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The Effect of Argumentation on Seventh Grade Students' Scientific Epistemological Beliefs and 21st Century Skills

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Abstract

The aim of this study is to examine the effect of argumentation over current teaching approach on scientific epistemological beliefs and 21st century skills of seventh grade students. This is a quasi-experimental design with pre-test and post-test control group. The sample of the study was composed of 79 seventh grade students (38 experimental; 41 control group) from two intact classes of an urban middle school instructed with the same teacher. The teaching methods were randomly assigned to the classes. The experimental group treated with argumentation, the control group treated with the current teaching approach without argumentation. As data collection tools; Scientific Epistemological Beliefs Scale and 21st century skills scale were used. Multivariance Analysis of Variance (MANOVA) was used for data analysis. The results showed that argumentation and the current teaching approach had a similar effect on students' scientific epistemological beliefs and 21st century skills.

Keywords: Scientific Epistemological Beliefs, 21st Century Skills, Argumentation, Middle School Students

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INTRODUCTION

Scientific and technological developments impact science teaching. Jerald (2009) stated that in addition to the academic knowledge and skills, students need different knowledge and skills in order to adapt to jobs. These are 21st century skills and they emerged with recent changes in the world. Some institutions such as The Partnership for 21st Century Skills [P21], National Research Council [NRC], North Central Regional Education Laboratory (NCREL) and Metiri Group (2003) evaluated and classified 21st century skills. Students' 21st century skills classification created by Kang, Heo, Jo, Shin, and Seo (2010), consists of three domains: cognitive, affective and sociocultural domains. *Cognitive* domain skills are consisting of knowledge management, knowledge structuring, knowledge usage skills and problem solving skills. Knowledge management skills require skills such as inquiry, using tools, using resources; knowledge structuring skills include reasoning skills and critical thinking skills; knowledge usage skills include judgement skills, evaluation skills and solution generating skills; problem solving skills need creative thinking skills. *Affective* domain skills are skills towards self-identity, self-worth, self-efficacy, self-responsibility and social membership. Self-identity is related to the individual's self-perception; self-worth skills are related to honesty, reliability, and awareness; self-efficacy includes skills to decide on the goal and to define personal obligations; self-responsibility includes self-responsibility and assertiveness skills. *Sociocultural* domain skills include social membership skills, social sensitivity skills, socialization skills and social fulfillment. Social membership is related to the awareness of the society's value judgment, hosting a sense of community and citizenship; social sensitivity includes understanding and tolerance towards cultures; socialization skills consists of communication skills; social fulfillment skills include skills such as being able to lead, and being able to work in teams (Kang, Heo, Jo, Shin, & Seo, 2010).

In the 21st century, people should have technological skills, cooperation and communication skills, self-management skills and leadership skills. Also, they should be open to new ideas, responsible and socially and culturally sufficient. (Eryılmaz & Uluyol, 2015). In addition to these, people should think creatively and critically and so produce solutions to problems by having the ability to cooperate. It is vital to develop students' 21st century skills because their 21st century skills are relatively low level (Fauziah & Feranie, 2018). The other reason for developing students' 21st century skills is that students need to be successful in business life and possess the characteristics of the century. As stated in the documents (such as P21; NRC, 2011), the development of 21st century skills could help the development of countries and solve real life problems.

Therefore, one of the goals of this research is to improve students' 21st century skills. Argumentation was used to improve 21st century skills of students. Jiménez-Aleixandre and Puig (2012) discussed the relationship between argumentation and critical thinking. They suggested that critical thinking is an important component in evaluating evidence. Another reason for using argumentation in the present study is that it is one of the approaches used in the literature to improve students' 21st century skills. For example, Küçük-Demir and Isleyen (2015) determined that the argumentation positively affected the creative thinking skills of ninth grade students with a single group pre-test and post-test experimental design. Nejmaoui (2019) stated that the experimental group students, who were asked to write with critical thinking skills, had a better level of ability to use more reliable evidence, mention counter arguments, support the results, and maintain the logical flow of ideas compared to the control group students, who were asked to write without specifying these skills. Komara and Sriyanto (2018) stated that the constructivist discussion is effective in helping students to develop their critical thinking skills while writing texts containing argumentation elements. Kumdang, Kijkuakul, and Chaiyasith (2018) found that 10th grade students develop creative thinking by argument-oriented inquiry. Pei, Zheng, Zhang, and Liu (2017) found that students with strong critical thinking skills performed better than the students with weak critical thinking skills in terms of relevance, openness, logic, and flexibility of argumentative writing.

As can be seen in the above studies, only one or a few 21st century skills are examined, the number of studies examining the development of middle school students' 21st century skills are also rare. Therefore, in the present study, unlike other studies, the development of 21st century skills as a whole will be examined and the research will be carried out with seventh grade students.

Shaakumeni (2019) stated that while developing 21st century skills, epistemological beliefs should be developed. Thus, in the present study, the development of epistemological beliefs was investigated. Individuals' perspectives and views towards science are a reflection of the epistemological beliefs. Scientific epistemological beliefs have an important place in terms of students' understanding of science and their ability to interpret scientific knowledge (Lederman, 1992). Epistemological beliefs can be defined as all views on the aim of science, the sources of scientific knowledge, and the changeable nature of knowledge (Elder, 1999).

Schommer proposed the following epistemological beliefs dimensions. These dimensions are as follows: simple knowledge, certain knowledge, quick learning and innate ability (Schommer, 1994). *Simple knowledge* dimension includes beliefs about whether knowledge is in a simple or interconnected complex structure. *Certain knowledge* dimension includes beliefs about whether knowledge is certain or not certain. *Quick learning* dimension includes beliefs that the learning occurs immediately, or gradually. *Innate ability* dimension includes belief that learning is due to the innate abilities of individuals or can be improved with experiences, and can be learned by everyone. Schommer (1994) stated that an individual can be in different developmental stages of these four dimensions independent from each other. In other words, while individuals have sophisticated beliefs in some dimensions, they may have unsophisticated beliefs in some other dimensions at the same time. Hofer and Pintrich (1997), like Schommer (1990) argued that epistemological beliefs consist of independent dimensions. However, unlike Schommer (1990), they stated that epistemological beliefs are formed from the *nature of knowing* and *nature of knowledge* and that the epistemological beliefs of the individuals vary according to the field (discipline). They suggested that epistemological beliefs consist of dimensions of the certainty of knowledge, simplicity of knowledge, source of knowing, and justification of knowing.

Conley, Pintrich, Vekiri, and Harrison (2004), examined 5th grade students' epistemological beliefs in terms of *source*, *judgment*, *development*, and *certainty* dimensions. The *source* dimension includes a continuum from obtaining information from a source other than the student to obtaining information from the student himself/herselves. The *judgment* dimension indicates the degree to which students' usage of their newly learned information in the judgment process. The *certainty* dimension includes a continuum from the belief that a question has only one answer to the belief that it has more than one answer. The *development* dimension includes a continuum that moves from the belief that knowledge is certain, to belief that knowledge can change and develop in line with newly obtained evidence. These dimensions are differing from the dimensions determined by Schommer (1994) in that they are directed to a specific discipline. Discipline-focused epistemological beliefs have a great effect on academic achievement (Muis, Bendixen, & Haerle, 2006). Tsai, Ho, Liang, and Lin (2011) stated that examining students' epistemological beliefs in a particular discipline is of great importance. Buehl and Alexandre (2006) stated that epistemological beliefs are shaped in terms of the different domains. For this reason, epistemological beliefs about the discipline have come to the fore. Therefore, in this study, it is aimed to determine and develop students' scientific epistemological beliefs.

It is important to study the development of students' scientific epistemological beliefs for several reasons. One reason is that students' epistemological beliefs affect their academic success. For example, Dorfner, Förtsch, Germ, and Neuhaus (2018) concluded that students who were taught with epistemic activities under the framework of argumentation had higher success. Another reason is that it is important to determine the epistemological beliefs of middle school students, because there are very few studies in these age groups (Bendixen, 2016). For these reasons, in the present study in order to develop students' epistemological beliefs, argumentation was used. The reason this is used is because argumentation is associated with epistemological beliefs. For example, Mateos, Cuevas, Martín, Martín, Echeita, & Luna (2011) stated that the epistemological, argumentative reading and writing beliefs held by psychology graduates are interrelated. Mason and Scirica (2006) found that after controlling the content knowledge and interests of eighth grade students, the participants having evaluative level of epistemological understanding formed higher arguments, counter arguments and rebuttal than the participants at the pluralist level. Some studies stated that epistemological understanding is predictive of students' argumentation skills (Schommer-Aikins & Hutter, 2002; Nussbaum, Sinatra & Poliquin, 2008; Khishfe, 2012; Liu & Roehrig, 2019; Noroozi, 2018; Şengül, Enderle, Schwartz, 2020). However, some studies have not proven that students' epistemic beliefs have an effect on argumentation (Noroozi & Hatami, 2018). The other reason is that it is one of the approaches used in the literature to develop epistemological beliefs. For example, Schommer-Aikins and Hutter (2002) emphasized that the inclusion of controversial topics in the curriculum can mutually support the development of epistemological beliefs. Liu and Roehrig (2019) stated that with a 3-year professional development program on climate change, science teachers have similar epistemological beliefs about climate change, but they differ in some aspects in terms of the expertise of scientists and the reliability of scientific evidence. They also found that there were differences between teachers' personal epistemology about science and their epistemological beliefs about climate science. Iordanou (2016) found that argumentation practices contributed to the development of students' epistemological beliefs.

The Argumentation, developed by Keys, Hand, Prain, and Collins (1999), is one of the inquiry-based science learning approaches. Toulmin (1958) defined argumentation as the process of making conclusions by providing the warrants for an idea or a hypothesis, supporting claims with data. Argumentation is not an attempt to reach an absolute truth. Argumentation is the process of testing more than one existing knowledge using claims and evidence (Toulmin, 1958). In the present study, Toulmin's argumentation approach was used. The Toulmin's argumentation includes the setting a claim, giving reasons to justify the claim, to use evidence and to refute counter-claims (Erduran, Simon, & Osborne, 2004). Recent argumentation studies are related to the construction of scientific knowledge and the development of mental activities. Also, recent learning and teaching approaches aim to improve students' scientific language skills, especially in science. From this point of view, argumentation also helps to develop knowledge, which is of great importance for speeches in a scientific language (Erduran, Ardac, & Yakmaci-Guzel, 2006). In argumentation, students use their previous knowledge for putting reasons that provide support for their views and make an effort to justify these views. Students who have opposing ideas express their views openly, explain their doubts and express alternative opinions. All students work like scientists; i.e. they form their warrants and support to prove their claims. In this way, they reconstruct their scientific knowledge (Driver, Asoko, Leach, Mortimer & Scott, 1994).

Scientific argumentation is not a simple argument or debate. The main purpose of argumentation is to convince the other by revealing acceptable ideas (Clark & Sampson, 2007). Argumentation is a logical activity, the ideas created by individuals on their own are not enough, arguments should reflect the views of different people. The purpose of scientific argumentation is to verify or refute the views of individuals. Scientifically, argumentation is the process of linking claims and data with justifications in experimental and theoretical terms (Jimenez-Aleixandre & Erduran, 2007). According to Driver et al. (2000), one of the main purposes of using argumentation in science teaching is to develop an understanding of scientific epistemology.

When the above-mentioned studies are examined, the argumentation could be helpful for the development of students' 21st century skills and epistemological beliefs because students form a scientific question, give priority to the evidence while answering the question, evaluate their own views in the light of other groups' views, and critically examine other explanations while determining the backing and rebuttal of their claims. Increasing the emphasis on argumentation in teaching environments will make it easier for students to adapt to be active, collaborative, competitive and innovative work environments.

Rationality: In science education, it has been found that even in inquiry, students do not use sufficient data and backings to support their claims and have difficulty in reasoning between alternative theories (Kelly, Druker, & Chen, 1998; Watson, Swain, & McRobbie, 2004). Some studies revealed that students could overcome these difficulties with argumentation (Acar, Turkmen, & Roychoudhury, 2010; Duschl & Osborne, 2002).

Scientific epistemological beliefs are an important element of students' learning (Hofer, 2001). Studies show that people should have sophisticated epistemological beliefs in order to construct their knowledge (Jehng, Johnson, & Anderson, 1993; Muis & Franco, 2009). For 21st century people, it is not only important to reach the information, but also how to analyze and use the information (Wagner, 2008). Individuals are not only expected to have knowledge, what is expected from individuals is to be constantly open to learning, to look critically, to adapt to innovations, to cooperate, to bring solutions to problems, in short, to have 21st century skills (Olkun & Toluk, 2003). Also, Lobczowski, Allen, Firetto, Greene & Murphy (2020) stated that argumentation will help students to gain 21st century skills and such studies are needed. This research is important in terms of filling this gap in the literature.

The purpose of this study is to examine the effect of argumentation on 7th grade students' scientific epistemological beliefs and 21st century skills. The research problems are as follow:

1. Is there a statistically significant difference between the pre-test scientific epistemological beliefs score of the control and experimental group students?

2. Is there a statistically significant difference between the post-test scientific epistemological beliefs score of the control and experimental group students?

3. Is there a statistically significant difference between the pre-test 21st century skills score of the control and experimental group students?

4. Is there a statistically significant difference between the post-test 21st century skills score of the control and experimental group students?

METHOD

Research Model

In this study, a quasi-experimental design with pre-test and post-test control group was used (Fraenkel & Wallen, 2000). In the study, there are two study groups, the experimental group was treated with argumentation and the control group was treated with the learning-teaching methods applied in the current science curriculum, which includes constructivist approach such as 5E learning model. In order to determine the effect of two different teaching methods on students' epistemological beliefs, the Scientific Epistemological Belief Scale was administered to both groups as a pre-test and a post-test. In order to determine the effect of the treatments on students' 21st Century Skills, 21st Century Skills Scale was applied as a pre-test and post-test to the both groups.

Participants

The sample of this study was composed of seventh grade students from two intact classes of a middle school. The experimental group was composed of 21 boys and 17 girls and the control group was composed of 21 boys and 20 girls, totally 79 students. The groups were randomly assigned as a control and an experimental group. The groups were instructed with the same teacher.

Implementation

It has been determined that the recommended time for the unit of Reflection and Light Absorption in the Mirrors in the science curriculum is 20 lesson hours and this is four weeks (Ministry of National Education [MoNE], 2018). The time required for introductory activities for the students to get used to the argumentation and to get to know the teaching method was set as 2 class hours. A total of 4 lesson hours was allocated for the pre-test and post-tests. Control group and experimental group activities were carried out by the science teacher, the first author. The first author has over 10 years of professional science teaching experience and received training in argumentation. Ethics committee approval was obtained for the implementation of the study.

Control Group

In the control group, lessons were planned according to the 5E learning model. A sample lesson was carried out as follows: In engage; teacher asked "How do you see yourself when you look at the inner surface of a spoon?". Then, the teacher asked "How do you see yourself when you look at the outer surface of a spoon?”. Students discussed the questions, the teacher revealed the students’ prior knowledge and knowledge gaps, thus, students’ interest for the topic was fostered. In explore; students were required to examine the activity photos in the textbooks. They discussed the similarities and differences among photos. Then, in the explain phase, teacher asked the following questions respectively. "How was the image formed in the flat mirror in the photo you are examining?", "How was the image formed in the hollow mirror in the photo you are examining?", “How is the image formed in the bump mirror in the photo you are examining?”. After receiving the necessary explanations from the students, in elaborate phase, to deepen "How can submarines see the sea?" and "What difficulties would we have faced without mirrors?" questions were asked. In evaluation phase, in order to evaluate the students, students did the activity in the textbook.

Experimental Group

The activities were prepared by considering the argumentation model of Toulmin. While forming the activities, the opinions of academicians who are experts in argumentation were taken and then necessary corrections were made in line with the feedback received. The pilot study of the teaching activities was carried out with students who were in the same school with the study groups but were studying in another section. After the pilot study, the title "Let's Observe" in the first part of Activity 1 was changed to "Let's test our claim".

In the experimental group, a sample lesson was carried out as follows: the teacher asked "What are the types of mirrors we use in our daily life?" to attract students' attention to the lesson. Then, teacher asked "Are the mirrors in stores or crossroads same as the mirrors we use in our house?" to increase students' motivation towards the lesson and to strength the students’ attention. The teacher distributed worksheets to create a scientific discussion environment without confirming the correctness or falsity of the students' answers. In activity 1, the worksheet includes the following question “Can you reverse the image of an object using a flat mirror, concave mirror, or bulge mirror?”. The students argued with their groupmates and formed a *claim*. Then, each group defended and made an explanation with the *backing* of their claim. Each group used their *rebuttal* for counter arguments that could come from other groups, and tried to understand the topic. The teacher asked further questions such as "Why did you set this claim?", "What data did you use to support your claim?", "Have any other claims made within the group?", "What data did you use to refute the other groups’ opposing claims?". Then, teacher asked "Has your claim changed at the end of the discussion?". At the end of the activity, the process was evaluated by distributing a self-assessment form to the students.

Data Collection Tools

The Scientific Epistemological Beliefs Scale developed by Elder (1999) and adapted into Turkish by Acat, Tüken, and Karadağ (2010), and the 21st century skills scale adapted into Turkish by Karakaş (2015) were used as data collection tools in this study.

Scientific Epistemological Beliefs Scale

Elder (1999) 's scientific epistemological belief scale consists of four factors. These are: I: Certainty: Knowledge is certain, II: Evolving: Knowledge is less certain, changeable, evolving, III: Authority: Knowledge comes from authority IV: Reasoning: Knowledge emerges from reasoning, thinking and testing. Acat et al. (2010) adapted the scale to Turkish as I: Authority and accuracy, II: Knowledge production process, III: Source of knowledge, IV: Reasoning and V: Change of knowledge.

Scientific Epistemological Beliefs Scale is a five-point Likert type and consists of 25 items. Higher scores from each dimension indicate sophisticated belief, lower score indicate unsophisticated belief. The internal consistency coefficient of the scale was between 0.57 and 0.86 in the dimensions, and 0.82 for the overall scale (Acat et al., 2010).

21st Century Skills Scale

The scale developed by Karakaş (2015), and consists of three main dimensions (cognitive, affective and sociocultural) and 12 sub-dimensions. Cognitive dimension; knowledge management skill, knowledge structure skill, knowledge usage skill, problem solving skill; Affective dimension; self-identity, self-worth, self-management, self-responsibility; Sociocultural dimension; social membership, social sensitivity, socialization skill, social performance sub-dimensions.

The 21st century skills scale is a five-point Likert type. Higher score from each dimension indicates sophisticated skill, lower score indicates unsophisticated skill. The internal consistency coefficients, Cronbach alpha coefficients of each sub-dimension of the scale was .77, .70 and .67, respectively (Karakaş, 2015).

Data Analysis

MANOVA was used for analyzing the sub-problems of the study.

RESULTS

Findings on Scientific Epistemological Beliefs

The Scientific Epistemological Belief Pre-test Scores of the Control and Experimental Group Students

Before performing MANOVA, the assumptions were checked and the assumptions were not violated. For testing multivariate normality assumption, skewness and kurtosis values were checked and they are given in Table 1. Hair, Black, Babin & Anderson (2010) stated that skewness values of between -2 to +2 and kurtosis values of between -7 to +7 is considered as normal.

Table 1 Descriptive pre-test scientific epistemological belief scores of control group (CG) and experimental group (EG) students

	Mean	Standard deviation	Skewness	Kurtosis
Authority and accuracy(CG)	2.26	0.89	0.930	0.717
Knowledge production process (CG)	3.47	0.55	-0.647	0.088
Source of knowledge(CG)	2.46	0.93	0.949	0.228
Reasoning (CG)	4.07	0.71	-0.553	-0.332
Change of knowledge (CG)	3.79	0.93	-0.975	0.880
Authority and accuracy (EG)	2.17	0.92	0.802	-0.184
Knowledge production process(EG)	3.73	0.49	-0.342	-0.184
Source of Knowledge(EG)	2.51	0.76	0.194	-0.609
Reasoning (EG)	4.18	0.66	-1.08	1.597
Change of knowledge (EG)	3.95	0.83	-0.498	-0.498

For testing homogeneity of covariance assumption, Box's M test value indicated that the observed covariance matrices of the dependent variables are equal across groups (F=0.716, p>0.05). Students' epistemological beliefs scores are independent from each other so the independency assumption was met. One-way between groups MANOVA results showed that there was no statistically significant difference between the scientific epistemological belief pre-test scores of the control and experimental group students (F(5, 73) =1.22, p=0.309 Wilks' Lambda= 0.923).

The Scientific Epistemological Belief Post-Test Scores of the Control and Experimental Group Students

Before analysis, the assumptions of MANOVA were checked and were met. Like previous section, multivariate normality assumption was tested and skewness and kurtosis values are given in Table 2. Hair et al. (2010) stated that skewness values of between -2 to +2 and kurtosis values of between -7 to +7 is considered as normal.

Table 2 Descriptive post-test scientific epistemological belief scores of control group (CG) and experimental group (EG) students

	Mean	Standard deviation	Skewness	Kurtosis
Authority and accuracy(CG)	2.10	0.86	1.259	1.337
Knowledge production process (CG)	3.63	0.46	-0.438	0.020
Source of knowledge(CG)	2.56	0.76	-0.100	-0.643
Reasoning (CG)	4.14	0.82	-1.526	2.280
Change of knowledge (CG)	4.01	0.73	-0.719	0.351
Authority and accuracy (EG)	2.12	0.78	0.636	-0.127
Knowledge production process(EG)	3.61	0.50	-0.909	0.645
Source of Knowledge(EG)	2.75	0.64	0.207	-0.019
Reasoning (EG)	4.23	0.68	-2.10	5.436
Change of knowledge (EG)	3.90	0.82	-0.655	-0.185

For testing homogeneity of covariance assumption, Box's M test value indicated that the observed covariance matrices of the dependent variables are equal across groups (F=0.865, p>0.05). Students' epistemological beliefs post-test scores are independent from each other so the independency assumption was met. MANOVA results showed that there was no statistically significant difference between the scientific epistemological belief post-test scores of the control and experimental group students (F (5, 72) = 0.534, p=0.750, Wilks' Lambda= 0.964).

Findings on 21st Century Skills

The 21st Century Skills Pre-Test Scores of the Control and Experimental Group Students

The assumptions were met. Multivariate normality assumption was tested and skewness and kurtosis values are given in Table 3. Hair et al. (2010) stated that skewness values of between -2 to +2 and kurtosis values of between -7 to +7 is considered as normal.

Table 3 Descriptive 21st century pre-test scores of control group (CG) and experimental group (EG) students

	Mean	Standard deviation	Skewness	Kurtosis
Cognitive (CG)	3.62	0.66	-1.042	2.179
Affective (CG)	4.06	0.73	-1.866	5.232
Sociocultural (CG)	3.77	0.68	-1.113	1.753
Cognitive (EG)	3.77	0.58	-1.436	3.985
Affective (EG)	3.20	0.43	0.489	0.932
Sociocultural (EG)	3.91	0.56	-0.433	0.708

For testing homogeneity of covariance assumption, Box's M test value indicated that the observed covariance matrices of the dependent variables are equal across groups (F=1.087, p>0.05). Students' epistemological beliefs post-test scores are independent from each other so the independency assumption was met. MANOVA results showed that there was no statistically significant difference between the 21st century skills pre-test scores of the control and experimental group students (F(3, 75)=0.712, p=0.548, Wilks' Lambda= 0.972).

The 21st Century Skills Post-Test Scores of the Control and Experimental Group Students

The assumptions of MANOVA were met. Like previous section, multivariate normality assumption was tested and skewness and kurtosis values are given in Table 4. Hair et al. (2010) stated that skewness values of between -2 to +2 and kurtosis values of between -7 to +7 is considered as normal.

Table 4 Descriptive 21st century post-test scores of control group (CG) and experimental group (EG) students

	Mean	Standard deviation	Skewness	Kurtosis
Cognitive (CG)	4.10	0.80	-2.049	4.586
Affective (CG)	3.96	0.63	-1.203	2.367
Sociocultural (CG)	3.63	0.54	-0.456	-0.475
Cognitive (EG)	3.83	0.46	-0.352	0.021
Affective (EG)	4.21	0.39	-0.598	0.272
Sociocultural (EG)	4.01	0.48	0.064	-0.439

For testing homogeneity of covariance assumption, Box's M test value indicated that the observed covariance matrices of the dependent variables are equal across groups (F=1.007, p>0.05). Students' epistemological beliefs post-test scores are independent from each other so the independency assumption was met. The results showed that there was no statistically significant difference between the 21st century skills post-test scores of the control and experimental group students (F(3, 74)= 1.229, p= 0.305, Wilks' Lambda= 0.953).

DISCUSSION AND CONCLUSION

The Effect of Argumentation on Students' Scientific Epistemological Beliefs

The result of the study showed that no significant difference was found between pre-test scientific epistemological beliefs of the experimental and control group students. In other words, according to the pre-test results, the experimental and control group students have similar characteristics in terms of their scientific epistemological beliefs. After instruction, there was no significant difference between the post-test scores of control and experimental group students. Thus, it could be stated that argumentation did not affect students' scientific epistemological beliefs. While the present study result is similar to various studies (Noroozi & Hatami, 2018; Nussbaum & Bendixen, 2003), it differs with some studies (Noroozi, 2018; Schommer -Aikins & Hutter, 2002).

The reason that there was no significant difference in terms of scientific epistemological beliefs between the groups may be that the implementation took a short period of four weeks. Carey, Evans, Honda, Jay, and Unger (1989) stated that it is difficult to change students' epistemological beliefs. Similarly, Schommer (1994) and Conley et al. (2004) stated that it will take time for students to develop their scientific epistemological beliefs. In addition, the fact that the students did not sufficiently do research from various sources such as textbooks and internet and did not take an active role in the argumentation may have negatively affected the development of their scientific epistemological beliefs. The fact that the timid students in the classroom did not participate in these discussions too much may have negatively affected the development of their epistemological beliefs. On the other hand, because the current program applied in the control group is based on inquiry-based teaching, the scientific epistemological beliefs of the control group students may have developed.

Some studies show that students' epistemological beliefs can be improved by inquiry-based teaching methods (Conley et al., 2004).

Another result of the study is that the students showed different sophisticated levels in terms of scientific epistemological beliefs in different dimensions. This result supports that students' scientific epistemological beliefs may be at different sophistication levels for different dimensions (Deryakulu, 2004; Schommer, 1990; Schommer, 1994; Songer & Linn, 1991; Yenice & Ozden, 2013). Buehl, Alexander, and Murphy (2002) stated that according to the discipline-oriented epistemological belief, individuals believe that knowledge in science is more absolute and unchangeable than in social sciences. This is similar to the present study in that students got the lowest score in the authority and accuracy dimension. Ku, Lai, and Hau (2014) stated that "participants who think that knowledge can be known by authorities produce less counter-arguments, produce less detailed and weaker arguments". Thus, it can be that students cannot carry out argumentation activities in a qualified way.

The Effect of Argumentation on Students' 21st Century Skills

The result showed that no significant difference was found between the 21st century skills pre-test scores of the experimental and control group students. This result indicates that students have similar characteristics in terms of 21st century skills before the implementation. After the implementation, there was no statistically significant difference between the 21st century skills post-test scores of the experimental and control group students. The reason for the present research result is that the current program can be said to have a significant effect on improving students' 21st century skills. The current science program includes some 21st century skills such as creative thinking, critical thinking, entrepreneurship (MoNE, 2018). The other reason for this result may be that an implementation of four weeks is not sufficient for developing 21st century skills. Teachers stated that the classroom environment is not sufficient for the development of 21st century skills, and that there should be laboratory activities or workshops to gain these skills (Çolak, 2018). The absence of a laboratory in the school where the implementation was made may have negatively affected the development of students' 21st century skills.

Teachers stated that the weekly course hour of the science course is not sufficient for the development of 21st century skills (Çolak, 2018). The fact that the mean of the 21st century skills dimensions are above three, out of five, the teaching method could not develop students' 21st century skills in a short time. The fact that the students are at the almost sophisticated level in terms of 21st century skills is similar to the findings of Karakaş's (2015) study. Erol and Taş (2012) stated that the reason why students' 21st century skills are sophisticated may be due to the fact that activities aimed at problem solving, scientific research, creative thinking, entrepreneurship, communication, using information and technologies, and developing critical thinking skills are included in all courses. In addition to all these, the crowded classrooms in which the teaching method was applied may have negatively affected the development of 21st century skills. Çolak (2018) stated that class size is an important criterion for the development of 21st century skills, and class size plays an important role in the preparation and implementation of the activities according to the individual differences of the student. Clark et al. (2009) stated that students' participation in scientific discussions in online environments can support the development of 21st century skills. The use of online environments in crowded classrooms can be effective in effectively applying the argumentation.

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