method, the researcher takes up the role of the teacher, and at the same time, combines theory and practice in a classroom setting. The present study was carried out in one of the public middle school. The researcher used two scales as pre and post-tests, they are Epistemological Beliefs Questionnaire and Metacognitive Awareness Inventory. The researcher used both descriptive statistics and inferential statistics so as to analyse the data. The researcher put forward descriptive statistics as percentages, mean, range, standard deviation, minimum, maximum, skewness and kurtosis on the other hand for inferential statistics the researcher used paired-sample t-test to analyse the mean differences between pre and post-tests. The results demonstrated that there is a significant difference between the mean scores for scientific epistemological beliefs pre-test and post-test. However, the results showed that no significant difference between the mean scores for metacognitive awareness pre-test and post-test.

Keywords. Scientific Epistemological Beliefs, Metacognitive Awareness, Argumentation, Argumentation-Based Inquiry Teaching, Teaching Experiment

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With recent technological, social and scientific developments, the main purpose of the education system became making students gain the ability to reach and use information rather than transfer it. So instead raising students who transfer information, teaching them where they can find the information, how to use it and gaining life skills became the priority. In order to make students gain life skills, rich experiences must be prepared and presented in classes. In this context, it is thought that making students learn through Argumentation-Based Inquiry that enables them to learn by doing and living would be more effective. When students are encouraged to learn via this method, decision making, critical thinking, interrogative thinking, creative thinking, relational thinking, making self-regulations, making inferences and problem solving would be the higher-level thinking skills they would also be using (Bloom, Hastings & Madaus, 1971; Haladyna, 1997; Facione, 1998; Henderson, 2001; Ann Haefner & Zembal-Saul, 2004; Caulfield-Sloan & Ruzicka, 2005; Aslan, 2010).

When requirements of the age of science and technology and acquisition of higher-level thinking skills are considered together, science classes are considered to be at the top the list of programs that need change and renewal. The science program in our country was last changed in the 2004-2005 education year and the program was updated in 2013 because of changing circumstances of the era and new scientific discoveries, and the name of the course was changed to "Fen Bilimleri" (Çalışoğlu, Tortum, Erişmiş & Koçyiğit, 2015). The renewed 2013 "Fen Bilimleri" program is based on Argumentation-Based Inquiry approaches and activities that enable students to structure the knowledge in their minds by providing a total perspective and making them take responsibility for their own learning processes (MEB, 2013). One other important aim of the program is to develop students' epistemological beliefs that show how they acquire and structure information in their minds, and their metacognitive awareness from elementary school to university (MEB, 2013). Therefore, in that context, the main aim of this study is to obtain a more detailed understanding on how teaching argumentation-based inquiry helps develop students' scientific epistemological beliefs and metacognitive awareness.

Research Questions

The research questions and sub-questions guiding the study were as follows:

1) Is it possible to detect any differences between students' scientific epistemological beliefs pre-test scores and post-test scores?

2) Is it possible to detect any differences between students' metacognitive awareness pre-test scores and post-test scores?

Significance of the Study

In most research done in Turkey and abroad, it is evident that epistemological beliefs of students have been studied using various variables (Smith, Maclin, Houghton & Hennessey, 2000; Buehl & Alexander, 2001; Cartier, Rudolph & Stewart, 2001; Deryakulu, 2002; Deryakulu & Bıkmaz, 2003; Eroğlu & Güven, 2006). The number of researches done on the effect of an applied teaching method on these beliefs is considerably less than the others (Songer & Linn, 1991; Hammer, 1994; Cano, 2005; Stathopoulou & Vosniadou, 2007). One of the research questions of this study is whether the applied teaching method (Argumentation-Based Inquiry Teaching) changes students' scientific epistemological beliefs or not. Argumentation-based inquiry was used as the teaching method in this research. In research done up to now in science education, this method has not been used to determine the scientific epistemological beliefs of middle school students. Consequently, this study is important in terms of filling this vacancy in the area.

Kramarski, Mevarech and Arami (2002) stated that there are important critical periods in students' mental development process, and metacognitive skills and awareness levels of students in these periods should be developed. Although there are lots of evidences on the importance of metacognitive knowledge and skills, researchers have not provided concrete suggestions on how to develop these knowledge and skills. Research has shown that different methods and applications should be made in order to develop students' metacognitive skills in the process of learning and teaching (Keys, Hand, Prain, & Collins, 1999; Hand, Wallace & Yang, 2004; Hohenshell & Hand, 2006). One other importance of the research emerges here. In that context, more research is necessary to show how much argumentation-based inquiry develops students' metacognitive awareness quantitively. Thus, findings that will be obtained from the research will provide data on how argumentation-based inquiry method serves students' metacognitive awareness in science education. So, it is believed that the results of the research would make contributions to the development of the current program. In this context, this research is also important in terms of the contributions it will make to the field literature.

Although argumentation and inquiry have an important place in science education, many science teachers face difficulties in including argumentation to courses, using scientific inquiry, making students understand significant concepts in science and including students in scientific

inquiries to develop their scientific implementations (Sampson & Gleim, 2009). Among the reasons for this are the fact that students and teachers do not have enough knowledge in matters such as scientific inquiry and how to carry out the argumentation, what the items of the argument are, what the relationship between them is, and how to evaluate the arguments. Because this research gives information on scientific inquiry and argumentation, includes other research done on this subject and provides an example on how to use them in classes, it is considered to provide a pathway to individuals who are having trouble with scientific inquiry, argumentation and applying them in courses.

When national literature was considered, it was seen that there were some studies investigating the influences of the argumentation-based inquiry method on scientific epistemological beliefs (Boran, 2014; Çekbaş, 2017; Kaçar, 2019; Kızkapan, 2019; Özcan, 2019). However, it was observed that the studies in which middle school students were selected as participants were rare and that the effects of argumentation-based inquiry method on scientific epistemological beliefs and on metacognitive awareness were not handled together within a single study. Thus, the present study will be of great significance in filling the gaps in the literature in this area. In a similar vein, when international literature was considered, it was also detected that the number of studies that aimed to determine the effects of the argumentation-based inquiry method on scientific epistemological beliefs was considerably small (Albe, 2008; Bell, Matkins, & Gansneder, 2011; Ryu & Sandoval, 2012, Schalk, 2012). Moreover, with regards to the grade levels, it was detected that in general, studies with participants at high school level were carried out (Albe, 2008; de Lima Tavares, Jiménez-Aleixandre, & Mortimer, 2010). With all the above-mentioned causes and because the language of the present study is English, it is considered that this study will make a contribution to fill the niches in the associated area in the literature.

It is desired for the students to acquire scientific literacy in science education; metacognition, which is a factor and an important component of scientific literacy, has been gaining considerable significance recently because metacognition encompasses high level thinking skills such as critical thinking, analytical thinking, creative thinking, data collection, interpretation and problem solving. One of the methods that is considered to be effective in making the students acquire scientific literacy is the argumentation-based inquiry method because this method enables the students to use their metacognitive thinking skills such as controlling, evaluating and tracking themselves (Ulu & Bayram, 2014). Hence, this study will investigate whether the argumentation-based inquiry method has an impact on the development of the metacognitive awareness of the students. When the

relevant literature is taken into consideration, there are studies, though few in number, that reach the conclusion suggesting that metacognitive awareness skills develop as a result of the use of argumentation method in education (Aydın & Kaptan, 2014; Ulu & Bayram, 2014). However, the participant groups in these studies are usually university students. A study with middle school students as the participant group that investigates the impact of the argumentation-based inquiry method on the development of metacognitive awareness would be helpful in filling the gap in the literature and lead the way to other researchers.

Method

Research Model

The teaching experiment is a conceptual tool which researchers use in organizing their activities in order to understand how students' progress over a long period of time (Steffe & Thompson, 2000). In the most general sense, it is a research method based on how a teacher or researcher establishes appropriate conditions for a better learning, taking into account his/her own influence, what variables are influential in students' learning, how they have integrated new knowledge with previously acquired ones and how they have structured this new knowledge (Cobb & Steffe, 1983; Steffe, 1991; Hunting, 1997). Even though it was produced by Piaget's (1952) clinical interview technique, the teaching experiment is much more extensive than clinical visibility because it reveals the knowledge of the learners and the variables that are effective in their learning, and it also includes the ways they organize knowledge and their experiences during this process (von Glasersfeld, 1995; Steffe & Thompson, 2000). The teaching experiment is considered to be the most effective and favorable type of research in the recent years to clearly demonstrate the characteristics of research studies in mathematics and science education (Lesh & Kelly, 2000). The reason for this is the teaching experiment gives an opportunity for an in-depth study of the development of an individual or a concept throughout the process (Steffe, Thompson & Glasersfeld, 2000).

Some teaching experiments can be done individually (one-on-one) or in small groups and or within a group (team, community). In the teaching experiment, the number of students may vary from one student to a whole class. Within the scope of the present study, whole-class teaching experiment method was used in the teaching period.

Classroom Teaching Experiment

The necessity of being involved in the mental processes of the students and the difficulties experienced in this process make the classroom teaching experiment valuable in the field of science education, even though the teaching experiment method is generally used in the field of psychology (Engelhardt, Corpuz, Ozimek & Rebello, 2003) and in the field of mathematics education (Steffe & Thompson, 2000). In this current study, the researcher used classroom teaching experiment in order to bring into open what the learners can learn through argument-based inquiry and to come up with ways and means to provide this learning. It is necessary to communicate with the learners in order to obtain qualified data in the direction of the research. One of the aims of this method is to understand the development of the participants throughout the teaching experiment and to create a model of their learning within the determined subject. Since it is considered as the best way to observe middle school students' scientific reasoning skills, scientific epistemological beliefs and metacognitive awareness in the process, the researcher used the classroom teaching experiment, classified as one of the methods of the teaching experiment (Cobb & Steffe, 1983). Through this method, it becomes possible to understand and observe students' knowledge structure, strategies used in the development process and general cognitive structures during the development process (Lesh & Kelly, 2000). In this method, the researcher takes up the role of the teacher, and at the same time, combines theory and practice in a classroom setting and works to respond to the problems that must be addressed in practice, thanks to the constructivist approach (Cobb & Sheffe, 1983; Steffe & Thompson, 2000; Güven, 2006). Besides, the researcher is the person who analyzes the information obtained. There is no standard form for a classroom teaching experiment because each classroom teaching experiment is unique and it changes according to the purpose of the study and the researcher's perspective. As the classroom teaching experiment could be defined as a dynamic method in the process of studying students' scientific epistemological beliefs and metacognitive awareness, the researcher used the classroom teaching experiment in the study.

Throughout her classroom teaching experiment, by taking the present pre-information of the students into account, the researcher who took constructivist approach as the basis, has designed educational tasks to be built by the students themselves instead of offering information that was previously prepared. Moreover, in her teaching experiment, the researcher made some retrospective analyses at certain stages of the experiment to continue the teaching process meticulously and carefully and to make meaningful teaching designs for the students. This way, the researcher aimed to see how the students' scientific epistemological beliefs and metacognitive awareness changed.

The teaching process was rehandled in accordance with these retrospective analyses and an attempt at creating the best teaching design was done. In other words, the cycle consisting of creating hypotheses, planning educational tasks and making retrospective analyses was continued all through the teaching experiment.

The Context of the Research

The present study was carried out in one of the public middle schools in Ankara. In order to collect the data, argumentation-based inquiry teaching implemented science lessons were used over the span of 16 weeks. Students received four hours of science lessons in a week during the study. The researcher used two scales as pre- and post-tests, they are Epistemological Beliefs Questionnaire (EBQ) and Metacognitive Awareness Inventory (MAI). Through the science lessons, students engaged in argumentation-based inquiry activities. These science lessons were developed through discussion with the teacher. The researcher and the teacher designed these activities in view of the 6th grade Science Education curriculum and its objectives.

The Role of the Researcher

In the teaching experiment, the principal role of the researcher is to act as a teacher. In this context, in this study, the researcher planned all stages of the research process and carried out his teaching practice in the chosen class for four months and recorded all the lessons on video, had individual interviews with the students before and after argumentation-based inquiry lessons, and asked questions that would reveal students' scientific epistemological beliefs and metacognitive awareness without guidance, had the students participate on all the educational activities planned in the teaching process and analyzed the data obtained as a result of this process in an objective way.

Planning of the Classroom Teaching Experiment

In this research study, the researcher who has a doctorate in the field of science education, and the teacher who has a doctorate in the field of science education, identified the research problem together. While describing the problem of research, science education literature was taken into consideration. The pilot study of the research was conducted in a different class than the original study group for one week. The study was conducted in a 6th grade science class in a public middle school. The evaluation of the pilot study also covered situations where attention should be paid to data accumulation. The classroom teaching experiment application took a total of 20 weeks and 80 lesson hours; two days and four lessons per week, which included the noble applications of the argumentation-based inquiry activities in the 6th grade science courses. In this process, the

researcher and the teacher came together to evaluate the activities, organize them and to create the next activity. The research group of your study should be given as detailed as possible.

Participants and Selection

28 students in 6th grade from a public middle school in the city center of Ankara constituted the participants of the study. The school where the research study took place was an institution affiliated with the Ministry of National Education, which provided dual education to the children of families with low and medium socio-economic levels in general. Permission was obtained from the Ministry's Department of Education Research and Development Office in order to perform this study as the participants attended a school affiliated with the Ministry of National Education

In order to be able to examine the study's research questions in depth and discover all the possible details and explain them, a number of criteria were set to select both the class and success level of the students (Patton, 2002; Yıldırım & Şimşek, 2005). The reasons for selecting these students for the research study can be summarized as follows:

Class level of the participants. Situations that require the ability to reason, to use intelligence, and to express how knowledge is obtained are perceived as "complicated" by the students. In order to avoid this situation, the 6th grade level of middle school, in which reasoning skills are slightly improved compared to the elementary school level, was included in the study.

Success level of the participants. The study was conducted under video recording as the responses of all students in the classroom are important for the experiment of classroom teaching. However, since it was not possible to conduct individual clinical interviews with the whole class, 15 students participating in the teaching experiment were selected for individual interviews. Students who participated in individual clinical interviews were selected according to their level of achievement. In this context, the researcher selected 5 students with a high level of achievement, 5 students with intermediate level of achievement and 5 students with low level of achievement, taking into account the teacher's views on students, the students' science course grades from 2018-2019 fall semester and the results of the exams administered at the school.

Data Collection Process

Two instruments, Epistemological Beliefs Questionnaire (EBQ) and Metacognitive Awareness Inventory (MAI) were administered as pre-and post-test to the participants of the study. The instruments were administrated to all the volunteer participants.

Epistemological beliefs questionnaire (EBQ). Epistemological Beliefs Questionnaire (EBQ) was used to evaluate middle school students' scientific epistemological beliefs. It was Özkan (2008) who translated and adapted The EBQ into Turkish and this questionnaire's developer was Conley, Pintrich, Wekiri, & Harrison (2004). The total Cronbach Alpha of the questionnaire was reported by Özkan as .78. Students' beliefs for the nature of knowledge and nature of knowing are measured in four dimensions; they are as follows; Source, Certainty, Development and Justification. For each dimension, Cronbach alpha was respectively (α = .70, .70, .59 and .77). 26-items rated on a 5-point Likert scale constitutes Cronbach alpha. (1= Strongly disagree, 5= Strongly agree). Using questionnaires with well-known reliability and validity and going even further and paying attention to the selection of questionnaires with high reliability and validity is very important in the field of education. Thus, the scientific epistemological beliefs questionnaire that is used in this study is a questionnaire that provides the reliability and validity in the literature and that has been adapted to Turkish.

Metacognitive awareness inventory (MAI). Metacognitive Awareness Inventory (MAI) was used to assess middle school students' metacognitive awareness. It is known that Schraw and Dennison (1994) developed MAI and Akin, Abaci and Cetin (2007) translated and adapted it into Turkish. The total Cronbach Alpha of the questionnaire was reported as .93. Students' knowledge of cognition and regulation of cognition is measured in eight dimensions as Declarative Knowledge, Procedural Knowledge, Conditional Knowledge, Planning, Information Management, Monitoring, Debugging and Evaluation. The researcher calculated Cronbach Alpha for each dimension. In terms of declarative knowledge, Cronbach Alpha was calculated .96, in terms of procedural knowledge it was .94, it was found .96 for conditional knowledge, .95 found for planning, for information management it was found 97, in terms of monitoring it was calculated .96, in terms of debugging it was 96 and finally for evaluation it was calculated .97. 52-items rated on a 5-point Likert scale constitutes Cronbach Alpha. (1= Strongly disagree, 5= Strongly agree). Using inventories with well-known reliability and validity and going even further and paying attention to the selection of inventories with high reliability and validity is very important in the field of education. Thus, the metacognitive awareness inventory that is used in this study is an inventory that provides the reliability and validity in the literature and that has been adapted to Turkish.

Data Analysis Process

For the quantitative data, statistical analyses were done by using the Statistical Package for Social Sciences version 24. The researcher used both descriptive statistics and inferential statistics so as to analyze the attained data. The researcher put forward descriptive statistics as percentages, mean, range, standard deviation, minimum, maximum, skewness and kurtosis, on the other hand, for inferential statistics the researcher used paired-sample t-test to analyze the mean differences between pre-and post-tests. Moreover, before conducting paired t test analysis, all assumptions of paired t test were verified. In the present study, it can be said that the results of the analyses are reliable with a 95% of probability since the researcher utilized an alpha level as .05. Moreover, if the alpha level is smaller than .05, it can be inferred that a considerable relationship exists between variables.

Results

The researcher applied a paired sample t-test to analyze if a statistically considerable difference exists between students' epistemological beliefs on pre-test scores and post-test scores.

Paired Sample T-Test for Scientific Epistemological Beliefs

In order to investigate whether there is a statistically significant difference between students' scientific epistemological beliefs pre-test scores and post-test scores, a paired sample t-test was used.

Assumptions of Paired Sample T-Test

Before the conduction of Paired Sample T-Test, assumptions of analysis which are level of the measurement, random sampling, independent observations and normality were checked. According to Field (2009), the t-test is quite robust over moderate violations of this assumption regarding normality.

Level of measurement. Our dependent variable should be continuous. In this study, total scores are the dependent variable, so they are continuous.

Random sampling. Scores used to obtain the sample data should be selected randomly. We assume that samples are selected randomly from populations.

Independence of observation. The values in the sample must consist of independent observations.

Normal distribution. I am going to check normality by testing skewness and kurtosis, Sig.value and Q-Q plots.

Normality

To test the normality assumption of this sub-research question, Skewness and Kurtosis Test Kolmogorov-Smirnov and Shapiro-Wilk Test, and Q-Q plots were applied. Skewness and Kurtosis Test results were satisfied as indicated in the Table 1. Skewness and Kurtosis values are between -2 and 2 (.52 and 1.73). Kolmogorov-Smirnow and Shaphiro-Wilk test results were satisfied as showed in the Table 2. Sig.value for Kolmogorov-Smirnow (0.19) and Shaphiro-Wilk (0.48) is greater than 0.05. In other words, the results were significant. In addition, visual inspection of Q-Q plots (see Figure 1) indicated no great deviations from normality. For that reason, it can be said that the distributions are normal.

Table 1.

Descriptive Statistics for Difference between Epistemological Beliefs Pre-tests and Post-tests Scores

			Statistic	**Std. Error**
Diffe_epis	Mean		-7.0370	2.97592
	95% Confidence Interval for Mean	Lower Bound	-13.1541	
		Upper Bound	-.9200	
	5% Trimmed Mean		-7.5226	
	Median		-9.0000	
	Variance		239.114	
	Std. Deviation		15.46331	
	Minimum		-40.00	
	Maximum		37.00	
	Range		77.00	
	Interquartile Range		15.00	
	Skewness		.524	.448
	Kurtosis		1.725	.872

Table 2.

Kolmogorow-Smirnow & Shapire-Wilk Tests Results for Difference between Epistemological Beliefs Pre-tests and Post-tests Scores

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Diffe_epis	.139	27	.192	.965	27	.484

Note: *a.* Lilliefors Significance Correction

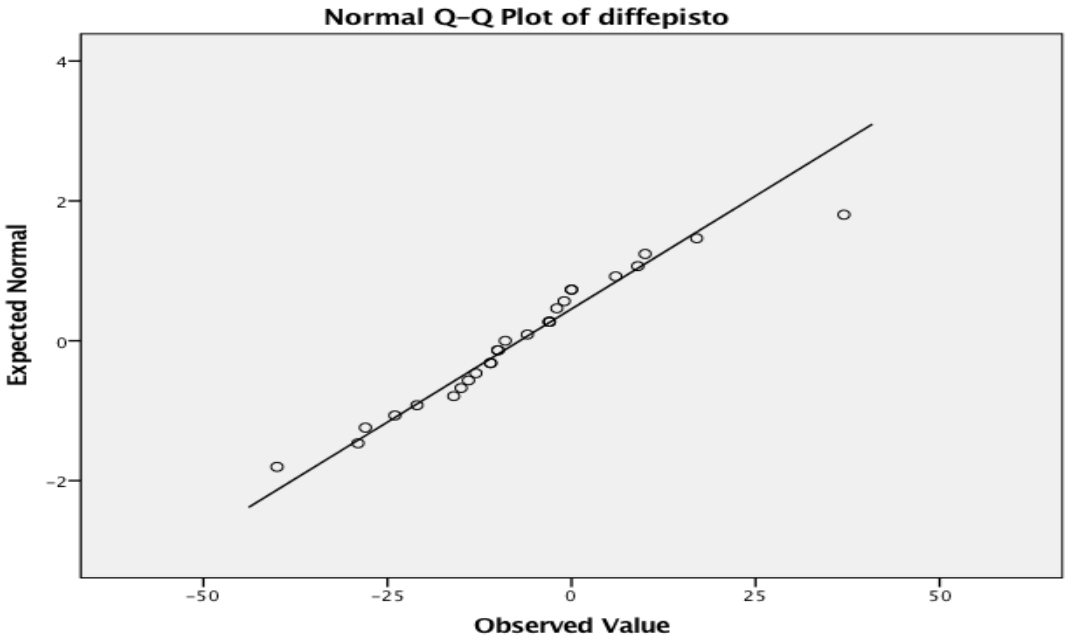

Figure 1. Normal Q-Q Plot of Difference between Epistemological Beliefs Pre-tests and Post-tests Scores.

Results of Paired Sample T-Test for Scientific Epistemological Beliefs

On Table 3, the outcomes of the descriptive statistics are shown. Pretest mean score of the descriptive statistics of the epistemological beliefs was found as (*M*=88.37, *SD*=10.16) and posttest mean score of the epistemological beliefs was found as (*M*=95.41, *SD*=13.40). It can be stated that a statistically considerable difference between the mean scores for epistemological belief pretest and epistemological belief posttest existed. It can be seen in Table 4 that there was a considerably greater difference between the mean of epistemological belief posttest scores and the mean of epistemological beliefs pretest scores, the first is greater than the latter t (26) = -2.37, p= .026 is less

than 0.05. The researcher found the mean difference as 15.46 with a 95% confidence interval ranging from -13.15 to -.91. The eta squared statistic (r2) (.18) indicated large effect size.

Table 3.

Descriptive Statistics for Epistemological Beliefs Pre-tests and Post-tests Scores

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Totalepis_Pretest	88.3704	27	10.16082	1.95545
Totalepis_Posttest	95.4074	27	13.39994	2.57882

Table 4.

Paired Sample t-Test for Epistemological Beliefs Pre-tests and Post-tests Scores (Overall)

	Mean	**Std. Deviation**	**Paired Std. Error Mean**	**Differences 95% of the Lower**	**Confidence Difference Upper**	**t**	**df**	**Sig. (2-tailed)**
Totalepis_Pretest-Totalepis_Posttest	7.03704	15.46331	2.97592	-13.15412	-.91996	-2.365	26	.026

Paired Sample T-Test for Metacognitive Awareness

In order to investigate whether there is a statistically significant difference between students' metacognitive awareness pre-test scores and post-test scores, a paired sample t-test was used.

Assumptions of Paired Sample T-Test

Before the conduction of Paired Sample T-Test, assumptions of analysis which are level of the measurement, random sampling, independent observations and normality were checked. According to Field (2009), the t-test is quite robust over moderate violations of this assumption regarding normality.

Level of measurement. Our dependent variable should be continuous. In this study, total scores are the dependent variable, so they are continuous.

Random sampling. Scores used to obtain the sample data should be selected randomly. We assume that samples are selected randomly from populations.

Independence of observation. The values in the sample must consist of independent observations.

Normal distribution. I am going to check normality by testing skewness and kurtosis, Sig.value and Q-Q plots.

Normality

To test the normality assumption of this sub-research question, Skewness and Kurtosis Test Kolmogorov-Smirnov and Shapiro-Wilk Test, and Q-Q plots were applied. Skewness and Kurtosis Test results were satisfied as indicated in the Table 5. Skewness and Kurtosis values are between -2 and 2 (-.28 and .87). Kolmogorov-Smirnow and Shaphiro-Wilk test results were satisfied as showed in the Table 6. Sig.value for Kolmogorov-Smirnow (0.20) and Shaphiro-Wilk (0.51) is greater than 0.05. In other words, the results were significant. In addition, visual inspection of Q-Q plots (see Figure 2) indicated no great deviations from normality. For that reason, it can be said that the distributions are normal.

Table 5.

Descriptive Statistics for Difference between Metacognitive Awareness Pre-tests and Post-tests Scores

			Statistic	**Std. Error**
Diffe_meta	Mean		-7.8846	7.15549
	95% Confidence Interval for Mean	Lower Bound	-22.6216	
		Upper Bound	6.8524	
	5% Trimmed Mean		-6.8462	
	Median		-9.5000	
	Variance		1331.226	
	Std. Deviation		36.48597	
	Minimum		-101.00	
	Maximum		61.00	
	Range		162.00	
	Interquartile Range		42.50	
	Skewness		-.278	.456
	Kurtosis		.873	.887

Table 6.

Kolmogorow-Smirnow & Shapire-Wilk Tests Results for Difference between Metacognitive Awareness Pre-tests and Post-tests Scores

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	df	Sig.	Statistic	df	Sig.
Diffe_meta	.105	26	.200*	.966	26	.518

Note: *This is a lower bound of the true significance

a. Lilliefors Significance Correction

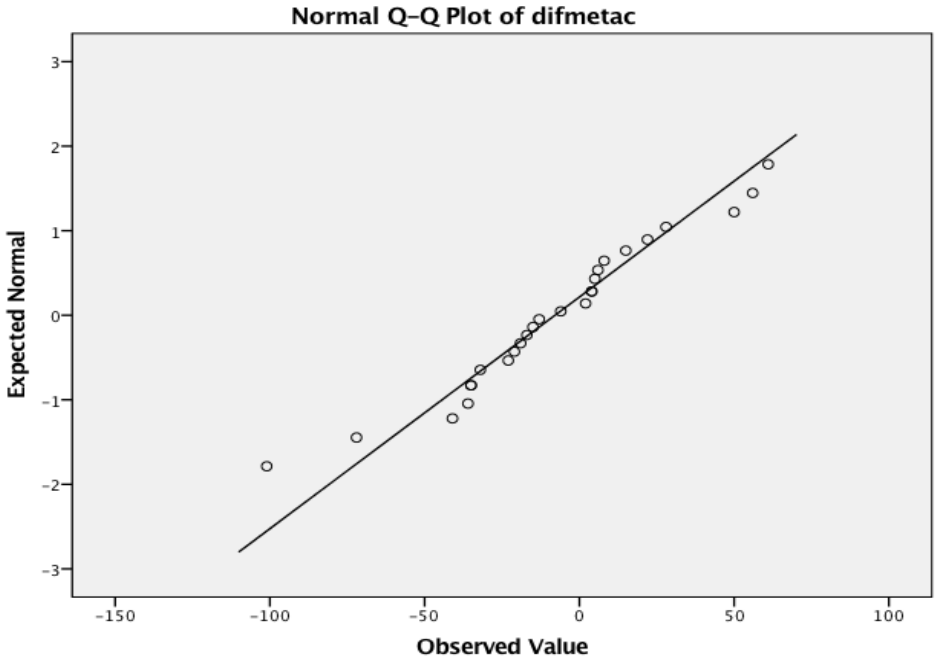

Figure 2. Normal Q-Q Plot of Difference between Metacognitive Awareness Pre-tests and Post-tests Scores.

Results of Paired Sample T-Test for Metacognitive Awareness

On Table 7, the outcomes of the descriptive statistics are shown. Pretest mean score of the descriptive statistics of the metacognitive awareness was found as (*M*=187.31, *SD*=25.01) and posttest mean score of the metacognitive awareness was found as (*M*=195.19, *SD*=34.20). It can be stated that a statistically considerable difference between the mean scores for metacognitive awareness pretest and metacognitive awareness posttest existed. It can be seen in Table 8 that there was a greater difference between the mean of metacognitive awareness posttest scores and the mean of metacognitive awareness pretest scores *t* (25) =-1.10, *p*=.28 is more than 0.05. The results

indicated that no significant difference between the mean scores for metacognitive awareness pre-test and metacognitive awareness post-test. The mean difference was 36.49 with a 95% confidence interval ranging from 7.16 to-22.62. The eta squared statistic (*r*2) (.05) indicated moderate effect size.

Table 7.

Descriptive Statistics for Metacognitive Awareness Pre-tests and Post-tests Scores

	Mean	N	Std. Deviation	Std. Error Mean
Totalmeta_Pretest	187.3077	26	25.01003	4.90487
Totalmeta_Posttest	195.1923	26	34.19593	6.70637

Table 8.

Paired Sample t-Test for Metacognitive Awareness Pre-tests and Post-tests Scores

	Paired Differences							
	Mean	Std. Deviation	Std. Error Mean	95% Confidence of the Difference Lower	Upper	t	df	Sig. (2-tailed)
Totalmeta_Pretest-Totalmeta_Posttest	-7.88462	36.48597	7.15549	-22.62162	6.85239	-1.102	25	.281

Discussion and Conclusion

When the students' quantitative findings related to the scientific epistemological beliefs of the students are examined in order to find answers to the first research problem, average of students' scores on scientific epistemological beliefs scale was *M*=88.37 prior to the application; *M*=95.41 after argumentation-based inquiry approach (Table 3). That is, when the pre-test and post-test results were compared with the paired sample test, a positively significant difference was found in favor of the final test results (t (26) = -2.37; p <0.05) (Table 4). Based on these results, it can be said that argumentation-based inquiry approach is effective for developing students' scientific epistemological beliefs. The studies in the relevant literature support this conclusion. The conclusion yielded by this study supports the conclusion of Boran (2014)'s study because in her study, Boran (2014) has reached the conclusion that teaching based on argumentation caused a change and development in the university students' scientific epistemological beliefs. Another study that supports the result of the present study is the study conducted by Ryu and Sandoval (2012). In their study, by using a qualitative research method, the researchers investigated whether scientific argumentation-based teaching process affected the students' scientific epistemological beliefs and if

so how it affected them and as a result, they reached the conclusion that argumentation approach both developed the scientific epistemological beliefs and enhanced epistemological criteria. In a similar vein; de Lima Tavares, Jiménez-Aleixandre and Mortimer (2010) have also concluded that argumentation-based teaching caused a development on the epistemological beliefs by using a qualitative method. In addition to these; some researchers who conducted studies on argumentation and epistemological beliefs (Kenyon & Reiser, 2006; Sandoval & Millwood, 2005; Sandoval & Millwood, 2008) have revealed results suggesting that argumentation-based teaching had important influences on epistemological beliefs. In the relevant literature, there are results that do not comply with the results of the present study as well as the ones that are in accordance with it. For instance, in Özcan (2019)'s study, teaching with argumentation-based inquiry approach created no change in the scientific epistemological beliefs of the students.

When the students' quantitative findings on metacognitive awareness of the students are examined in order to find answers to the second research problem, average of students' scores on metacognitive awareness scale was *M*=187.31 before the application, while being *M*=195.19 after argumentation-based inquiry approach (Table 7). There was not a statistically significant difference between average points when the pre-test and post-test results of metacognitive awareness were compared with the paired sample test ($t(25) = -1.10$; $p < 0.05$) (Table 8). When these findings are examined, it can be said that argumentation-based inquiry approach is not effective in increasing the level of metacognitive awareness of the students. This result may have different reasons. When the relative literature is considered, conclusions that are not in accordance with the result of the present study can also be seen (Aydın & Kaptan, 2014; Ulu & Bayram, 2014). These researches have reached conclusions suggesting that argumentation-based teaching was effective on the students' metacognitive awareness and their use of metacognitive strategies. Again, in another study carried out by Erenler (2017), a result revealing that argumentation-based inquiry method had positive effects on the development of students' metacognitive awareness was reached. In other words; some studies in the literature (Aydın & Kaptan, 2014; Erenler, 2017; Ulu & Bayram, 2014) do not support the result of the present study. Nonetheless, there are also studies that support the conclusion of the present study besides those that do not (Doruk, Duran, & Kaplan, 2018). For example, in their study, Doruk et al. (2018) investigated whether argumentation-based teaching had any effect on the metacognitive awareness of the 8th grade students by using a mixed method in which qualitative and quantitative data were used together. In their study, they reached the conclusion that argumentation-based teaching did not have a significant effect on the students'

metacognitive awareness as a result of the evaluation of the quantitative data. The result obtained by these researchers is completely in accordance with the result of the present study.

Recommendations

Argumentation-based inquiry approach requires a different perspective on learning and teaching. Besides, it takes a lot of effort and a long time to think outside the box and gain a new perspective. The aims and pathway to these aims must be determined realistically. Science Education curriculum has an anticipated period for each unit. The practitioners of the curricula are trying to bring the students in the concepts and achievements related to the unit during this anticipated period. Practitioners of instructional programs have to make good use of the time if they want to teach the concept and achievements of the unit by using argumentation-based inquiry approach within the anticipated period. This is why, argumentation-based inquiry approach should be planned carefully when it is to be used. By this way, concepts and achievements related to the unit can be taught within the anticipated time for each unit of the curriculum. In addition, practitioners need to have sufficient knowledge of the fundamental principles of this approach in order for argumentation-based inquiry approach to be implemented within the classroom. In this context, practitioners may get in-service training on argumentation-based inquiry approach and its in-class implementations. In in-service training, training given to practitioners should be more practical and rather than informative.

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Conflict of Interest

It has been reported by the author that there is no conflict of interest.

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Ethical Standards

I have carried out the research within the framework of the Helsinki Declaration. The consent forms were utilized. The participants were informed about the study and volunteered to participate.

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