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CONTENTS

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The Impact of High-Level Teacher Questioning on Elementary School Students' Achievement, Retention and Attitude in Science

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Abstract

This research aimed to investigate the impact of high-level teacher questioning on 6th grade students' science achievement, retention of learning and their attitudes toward science. A quasi-experimental pretest-posttest control group design was employed in this research. Participants consisted of 43 students enrolled in two intact 6th grade classes of a science teacher in a public elementary school. Two classes were assigned as either an experimental group or a control group randomly. Students in both groups were taught electricity concepts through student centered activities aligned with the national elementary school science curriculum. Difference between the two groups was the type of questions used by the teacher during the instruction. Background Questionnaire, Science Achievement Test, Attitude Scale and Structured Interview Form were used to collect data. ANCOVA results revealed a significant difference in science achievement and retention of learning across two groups, in favor of experimental group. However, independent t-test results demonstrated that students' attitudes toward science were not significantly different across the groups. Moreover, interview results supported the findings obtained from the achievement test.

Introduction

Innovations and developments in education and changing needs of society in the twenty-first century have influenced expected roles of the citizens of countries all over the world. This change demands having individuals who generate knowledge and transfer it to daily life, and are capable of using problem solving, critical thinking, decision-making, enterprising, empathy and communication skills (Ministry of National Education [MoNE], 2018). Instructional approaches used in science education are important in this context. One of the effective teaching approaches that helps to develop twenty-first century skills is inquiry-based learning.

Inquiry-based learning is a teaching-learning approach that emerged in the Western world in the 1950s. Being a process-oriented teaching pedagogy, it aims to teach how science is done as a process and procedure rather than teaching science as a body of knowledge. This approach has been emphasized as a main instructional approach to teach science to elementary school students in Turkish national science curriculum since 2013 (MoNE, 2013, 2018). Inquiry in the classroom varies depending on the relative amounts of student versus teacher control over an activity. There are essentially three forms of inquiry-based learning named as structured, guided and open inquiry. The more responsibility the learners take, the more open the inquiry. In a structured form of inquiry, students engage in investigations that are highly structured by teachers. In such an environment, learners follow prescribed procedure to test the questions provided by teachers. In an open form of inquiry, learners pose their own questions, design testing procedure, gather data, and make conclusions based on their own investigations (National Research Council, 2000).

Guided inquiry lies between structured and open inquiry. In this type of inquiry, investigation questions are provided by teachers, but the procedure is determined by learners. Students generally work in productive small groups while testing their questions; they make observations, record, analyze and interpret data. Each group summarizes their research and presents findings to the whole class. Throughout the process, students try to understand and discover new concepts. Teachers act as a guide and resource person in all steps of inquiry task. In order to stimulate learners to elaborate on their own views and draw conclusions based on their findings, teachers facilitate both small group and large group discussions (Martin, 2009).

Small group and whole class discussions naturally occur in effective inquiry-based classrooms. Some researchers in science education label these productive discussions as interactive scientific discussions (Chinn &

Anderson, 1998). Communication primarily occurs in the form of speech in the process of scientific discussion; students draw conclusions based on their investigations, revise their explanations considering others' feedback, provide evidence to support their claims and attempt to refute opposing viewpoints. Students' engagement in interactive scientific discussion increases their engagement and motivation to learn science and leads to conceptual change and scientific understanding (Chinn & Anderson, 1998; Kuhn, 1993).

Classroom Interactions

Mortimer and Scott (2003) proposed an analytical framework stemming from Vygotsky's theory of social development to analyze and describe student-to-student and teacher-to-student interactions in science classes. Classroom interactions could be in the form of either triadic or chain pattern. In a triadic pattern, classroom discourse proceeds in an order of Initiation-Response-Evaluation (IRE); where a dialogue is initiated by teachers with a question following students' responses and ended with teacher evaluation of the answers. Teacher's evaluation of a student's response limits other students' participation to express their own ideas. Chain pattern of discourse is in the sequence of Initiation-Response-Feedback-Response-Feedback (IRFRF). In this structure, teachers initiate the dialogue with a case or an interesting question, students respond to that question, teachers give feedback to students' responses as well as by asking for feedback from other students, without any evaluation. This sequence continues as response and feedback, which allows teachers to get different ideas from students.

Communicative approach is placed at the center of the analytical framework of Mortimer and Scott (2003). This approach concentrates on how diversity of ideas are developed through teacher-to-student interactions during lessons. The talk between teacher and students is categorized based on two dimensions. The first one is related to the degree of openness to different point of views, which ranges from authoritative to dialogic talk. Authoritative discourse does not acknowledge students' different ideas that are not aligned with the predetermined view. In contrast, dialogic discourse allows alternative thinking, students with different ideas are valued. The second dimension is related to the extent of participation of students, which ranges between non-interactive and interactive talk. An interactive classroom interaction involves engagement of more than one student, while a non-interactive one does not consider participation of others (Scott et al., 2006). Based on the two dimensions, communicative approach can be classified as follows: 1) interactive/dialogic, 2) non-interactive/dialogic, 3) interactive/authoritative and 4) non-interactive/authoritative (Scott et al., 2006; Scott & Mortimer, 2005). Teachers adopting interactive/authoritative communicative approach create an authoritarian classroom structure and allow participation of students for the purpose of supporting predetermined scientific view. The non-interactive/authoritative approach can be exemplified by expository teaching, where teachers deliver a predetermined view in the form of monologue. Role of teachers in an interactive/dialogic discourse is to value students' ideas, to take account of different point of views and to engage students in dialogues. In non-interactive/dialogic communicative approach, teachers explain different views to learners without allowing their involvement in the classroom discourse.

In an authoritative discourse, cognitive contributions of students are often excluded (Molinari et al., 2013; Molinari & Mameli, 2013). Teachers just focus on the scientific point of view and ignore alternative perspectives. Teachers can give information directly to the students, and evaluate the responses of the students such as right, wrong or incomplete. If the students' responses are not scientifically correct, teachers may not accept them or may refuse sharply (Edwards & Mercer, 1987; Lemke, 1990; McMahon, 2012). Although there is a student voice in this authoritative discourse, students' ideas that are not congruent with that of teachers are rejected. Teachers may summarize the main points of the lesson or classify the things based on their properties (Oh & Campbell, 2013; van Booven, 2015). In a classroom where dominant mode of discourse is dialogic, teachers encourage students to talk and debate with each other, to express their own thoughts freely, to listen to others, to develop scientific understandings, and to transfer newly acquired knowledge to new situations. Teachers moderate the discussion among the students. In a dialogic discourse, students' voices are heard in addition to teacher's voice. The important thing here is not only to hear the voices of the students but also emergence and consideration of different ideas (Mercer, 2010; France, 2019). Therefore, teachers may ask students to clarify or deepen their responses during the classroom talk (Pimentel & McNeill, 2013; Scott et al., 2006; van Zee & Minstrell, 1997). Teachers can also use focus moves to ensure students to monitor what is happening in the classroom (Christodoulou & Osborne, 2014; van Zee & Minstrell, 1997). In a dialogical discourse, teachers can encourage learners to take ownership for their learning (Crawford, 2000; Pimentel & McNeill, 2013). In addition, teachers can guide learners to assess, to critique, to judge and finally to legitimate their own and others' ideas and claims (Christodoulou & Osborne, 2014; van Zee & Minstrell, 1997). Moreover, teacher speech can lead students to present justified claims (Jadallah et al., 2011; McMahon, 2012; Soysal, 2019). For an effective dialogue in the classroom, a subject-matter topic that students are familiar with should be chosen and students need to be informed about providing evidence based on their investigations (Erduran et al., 2004). Previous experiences promote students' participation into classroom dialogues. If students connect new information into their existing cognitive structure, learning becomes meaningful and consistent. In addition, doing investigations in science classes facilitates students' development of reasoning skills and construction of evidence (Chen, 2020).

As highlighted above, teachers have an active role in a classroom interaction and take several actions that lead to interventions such as clarifying, elaborating, reviewing and sharing student ideas (Mortimer & Scott, 2003; Scott, 1998). A common form of teacher intervention is to support conceptual understanding by asking questions. Eliciting students' prior understandings and experiences via questioning helps to raise, maintain and resolve uncertainty which further leads to create and manage dialogic discourse (Chen, 2020). Through questioning, a teacher can introduce a new concept, concentrate on student response, mark key concepts, check students' understanding, make ideas available to whole class, and summarize what has been covered.

Teacher Questioning

Questioning is an integral part of educational process. Teacher questions are frequently used in science classrooms. When teachers ask the right questions for the right purpose and at the right time, they can help students to understand science phenomena (Lemke, 1990; Mortimer & Scott, 2003; Scott et al., 2006). Effective teacher questioning also leads to scientific inquiry and reasoning. Questions play a crucial role in explaining and summarizing ideas, proposing claims, and backing up those claims with evidence (Chin, 2004; Chin & Osborne, 2008).

High-level teacher questioning has a great impact on shaping discourse that occur in a classroom (Chin, 2007; France, 2019). Quality rather than quantity of teacher questions is effective in promoting student learning (Gall, 1970). Asking higher cognitive level questions facilitates students' connection of new information with their existing knowledge and accordingly increases their achievement (Çimer, 2007). To build a dialogic interaction, teachers need to ask questions that allow multiple potential student responses. The important thing is that questions asked by teachers should not have a single correct answer. It was reported that students could express their thoughts using compound and complex sentences with vocabulary specific to content when teachers ask open-ended questions that encourage student thinking (Morris & Chi 2020; Oliveira, 2010). Using multiple representations when asking questions facilitates students' construction of abstract knowledge in their minds (Chen, 2020). Moreover, studies have demonstrated that science classes initiated with open-ended teacher questions and sustained with student dialogues improve student achievement (Lee & Kinzie, 2012).

Studies demonstrated that students do not ask too many questions spontaneously when teachers do not ask any questions (Chin & Osborne, 2008; Aguiar et al., 2010). As teachers ask low-level questions, number of students' questions decreases (van Zee et al., 2001). Conversely, when teachers ask high-level questions, students' questions increase not only in quantity but also in quality (Chen et al., 2017). The quality rather than the quantity of students' questions was found associated with their achievement in their classes (Harper et al., 2003). These findings imply that it is crucial for teachers to adopt high-level questioning in order to build dialogic learning where learners develop high-level questions (Günel et al., 2012).

As stated above, productive teacher questioning practices has the potential of building an effective classroom environment where learners are encouraged to develop positive attitudes toward science. Attitude toward science is a significant affective construct described as the extent to which an individual likes or dislikes science (Oliver & Simpson, 1988). Students' feelings regarding classroom activities contribute to their learning and attitudes toward science (Salta & Tzougraki, 2004; Talton & Simpson, 1987). Studies have demonstrated that students' positive attitudes could be improved by using effective science instruction (Artino, 2012). Existing literature generally showed positive associations of attitudes toward science with science achievement (e.g., Liou et al., 2020).

Previous literature consistently demonstrate that communicative approaches adopted in science classes are predominantly authoritative (Ateş et al., 2016; Kaya et al., 2016; Mercer et al., 2009; Ryder & Leach, 2006). One reason of preference of authoritative approach rather than dialogic approach is its features of convenience and easy to use (Mercer et al., 2009). Another reason is related to lack of time because dialogic discourse requires much time compared to authoritative discourse (Uçak & Bağ, 2018). In order to have science classes aligned with the principles of inquiry-based teaching approach stated in national science curriculum (MoNE, 2018), teachers need to organize and maintain a classroom environment where dialogic communicative approach is adopted (Mortimer & Scott, 2003) and new social norms are constructed (Özmantar et al., 2009). However, studies reveal that teachers are not sufficient in creating dialogic interaction in science classes (Ateş et al., 2016; Kaya et al., 2016). Teacher questioning is a significant agent that leads to dialogic learning environment (Chen et al., 2017). Early studies mainly aimed to analyze and determine types of classroom discourse (Ateş et al., 2016; Kaya et al., 2016; Ulu, 2017). Different from those studies, this study adopted quantitative research design to investigate the impact of high-level teacher questioning on elementary school students' science achievement and retention of learning in electricity unit. Learning tasks that are fun, interactive and enjoyable help to develop positive attitudes toward science (Koballa & Glynn, 2004). For this reason, the impact of high-level teacher questioning on students' attitudes toward science was also investigated in this context. In addition, students' views about the intervention used in experimental group was elicited. Specifically, teacher questions that aim to initiate and maintain dialogic discourse were used as an intervention. This study has the potential of serving as a guide for teachers on using high-level questioning that encourage dialogic interaction and learning in science classes. Accordingly, following research questions were proposed:

1. What is the impact of high-level teacher questioning on 6th grade students' science achievement and retention of learning in electricity unit?
2. What is the impact of high-level teacher questioning on 6th grade students' attitudes toward science?
3. What are the views of 6th grade students regarding the implementation of the high-level teacher questioning?

Method

Design of the Study

This study utilized a quasi-experimental pretest-posttest control group design in order to investigate the impact of high-level teacher questioning on students' science achievement, retention of learning and attitudes toward science. Quasi-experimental design is frequently used in educational research when random assignment is not possible or practical (Fraenkel et al., 2012). The dependent variables were scores on Science Achievement Test and Attitude Scale while the independent variable was teacher questioning.

Participants

Participants included 43 students enrolled in two 6th grade classes of a public elementary school in a city located in the central region of Turkey. Convenience sampling technique was utilized for selecting participants in this study. Convenience sampling can be used in cases when it is difficult to choose a random or systematic non-random sample. In this type of sampling, a certain group of people are chosen because of their availability and easy access (Fraenkel et al., 2012). All taught by the same teacher, one class was assigned as experimental group (13 boys and 9 girls) and the other class as control group randomly (12 boys and 9 girls). Students' ages were between 12 and 13 years old.

Data Collection

Data were gathered using Background Questionnaire, Science Achievement Test, Attitude Scale and Structured Interview Form. Details about these tools were provided below.

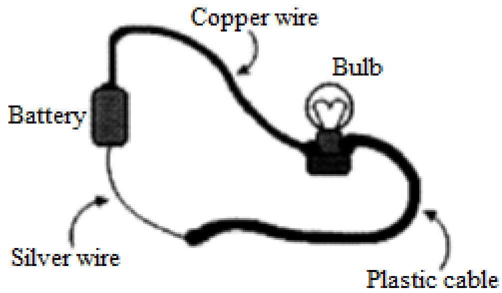
Background Questionnaire

This questionnaire was administered to the students to provide information about their background characteristics, namely, age, gender, previous science grade, and educational level of parents. Level of education completed by parents were asked in multiple-choice format with following options: 1- primary school, 2- elementary school, 3- high school, 4- university and 5- postgraduate degree.

Science Achievement Test

This test was constructed by the researchers to assess students' achievement in electricity unit. In the first stage, an item pool consisting of 34 questions was generated considering the objectives of the 6th grade electricity unit stated in the national elementary school science curriculum (MoNE, 2013). Researchers benefited from textbooks and nationwide student selection exams for high schools when writing test items. For content validity, a table of specification, that include objectives of the electricity unit and items for each objective, was prepared by the researchers. Questions were also considered to be at different cognitive levels of Bloom's taxonomy. Then, an expert in science education was consulted to render judgment on the appropriateness, adequacy and suitability of the science achievement test using the table of specification. This test was also examined by a Turkish language teacher and an elementary school science teacher for face validity. Based on comments provided by the experts, some items were revised, some were discarded. In all, 20 items were included in the final form of the test. A pilot study was conducted with 20-item science achievement test to assess its reliability. Reliability of the instrument was computed as .84 using Kuder-Richardson (KR-20) formula.

Final version of science achievement test included 20 multiple-choice questions in the electricity unit (See Figure 1 for sample item). Items were related to conductive and insulating materials, electrical resistance and factors affecting electrical resistance. Each item included one correct answer and three distracters. One point was given for each correct response; zero point was given for non-response or a wrong response. Total score of the test ranged between 0 and 20. Science Achievement Test was used in the two groups as a pretest before the treatment, a posttest after the treatment, and a retention test four weeks after the posttest. All tests were administered by the teacher in a class hour.



Which of the following should be done to light up the bulb in the above electric circuit?

A) Copper wire should be used instead of silver wire.
B) Plastic cable should be used instead of copper wire.
C) Silver wire should be used instead of plastic cable.
D) Silver wire should be removed from the circuit.

Figure 1. A sample item used in Science Achievement Test

Attitude Scale

Students' attitudes toward science were assessed utilizing Attitude Scale developed by Akıllı (2008). The scale consists of 28 items (e.g., "I like science classes") measured on a 5-point Likert type scale ranged from 1 = fully disagree to 5 = fully agree. It includes both positively and negatively worded statements. After reverse coding of negatively worded items, total score was calculated. The minimum score of this scale was 28; while the maximum was 140. Higher scores indicate positive attitudes of the students while lower scores express negative attitudes toward science. A reliability coefficient of .85 was obtained for the original scale while it was computed as .86 for the present study. This scale was administered to both groups before and after the instruction and took approximately 15 min.

Structured Interview Form

In order to support the experimental data, a structured interview was constructed by the researchers and conducted to the experimental group students. A researcher in science education was consulted to examine the first draft of the interview form which included five open-ended questions. Interview form was revised and re-organized by combining similar questions, and the number of open-ended questions was reduced to three, based on the comments of the expert. The reason behind the use of a structured interview form was to elicit students' opinions regarding the instruction guided by high-level teacher questioning in order to support findings obtained from self-report instruments. Through interviews, students were asked to compare their science classes in electricity unit with that of in previous units (e.g., How do you compare your science classes in electricity unit with that of in previous units?). Students were also asked to describe any changes that they observed in themselves and their teacher throughout the implementation. Face-to-face interviews were conducted by the first author with five volunteering students. All interviews were audio recorded after informed consent was obtained. The interviews lasted approximately 15 minutes.

Procedure

This study lasted four weeks with four 45-min sessions per week. Electricity concepts were instructed as part of the regular science curriculum by devoting equal amount of instructional time for both groups. Students in both groups were instructed using student centered activities aligned with the national elementary school science curriculum. The difference across two groups was teacher questioning strategy during the instruction. For internal validity, both groups were instructed by one of the researchers, who is also a science teacher in the elementary school selected for this study. The teacher is a PhD in science education and took several PhD courses (e.g., discourse analysis). He is also experienced in teaching science for 15 years. In order to minimize implementation threat to internal validity, lessons, especially classroom interactions were video-recorded by the teacher in both groups, after obtaining necessary permissions and consent forms. Prior to the instruction, the Science Achievement Test and Attitude Scale were administered to the students in the two groups. Following the instruction, the same instruments were given to both groups. At the end of the implementation period, face-to-face structured interviews were held with five volunteering students in the experimental group in order to elicit students' opinions regarding the instruction guided by high-level teacher questioning. One month later, Science Achievement Test was re-administered to all of the students as a retention test.

Implementation in Control Group

Lesson plans were developed considering the instructional approach specified in national elementary school science curriculum. Students engaged in experiments and activities related to the conductive and insulating materials, electrical resistance and factors affecting electrical resistance. In choosing classroom activities, the teacher used textbook, smart board, and Education Information Network which is developed by Turkish Ministry of Education. Students conducted experiments in the laboratory after the teacher reminded students of the laboratory safety rules. During the laboratory activity, students recorded their observations and then they interpreted their data. Students individually filled out a laboratory report which included following sections: Purpose, materials, procedure, observations and data, and conclusion. Students were also asked to respond questions both included in the textbook and provided on the smart board. The teacher mostly asked knowledge and procedural questions which require students to give short answers without leading to any further dialogic interaction (e.g., What are conductors? What materials are generally used as conductors?). As in his previous classes, the teacher also did not use effective talk moves in the classroom. Therefore, in the control group, dialogic interaction did not occur.

Implementation in Experimental Group

The instructional process followed in both groups was the same except teacher questioning. In the experimental group, the teacher asked questions that allow discussion and debate in the classroom. When students were asked to respond questions included in their textbook or shown on the smart board, they were also asked to provide reason for their answer in oral or written format. Types of the questions used in the experimental group allowed students' participation in learning tasks and helped to create dialogic interaction in the classroom environment. The purposes of the questioning are shown in Table 1.

Table 1. Purpose of questioning along with samples

Purpose of questioning	*Sample question*
require students to give reasons for their responses	Why do you think like that? How do you know?
make students to provide evidence for their claims	Do you have data that support what you said? What is your evidence?
make students to convince others	How do you convince your classmate?
to clarify students' responses	I could not understand, could you repeat and explain a bit more?
to facilitate student-to-student interaction	Does it make sense to you? What do you think about your friend's idea?

In order to illustrate how teacher questions facilitated dialogic talk, an excerpt of classroom interaction related to the conductive and insulating materials is given in Table 2. This table indicate that teacher questions helped to create a discussion environment, which can be defined as interactive/dialogic interaction. The teacher attempted to get student response in accordance with chain pattern. Students were encouraged to provide reasons for their answers, and thereby it was aimed to make students construct knowledge in their minds rather than simple memorization and recall of facts and information. Although students had difficulty in adapting to such dialogues in the classroom at the beginning, they got used to it in time.

Table 2. An excerpt of classroom interaction drawn from experimental group

Line	Person	Speech
1	Teacher	What are the differences between the properties of conductive and insulating materials? What property does it take for a substance to be conductive?
2	Student 1	It might be related to density of materials.
3	Teacher	How?
4	Student 1	For example, gold is a good conductor. Its density is also high.
5	Teacher	So you mean that plastic has lower density? How do you know that the density of gold is more than that of plastic?
6	Student1	We learned in our lesson (We did its experiment).
7	Teacher	Well, so the amount of it (gold) in the same volume was heavier, right? So, what kind of property can the substance of high density have so that it transmits the electric current more?
8	Student1	Since its particles are closer together, it is easier to transmit electricity.
9	Teacher	So is it easier for it (electricity) to jump from one side to another side?
10	Student 2	Sir, the number of particles per unit volume is equal to density.
11	Teacher	Density is the number of particles per unit volume… Well, as your friend said … So if you take equal volumes of gold and plastic and weigh them, the gold weighs more, doesn't it? As your friend said, the mass per unit volume is higher. Does anyone want to add anything else? Any other thoughts?... So, because the particles are close to each other, you mean that the transmission of electricity is easier?
12	Students	Yes…
13	Teacher	Does anyone want to summarize what your friends are saying? Is there anyone who wants to compile and gather (ideas), and compile and say it stems from …?

Data Analysis

Quantitative data were analyzed using parametric tests with IBM 21 SPSS software because skewness and kurtosis values of the dependent variables ranged between -2 and +2 (Can, 2017). Pretest scores on Science Achievement Test and Attitude Scale were analyzed through independent t-test. The groups were compared on the posttest mean scores of Science Achievement Test using Analysis of Covariance (ANCOVA) by controlling the pretest scores. Posttest scores of the Attitude Scale and retention test scores of the Science Achievement Test were analyzed via independent t-test. The statistical decision was made using a significance value of .05 ($p < .05$). For independent t-test analysis, Cohen's *d* index was computed to find out the size of the difference across the groups. Effect size was interpreted based on the criteria suggested by Cohen (1992) as small ($.2 < d < .5$), medium ($.5 < d < .8$) and large ($d > .8$). For ANCOVA, partial eta squared value was interpreted for effect size measure. Green and Salkind (2014) suggested values for small ($.01 < \eta^2 < .06$), medium ($.06 < \eta^2 < .14$), and large ($\eta^2 > .14$) effect sizes. Meanwhile, the data obtained from structured interviews were analyzed descriptively. Audio recordings obtained from interviews were transcribed into text and the findings were presented based on the questions used in the interviews. Direct quotations were also used to highlight the students' opinions. The interviewees were named from Student 1 to Student 5 due to ethical concerns.

Results

Findings obtained from the administration of Background Questionnaire, Science Achievement Test and Attitude Scale were presented in this section. The findings of the student interviews were also reported.

Findings of the Background Questionnaire

Independent t-test results comparing students' scores on background characteristics across two groups were depicted in Table 3.

Table 3. Independent t-test results on students' background characteristics

Dependent Variable	Group	n	Mean	SD	t	df	p
Previous science grade	Experimental	22	66.95	21.91	1.23	41	.225
	Control	21	59.86	15.44			
Mother education level	Experimental	22	2.00	.98	-.97	41	.338
	Control	21	2.29	.96			
Father education level	Experimental	22	3.09	1.23	.67	41	.510
	Control	21	2.86	1.06			

As shown in Table 3, prior to the treatment, experimental group held higher mean scores than the control group with respect to previous science grade. Independent t-test analysis revealed that mean scores of previous science grade were not significantly different across two groups, $p > .05$. Table 3 also shows that students' parent education level was generally lower than high school. Education level of mothers was found lower than that of fathers. The difference in parent education level was not significant between the two groups, $p > .05$. From these results, it may be interpreted that both groups were equal prior to the instructional treatment in terms of students' background characteristics.

Findings of the Science Achievement Test

Science Achievement Test was administered as a pretest before the treatment, a posttest after the treatment and a retention test one month after the posttest. Independent t-test results comparing the two groups with respect to pretest scores on Science Achievement Test were depicted in Table 4.

Table 4. Independent t-test results on pre-test scores of science achievement

Group	*n*	*Mean*	*SD*	*t*	*df*	*p*
Experimental	22	9.55	3.42	2.06	41	.046
Control	21	7.62	2.64			

As shown in Table 4, experimental group held higher mean scores than the control group with respect to science achievement, prior to the treatment. Independent t-test analysis revealed that difference in the mean scores of science achievement was significantly different across two groups, $p < .05$. This result demonstrated that the two groups were not equal prior to the instructional treatment in terms of science achievement. Therefore, Analysis of Covariance (ANCOVA) was run for analyzing students' posttest scores on Science Achievement Test in order to control the effect of the pretest scores (Table 5).

Table 5. ANCOVA results on the posttest mean scores of science achievement across two groups using pretest mean scores as a covariate

Source	Sum of Squares	df	Mean Square	F	p	Partial eta squared
Pretest	226.46	1	226.46	18.26	.000	.31
Group	67.87	1	67.87	5.47	.024	.12
Error	495.99	40	12.40			
Total	7611.00	43				

Table 5 shows that experimental group students ($n = 22$, $Mean = 14.50$, $SD = 4.62$) significantly outperformed those in the control group ($n = 21$, $Mean = 10.38$, $SD = 3.71$) on posttest scores of science achievement, $p < .05$. Partial eta squared value was computed as .12, indicating a medium effect size. This finding suggests that observed difference was not only statistically significant but also practically meaningful, which also means that high-level teacher questioning really does have an effect on science achievement. One month after the posttest, Science Achievement Test was administered as a retention test. Table 6 displays independent t-test findings across the groups with respect to retention of learning.

Table 6. Independent t-test results on retention test scores of science achievement

Group	*n*	*Mean*	*SD*	*t*	*df*	*p*
Experimental	21	14.71	4.27	2.66	40	.011
Control	21	11.43	3.71			

Table 6 demonstrates both a statistically significant and practically important difference in students' retention test scores of science achievement in the favor of experimental group ($p < .05$; Cohen's $d = .82$). This finding also reveals the long-term effects of high-level teacher questioning on students' science achievement.

Findings of the Attitude Scale

Independent t-test results comparing the two groups in attitude toward science were depicted in Table 7.

Table 7. Independent t-test results on attitude toward science

Dependent Variable	Group	n	Mean	SD	t	df	p
Pretest	Experimental	22	97.73	12.95	.60	40	.55
	Control	20	95.15	14.73			
Posttest	Experimental	22	101.45	13.18	.93	40	.358
	Control	20	98.45	7.07			

As shown in Table 7, students in the experimental group held higher mean scores in attitude toward science than those in the control group both before and after the implementation. Independent t-test results demonstrated that difference in both pretest and posttest mean scores of attitude toward science were not significantly different across two groups, $p > .05$.

Findings of the Student Interviews

Interview results revealed that students mainly viewed the difference between the instructional approach followed in electricity unit and the instruction used in previous units as teacher questioning. Students thought that the teacher asked thought-provoking questions while teaching electricity unit. They also stated that the teacher gave feedback to their responses without evaluating them as correct or false, and directly giving the correct response. For example, a student stated his ideas as follows; "The teacher was asking us questions. He did not say the answer even if we did not give the correct answer".

Based on the students' views, the teacher also extended and elaborated students' responses. The teacher gave value to students' ideas; that is, he tried to take opinions of everyone in the classroom and asked for different points of view. For example, a student responded as follows: "(Our teacher) was taking opinions and views of whole class, asking for any other answer". Students expressed that the teacher questioned why they thought like that, following their responses. Students further claimed that they understood electricity unit very well because of the teacher's 'why' questions followed by 'what' questions. For instance, a student stated her views as, "...Our teacher asked us to answer the questions by providing reasons. Therefore, I understood the subject better.".

Interview results further indicated a positive shift in students' attitudes toward science. Interviewees viewed science classes as entertaining, not boring. They expressed that instructional approach used in the electricity unit caused them some positive changes, such as learning better, talking much and getting higher grades. For instance, an interviewee expressed her opinions as, "I think, it (science class) was different from other (previous) units, simple and fun. I'd like to have science classes in a way that is used in the electricity unit. Because, for me, it's fun in this way". Moreover, almost all of the interviewees preferred to have further science classes as in the electricity unit.

Discussion

This research examined the impact of high-level teacher questioning on science achievement, retention of learning, and attitudes toward science in electricity unit at elementary school level. The findings revealed significant differences both in posttest and retention test scores of science achievement across the groups in the favor of the experimental group, revealing a large effect size. This finding implies that as teachers ask questions that aim to initiate and maintain dialogic discourse, their students' science achievement increases and this impact is persistent over time. This result is aligned to the previous research revealing positive impacts of effective questioning on learning and achievement (Chin, 2004; Chin & Osborne, 2008; Güveli, 2019). Questions asked in the classroom serve as a key factor in learners' elaboration of their own ideas, construction of new claims, and providing evidence to support those claims. High-level teacher questioning facilitates students' construction of their own knowledge in their minds and long-term retention of knowledge. Teachers have the main responsibility in creating a learning environment that allows students to ask questions and transforming the classroom interaction from authoritative to dialogic. However, studies consistently reveal that most teachers do not use effective questioning strategies in their classrooms (Zhu & Edwards, 2019; Cumhur & Güven, 2018). Asking high-level and follow-up questions activate students' thinking processes, which in turn lead students to participate in classes and learn the concepts better (Günel et al., 2012; Lim et al., 2020). Asking high-level questions stimulates recall of prior knowledge and facilitates students' connection between the concepts (Harper et al., 2003, Çimer, 2007). As the level of the teacher questioning increases, the students tend to think critically considering multiple perspectives and give a longer and more in-depth response rather than just "yes" or "no" (Aziza, 2018; Schindler et al., 2018).

Meanwhile, the findings of the current study demonstrated a non-significant difference in attitudes toward science across two groups. This study is similar to that of Uyanık (2016) who found a significant difference in academic achievement and retention but not a significant difference in attitude of 4th grade students in a research testing the effect of learning cycle method in primary science. The reason of having a non-significant group difference in students' attitudes toward science might be associated with relatively short period of the study. Although the teacher had an experience of 15 years, his experience in using high-level questioning in science classes was limited to six months at the time of the study. Studies consistently have revealed that at least 18 months is required for significant changes in teachers' questioning pedagogy (Chen et al., 2017; Martin & Hand, 2009). Moreover, four-week experimental procedure might be limited for development in students' attitudes toward science. This finding is congruent with the existing research indicating that change in attitude requires time to occur (Ferkany et al., 2014; Kapici et al., 2020; Uyanık, 2016). Moreover, using self-report instrument for measuring attitudes toward science might be limited in assessing the impact of the treatment because interview findings of the current research demonstrated positive attitudes toward science in the experimental group. Similar long-term studies using in-depth qualitative data might be useful in enhancing our understanding regarding the impact of high-level questioning on students' attitudes toward science.

Interviews also elicited students' opinions about the intervention used in experimental group. Students thought that teacher questioning process which include thought provoking questions, non-evaluation of responses, extending and elaborating responses, and valuing students' ideas created an entertaining learning environment and contributed to their understanding of science concepts. Such findings suggest that effective teacher questioning has positive impacts on students' learning outcomes. Results of the interviews are also congruent with the results of the current research indicating the impact of high-level teacher questioning on students' science achievement and retention of learning.

Conclusion and Recommendations

This study highlighted the role of effective teacher questioning in creating dialogic classroom interaction and thereby increasing students' science achievement and retention of learning. Dialogic talk is an important aspect of inquiry-based teaching approach which has been emphasized in school science curricula of many countries including Turkey (MoNE, 2013, 2018). However, studies consistently revealed that teachers generally adopted authoritative approach in science classes (Ateş et al., 2016; Kaya et al., 2016; Mercer et al., 2009; Ryder & Leach, 2006). This study can guide teachers on how they can create dialogic interaction through effective questioning, and in turn how they can improve their instructional practices. If teachers ask high-level questions to students, they become more effective and efficient in the classroom, sustain dialogues with their students and feel more confident in teaching (Forster et al., 2019; Karademir et al., 2019; Rodriguez & Bonner, 2018).

In interpreting the results of this research, it is worth to consider following limitations. First, duration of the research was limited to four weeks. There were significant improvements in students' science achievement and retention of learning. However, students' attitudes toward science was not significantly improved. Similar long-term studies might be undertaken to examine the impact of teacher questioning on students' attitudes toward science. Another limitation of the research is related to the sample size and sample selection procedure. This study comprised a relatively small sample size and utilized convenience sampling which limits the generalizability of the findings. Therefore, similar studies can be conducted on larger samples representing the population. Future studies with different levels of students in a variety of context and investigating the effect of student questioning on different learning outcomes are also recommended.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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The Relationship between Academic Coping, Approach Achievement Goals and the Fear of Shame and Embarrassment in Science Class

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Abstract

This study aims to examine the relationship between approach achievement goals, the fear of shame embarrassment failure, and coping strategies in secondary school science courses. Academic coping was handled in four dimensions: positive, projective, denial, and non-coping. The sample of the study included 249 sixth, seventh, and eighth-grade students studying at one of the largest cities in the eastern part of Turkey. Descriptive statistics of variables were determined with the SPSS program. The relationship between the variables of the study was examined with the path analysis using the Amos program. According to the results of the analysis, a positive correlation was found between performance-approach goals and positive coping strategies. Fear of shame and embarrassment was positively correlated with positive coping and non-coping from the coping strategies and with mastery-approach goals from the approach achievement goals.

Introduction

Coping is defined as the strategies used to manage a negative or stressful event or an academic failure. Coping can also be defined as a response to the barriers to achieving one's cognitive, behavioral, or emotional goals. (Folkman & Moskowitz, 2004; Kamins & Dweck, 1999; Lazarus & Folkman, 1987). In the educational environment, students face academic difficulties such as difficult tasks, group work and exams that affect their cognition and they experience the fear of failure. The fear of failure is directly related to how people define and perceive academic failure (Elliot & Sheldon, 1997; Elliot, 1999). Students' fear of failure in the learning environment constitutes both a cognitive and complex stress response (Bledsoe et al., 2018; Raftery-Helmer & Grolnick, 2016; Skaalvik, 1999). Achievement goals are one of the reasons why students manage their emotions when they face stressful academic situations and how they survive this difficult period. Achievement goals are more about why students want to do well in a task or exam rather than being successful in an exam or a task (Ames, 1992; Urdan, 1997; Pintrich, 2000). Related research shows that students' achievement goals are significantly linked to their use of various coping strategies (Brdar et al., 2006; Friedel et al., 2007; Flavell, 1999).

The Relationship between Academic Coping and Approach Achievement Goals

Academic coping is behaviors, strategies, or emotions used to deal with an event, such as a response to negative events or stress (Folkman & Moskowitz, 2004; Kamins & Dweck, 1999; Lazarus & Folkman, 1987). Tero and Connel (1984) categorized coping strategies into four categories: positive, projective, denial and non-coping strategy. In positive coping students ask for help and find out where the wrong was performed, students blame other people in projective coping, students try to ignore failure and tell that failure is not important in denial coping. Finally, non-coping refers to self-accusation. These students feel terrible if they choose not to cope (Friedel et al., 2007; Kaplan & Midgley, 1999). Some coping strategies are related to positive outcomes and others are related to negative outcomes. Therefore, researchers categorized coping strategies as adaptive and maladaptive strategies. Maladaptive coping strategies include projective coping, denial coping and non-coping, and adaptive coping strategy includes positive coping. According to the relevant literature, students' use of various coping strategies is significantly related to goal orientation. According to the researchers, mastery goals are positively related to adaptive coping strategy, and performance goals are positively associated with maladaptive coping strategies (Brdar et al., 2006; Friedel et al., 2007; Ntoumanis et al., 1999; Taye & Zhou, 2009). Based on the aforementioned studies, the use of various coping strategies of the students and the results of the students' achievement goals were examined in this study.

The Relationship between Academic Coping and the Fear of Shame and Embarrassment

According to previous research, the fear of failure has indirect effects on choosing a task, performing a task to complete it, and success behaviors. (Elliot & Church, 1997; Elliot & Sheldon, 1997; Elliot & McGregor, 1999; Conroy & Elliot, 2004; Elliot et al., 2005). Based on the domino effect of fear, fear is seen as a precursor to direct achievement goals (Elliot, 1999), and achievement goals are thought to directly affect achievement behavior. The fear of failure is seen as the determinant of the approach achievement goals. Researchers have stated that the most important factor underlying the fear of failure is the sense of shame and embarrassment. (Atkinson, 1957; McGregor & Elliot, 2005). The first dimension of the fear of failure, the fear of failure based on shame, expresses people's negative self-evaluation of themselves. The fear of failure is seen as a tendency to perceive the embarrassment and a possibility to be humiliated by peers, for this reason, students try to avoid failure (Atkinson, 1957; Conroy, 2001; Conroy et al., 2002; Conroy et al., 2002b; Conroy et al., 2003; Conroy & Elliot, 2004; Elliot et al., 2005; McClelland et al., 1953; Sagar & Stober, 2009). Students with a high fear of failure are more ashamed of failure than those with low fear of failure (McGregor & Elliot, 2005). According to related studies, it is generally seen that students' fear of failure is associated with using maladaptive coping strategies (Blankstein et al., 1992; Veisson et al., 2004). In other words, students with low fear of failure are more successful in coping with fear.

The Relationship between Approach Achievement Goals and the Fear of Shame and Embarrassment

Students focus on improving themselves in mastery-approach goals while they show themselves sufficient and hardworking to others in performance-approach goals (Pintrich, 2000; Pintrich & Schunk, 2002). Students' learning environments affect their goal orientation (Greene et al., 2004; Linnenbrink, 2004). It is thought that embarrassment might be involved in important ways of adapting the student to the learning environment and in student learnings (Johnson, 2012). The fear of failure is a precursor to achievement goals (Elliot, 1999; Elliot & Sheldon (1997). In previous studies, performance-approach achievement goals were positively associated with the fear of shame and embarrassment and general failure fear (Conroy & Elliot 2004; Conroy et al., 2004; Nien & Duda, 2008). Besides, no relationship was found between mastery-approach goals and the fear of failure (Conroy et al., 2003).

Purpose and Proposed Model of the Study

In the above-mentioned literature, it is thought that approach achievement goals and the fear of shame embarrassment failure in science courses significantly affect students' use of various coping strategies. In addition, the fear of shame and embarrassment is thought to be the essence of the fear of failure (Atkinson, 1957; McGregor & Elliot, 2005) and it is associated with approach achievement goals. However, it is seen that previous studies were generally conducted in Western countries in terms of the relationship between related variables. Given the possibility that the relationship between approach achievement goals and other variables might be influenced by socio-cultural factors in different contexts (Mclnerney, 2008; Sungur & Senler 2009), further studies on this issue are needed.

Students often experienced shame and embarrassment because of their failure and attributed the failure to a lack of talent (Mcgregor & Eliot, 2005). Atkinson (1957) associated shame with fear of failure and stated that shame is the equivalent of pride. While shame is an extremely disruption feeling, it is seen as the core of the fear of failure, and an intrinsic feeling that guides one's achievement goals and coping strategies (Gilbert, 1998). Shame appears as an emotion that affects the whole self of the person who can be devastating.

This study was conducted with students in the exam-oriented competitive education system in Turkey. The results obtained from the science lesson of secondary school Turkish students might show some inconsistencies with the students in Western countries. Sungur and Senler (2009) and Kahraman and Sungur (2013) interpreted the findings considering the Turkish education system and culture. Investigation of achievement goals in terms of various variables in both Western and non-Western cultures can provide an opportunity for effective instructional design to investigate the impact of culture on learning and teaching.

Given the relevant literature, there are studies that examine the relationships between different variables such as fear of shame and embarrassment with coping strategy (Elliot, et.al., 2005; McGregor & Elliot, 2005; Sagar & Stober, 2009); approach achievement goals with coping strategy (Brdar et al., 2006; Friedel, et.al., 2007; Zhou & Kam, 2017); fear of shame and embarrassment with approach achievement goals (Bartels & Ryan, 2013;

Conroy & Elliot 2004; Conroy et al., 2003). However, there are a limited number of studies in which coping strategy, fear of shame and embarrassment and approach achievement goals are examined together. In the present study, the relationship between all variables was examined using a path model considering the relevant literature. Path analysis can allow simultaneous examination of the relationships between variables. This study aims to investigate the relationship between approach achievement goals, the fear of shame embarrassment failure, and academic coping strategies in secondary school science lessons. The research model formed in accordance with this aim and the relevant literature is presented in Figure 1.

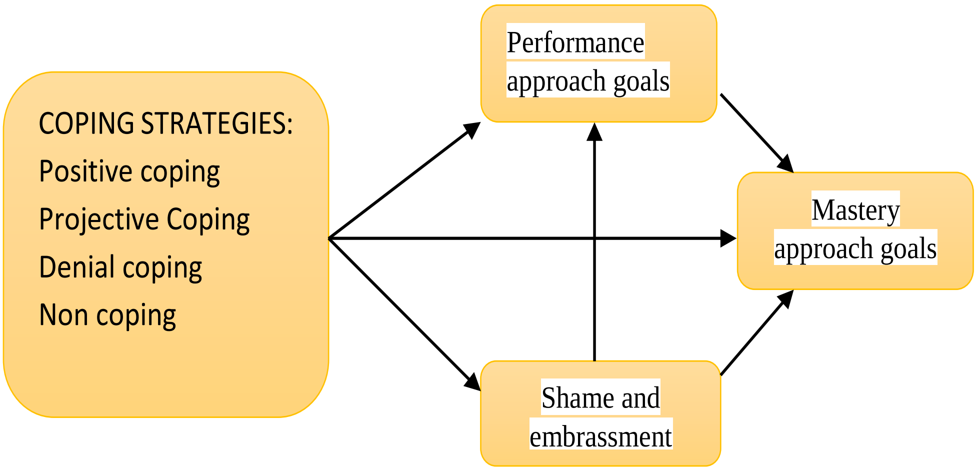

Figure 1. A proposed research model for the relationship between academic coping, approach achievement goals and fear of shame and embarrassment in science

Method

This study is a correlational study in terms of examining the relationship between variables. Correlational research is the study of the relationships between two or more variables without any interference with the variables. The current study is a correlation study that examines the relationships among the fear of failure, approach achievement goals, and academic coping strategy. By use of this method, it is aimed to reveal the relations among the variables of interest and determine the levels of relations. The relationship between the literature-supported model and the data was examined by the path analysis method.

Sample

Participants of the study involve 6th, 7th, and 8th grade students studying in four public schools in the city of Erzurum. Erzurum is one of the largest cities in the eastern part of Turkey. The schools where the study would be carried out were selected through convenience sampling. These schools were easily accessible to the authors of the study. In the current study, there were 249 participants; 109 (45.60%) of whom were female students and 130 (54.40 %) of whom were male students. The study involved 91 (38%) 6th grade students, 97 (40%) 7th grade students, and 51 (21%) 8th grade students. The mean age of the participants was 12.62. (SD= .93). The students' year-end average for a science lesson was 80.10 over 100 in the previous term (SD=12.9).

Data Collection Tools

The data were collected through Demographic Information Questionnaire, Fear of failure Inventory, Achievement goals Questionnaire, and Academic Coping Inventory.

Demographic Information Questionnaire

With the purpose of obtaining background information about the students, the participants were asked about their gender, date of birth, grades, the year-end score for a science lesson in the previous term.

Fear of Failure Inventory

Fear of failure inventory was developed by Conroy et al. (2002a) to assess the fear of failure of the students. It was adapted into Turkish by Kahraman and Sungur (2013). It is a five-point Likert scale (1= Strongly Disagree, 5= Strongly Agree) with 25 items. The scale includes five sub-dimensions. In the current study, the sub-dimension of the scale's fear of shame and embarrassment (n = 7 items, e.g. When I fail, it is embarrassing if others are there to see it) was used. The results of the confirmatory factor analysis conducted by Kahraman and Sungur (2013) provide evidence about the validity of the Turkish version of the scale. Cronbach's alpha reliability coefficient was estimated .80 for the fear of shame and embarrassment. The reliability levels obtained in this study were similarly high. Cronbach's alpha coefficient for the fear of shame and embarrassment was .853.

Achievement Goals Inventory

Achievement goals inventory was developed by Elliot and Church (2001) to assess students' adaptation of goals. It is a five-point Likert scale ranging from strongly agree to strongly disagree. It consists of 15 items in four sub-scales namely: mastery-approach goals (3 items), mastery avoidance goals (3 items), performance-approach goals (3 items), and performance-avoidance goals (6) items. The current study was carried out with the sub-dimensions of mastery-approach goals and performance-approach goals.

Mastery-approach goal is about self-improvement, learning new things, and developing skills. (e.g. I desire to completely master the material that presented in this science lesson). Performance-approach goal is related to the willingness to show their knowledge and skills to others and to appear more successful compared to others (e.g. It is important to me to do better than other students). The Turkish version of achievement goals inventory was translated and adapted into Turkish by Senler and Sungur (2007). The coefficient alpha values for the Turkish sample were found to be .81 for mastery-approach goals, .69 for performance-approach goals. The reliability levels obtained in this study were similarly high. In this study, Cronbach's alpha reliability coefficients were found to be .750 for the performance-approach goal, .760 for the mastery-approach goal.

Academic Coping Inventory

Academic coping inventory was developed by Tero and Connell (1984) to assess students' coping strategies when faced with academic failure. It is a five-point Likert scale from 1 ''do not believe at all'' to 5 ''completely true''. It consists of 13 items in four sub-scale. Positive coping assesses students' adaptive strategy (3 items, e.g. I would try to see what I did wrong), while students who prefer projective coping blame others (3 items, e.g. I would say it was the teacher's fault). Students who prefer denial coping generally say that they do not care about the negative event (3 items, e.g. I would say it wasn't important) and in non-coping, students blame themselves (4 items, e.g. I would get really mad at myself). All items in the questionnaire start with a stem that ''If something bad happened to me during a science lesson, such as doing poorly on a test or not being able to answer a question in class...'' and students complete this stem with items.

The Turkish version of the academic coping inventory was translated and adapted into Turkish by Kahraman and Sungur (2013). The coefficient alpha values for the Turkish sample were found to be .730 for positive coping, .840 for projective coping, .840 for denial coping and .800 for non-coping. In this study, Cronbach's alpha reliability coefficients were found to be.795 for positive coping, .835 for projective coping; .779 for denial coping, and .755 for non-coping.

Procedure

The survey was in paper form. The first author of the study collected the data in class and no particular class was selected. Directions written on the surveys were also explained by the data collector and it was explained that the data were going to be used only for scientific research purposes. The participants were not asked any information that would reveal their identity. The participants completed surveys within one class period that is 40 minutes. All the data were collected in two and a half months.

Results and Discussion

Descriptive Statistics

Descriptive statistics (mean, standard deviation, reliability coefficient, Pearson correlations, skewness, and kurtosis) related to the variables in the study were tested through the SPSS program. Pearson correlations among variables of the study were presented in Table 1. The biggest correlation is between non-coping strategies and the fear of shame and embarrassment (r= .540, p<.01), while the smallest correlation is between denial coping and performance-approach goals (r=-.234, p<.05) (see Table 1).

Table 1. Pearson correlations among the variables of the study

	1	2	3	4	5	6	7
1. Positive coping	1	-.274**	-.263*	.241*	.538**	.300**	.274**
2. Projective coping		1	.359**	.209**	-.396	.264	.209
3. Denial coping			1	.265*	-.234*	-.292	.275
4. Non coping				1	.213	.378**	.540**
5. Performans-approach goals					1	.431**	.342*
6. Mastery-approach goals						1	.365**
7. Shame and embarrassment							1

Note: *p < . 05, **p < .01

Arithmetic means of the dimensions such as positive coping (M = 4.22; SD = .059), performance-approach goals (M = 4.19; SD = .054), mastery-approach goals (M = 4.04; SD = .063), and fear of shame and embarrassment (M = 3.28; SD=.068) are above the average value (see table 2). Projective coping (M = 2.04; SD = .075), denial coping (M = 2.18; SD = .068) and non-coping (M = 2.89; SD = .073) dimensions were below the average (see Table 2). Since the Skewness and Kurtosis values of the variables vary between ±2.0, the data is in normal distribution (George & Mallery, 2010).

Table 2. Descriptive statistics for the variables of the study

	Mean	Std error	Skewness	Kurtosis
1. Positive coping	4.22	.059	-1.53	2.03
2. Projective coping	2.04	.075	.993	-.003
3. Denial coping	2.18	.068	.68	-.359
4. Non coping	2.89	.073	.085	.157
5. Performans-approach goals	4.19	.054	-1.37	2.01
6. Mastery-approach goals	4.04	.063	-1.06	.460
7. Shame and embarrassment	3.28	.068	-.462	-.513

Inferential Statistics

To investigate the proposed relationships among academic coping dimensions, approach achievement goals, and fear of shame and embarrassment in science, path analysis was conducted using AMOS. Fit indices were used to evaluate how well the proposed model fit to the data. The model created to test is among the acceptable fit indices. The fit indices obtained from the analysis using the Maximum Likelihood method are presented in Table 3 and the Amos program Output representing the model is given in Figure 2. The standardized path coefficients are presented in Table 4 and significant path coefficients are displayed in Figure 3.

Table 3. Result of the Fit indices

	X^2	df	X^2/df	GFI	AGFI	CFI	IFI	RMSEA
Fit indices	399.215	277	1.44	.890	.860	.948	.947	.043
Good fit indices*			≤3	≥0,90	≥0,90	≥0,95	≥0,95	≤0,05
Acceptable fit indices*			≤5	≥0,85	≥0,85	≥0,90	≥0,90	≤0,08

* source (Hair et al., 1998; Kline, 1998; Schermelleh-Engel et al., 2003; Simsek, 2007).

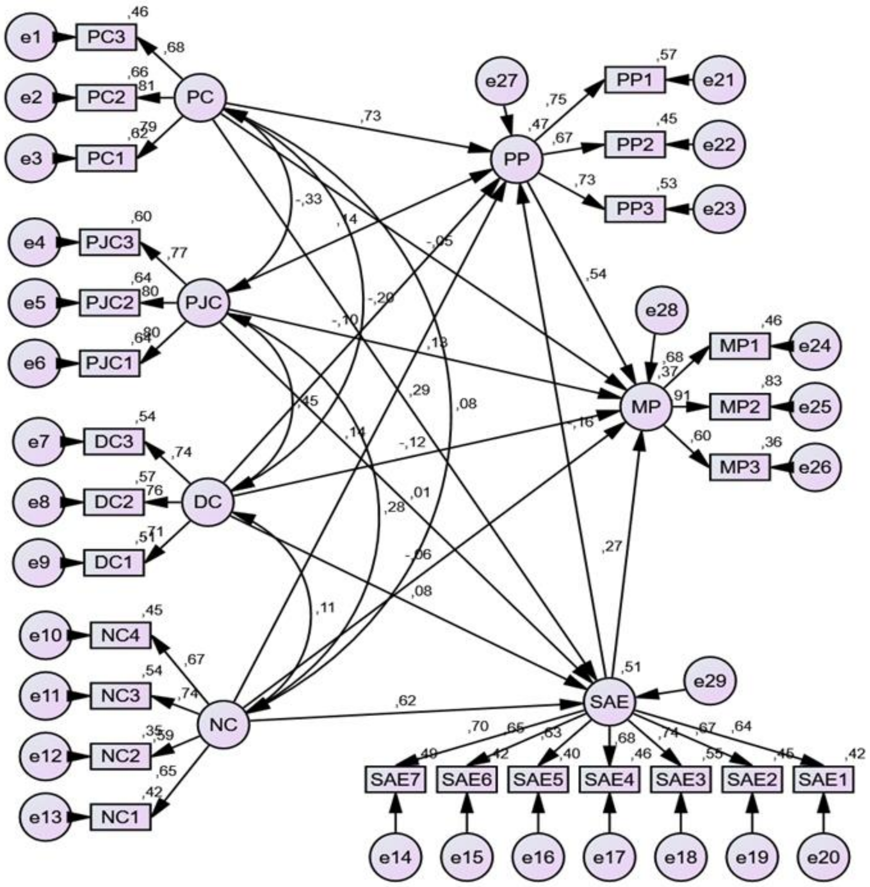

Figure 2. Amos output for the model
(Positive coping= PC, Projective coping=PJC, Non-coping=NC, Denial coping=DC, Shame and embarrassment=SAE, Performance-approach goals=PP, Mastery-approach goals=MP)

Table 4. Standardized coefficient

		Standardize β	SE of the estimates	t	p	R^2
Shame and embarrassment	Positive coping	.286	.103	3.678	***	
	Non-coping	.622	.094	6,310	***	
	Projective coping	.013	.080	.155	.877	.51
	Denial coping	.082	.078	1.059	.290	
Performance-approach goal	Positive coping	.728	.114	6.581	***	
	Projective coping	.140	.068	1.491	.136	
	Non-coping	.135	,088	1.141	.254	
	Denial coping	-.096	.067	-1.114	.265	.47
	Shame and embarrassment	-.160	.092	-1.344	.179	
Mastery-approach goals	Shame and embarrassment	.272	.095	2.259	.024	
	Performance approach goal	.542	.134	4.129	***	
	Projective coping	.132	.069	1.425	.154	
	Denial coping	-.124	.067	-1.472	.141	
	Non-coping	-,064	.087	-.555	.579	.38
	Positive coping	-.050	.137	-.386	.699	

According to the results of the analysis, academic coping strategies accounted for 51% of the variance in the fear of shame and embarrassment. According to the parameter estimates, high levels of positive coping strategies (β = .286; p<0,05), non-coping strategies (β = .622; p<0,05) are statistically significantly and positively linked to fear of shame and embarrassment. Academic coping strategies and the fear of shame and embarrassment accounted for 47% of the variance in performance-approach goals. The relationship between performance-approach goals and positive coping (β=.728; p<0.05) is statistically positive. The fear of shame and embarrassment, academic coping strategies and performance-approach goals accounted for 38% of the variance in mastery-approach goals. The fear of shame and embarrassment (β=.272; p<0,05), performance-approach goals (β=.542; p<0,05) are statistically significantly and positively linked to mastery-approach goals.

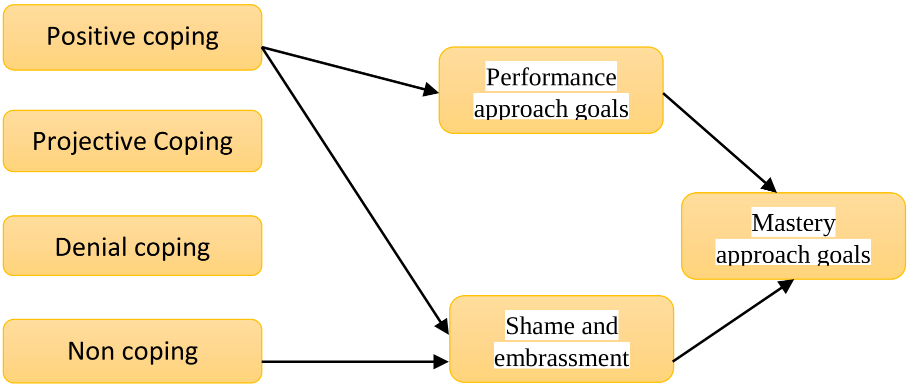

Figure 3. Path model with significant paths

Conclusion

The Relationship between Academic Coping and Approach Achievement Goals

According to the results of the path analysis, adaptive coping strategy, also known as the positive coping was found to be positively correlated with performance-approach goal. In the current study, the expression in the following can be said by looking at the relationship between students' performance-approach goal and positive coping strategy: the students with the aim of discovering knowledge, developing skills, and doing better than other students in the science lesson try to see where they made mistakes when they encounter an academic failure and they make more efforts next time. Students with this acquisition try to find out where the wrong is and they prefer to blame others for this failure less. This finding of the study is supported by the study (Kahraman & Sungur, 2013), which states that the performance-approach goals in the literature are positively related to both adaptive coping strategy and maladaptive coping strategies (Brdar et al., 2006; Friedel et al., 2007; Taye & Zhou, 2009). However, this finding is not supported by the study of Brdar (2009). Findings in these studies suggest that students with mastery goals use more adaptive coping strategy and students with performance goals use more maladaptive coping strategies. Besides, in these studies, the mastery-approach goal was positively associated with adaptive coping (Friedel et al., 2007) and negatively associated with maladaptive coping (Brdar et al., 2006; Friedel et al., 2007; Taye & Zhou, 2009). According to the relevant literature, performance-oriented students use less adaptive strategy and generally blame others when they face academic failure. That is, students who use performance-approach goals use less adaptive strategy and students are less likely to do better in the later process or to think about where they made mistakes. Skaalvik (2018) similarly stated that there is a negative weak relationship between performance-approach goals and adaptive coping strategy, and there is a positive strong correlation between mastery-approach goals and adaptive coping strategy. In this study, the lack of a significant positive relationship between mastery-approach goals and academic coping was an unexpected result in light of the relevant literature.

The Relationship between Academic Coping and the Fear of Shame and Embarrassment

In the present study, the fear of shame and embarrassment were found to be positively correlated with positive coping, and non-coping strategy from maladaptive coping strategies. When students meet an academic failure in a science lesson, they blame themselves not others, and do not try to ignore failure by trying to find out where the mistake is made. Students who think that failure will embarrass themselves will feel bad when they face a bad situation such as failing a test or failing to answer a question in the science lesson and try to make the activities or answer the questions better next time. In other words, students who think that failure is embarrassing do not forget what happened, they blame themselves rather than others and do not ignore failure. The positive relationship between the fear of shame and embarrassment and non-coping in the present study is consistent with the results of the study by Kahraman and Sungur (2013). In the present study, unlike the literature, it can be concluded that the fear of failure is not only related to the maladaptive coping strategies but also the adaptive strategy. According to previous studies, students who have the fear of failure blame others, feel bad, that is to say, they use maladaptive coping strategies (Blankstein et al., 1992; Bartels & Magun-Jackson; 2008; Veisson et al., 2004).

The Relationship between Approach Achievement Goals and the Fear of Shame and Embarrassment

The fear of shame and embarrassment, which is a dimension of the fear of failure, expresses people's negative self-evaluations about themselves, and they think that failure will embarrass them. In other words, the fear of failure is seen as a tendency to be embarrassed and a possibility of humiliation by peers (McGregor & Eliot, 2005; Kahraman & Sungur, 2013). According to the results of the path analysis in the present study, the fear of shame and embarrassment is positively related to the mastery-approach goal. The students who have the fear of shame and embarrassment because of their failure want to understand science lesson well, learn as much as possible and understand everything fully. Students who have the fear of embarrassment are not interested in their friends' achievements and good grades and do not care about doing activities or assignments better than their friends.

In the study conducted by Elliot and Sheldon (1997), mastery and performance goals were considered as approach achievement goals without differentiation and their relationship between the fear of failure was investigated. In conclusion, they found that the fear of failure might be one of the pioneers of approach achievement goals, which is consistent with the present study finding. Conroy et al. (2003) examined the effects of the fear of failure on achievement goals using the 2x2 achievement goal model, which includes mastery-approach, mastery-avoidance, performance-approach and performance-avoidance in sport. The results showed that there was a positive relationship between the fear of failure and performance-approach goals and that there was no relationship between the mastery-approach goals and the fear of failure. Besides, the fear of shame and embarrassment failure has a positive relationship with the performance-approach goal. In these studies, the fear of failure is considered as a precursor of performance-approach goals (Bartels & Ryan, 2013; Conroy & Elliot, 2004; Elliot & McGregor, 2001; Elliot & Murayama, 2008; Nien & Duda; 2008). In addition, Kahraman and Sungur (2013) found no significant relationship between the fear of shame and embarrassment and performance and mastery-approach goals. In a different study with university students, the performance-approach goals significantly explained the variance in fear of failure variables (Bartels & Ryan, 2013).

The findings of these studies are not consistent with the findings of the present study. According to the researchers, if students perceive the mastery goals of the social environment as important, they tend to adopt mastery goals, and if they perceive the performance goals from the social environment, they tend to adopt performance goals (Bong, 2008; Gonida et al., 2007; Kim et al., 2010). Turkish secondary school students, whose fear of shame and embarrassment are dominant, focus on learning everything as much as possible in science class (mastery-approach goals) rather than being more successful than other students (performance-approach goals). Turkish society has a collectivist culture, and fear of failure in the education system is dominant (Sungur & Şenler, 2009). Students who aim to have a good career in Turkey want to be successful in the science course as well as getting high scores in the university exam. Because the goals are very important, and the high score is the key to the faculty they want.

Limitations

There are some limitations in the present study. The variables of the study depend on the students' use of academic coping strategies, choosing approach achievement goals and fear of shame and embarrassment. Since the study is correlational, it is not possible to establish a cause-effect relationship between the variables of the study. The sample of the study was limited to 249 students studying in public secondary schools. Besides, considering the relationship between the variables is specific to the science lesson, it is necessary to examine the relationships in other subjects as well. Each dimension of the fear of failure scale characterizes different features. For example, there are sub-dimensions such as fear of losing social interest, uncertain future, devalue self-estimate, and upset others. Other dimensions may also be associated with approach achievement goals or coping strategy. However, in the current study, path analysis was created with the fear of shame and failure, and the study was limited in this aspect.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Effects of 7E Instructional Model with Metacognitive Scaffolding on Students' Conceptual Understanding in Biology

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Abstract

The main aim of this study was to explore the effect of 7E instructional model with metacognitive scaffolding and gender on 9th grade students' conceptual understanding of human biology concepts and misconceptions. The research method was a quantitative research method and the research design was quasi-experimental research design with pre-test – treatment – post-test. The study was conducted on four purposely selected schools and four classes and teachers (one from each school) and assigned as treatment group 1, treatment group 2, treatment 3 and comparison group randomly. These groups were instructed with 7E instructional model alone, 7E instructional model with metacognitive scaffolding, conventional approach with metacognitive scaffolding and conventional approach respectively to teach human biology for 10 weeks. Human biology conceptual understanding test was administered for all groups as pre-test and post- test. The ANOVA results showed that 7E instructional model supported with metacognitive strategies had a significantly superior effect over the other instructional methods for enhancing students' conceptual understanding and minimizing misconceptions. However, no significant difference was found between males and females in students' conceptual understanding. Hence, metacognitive scaffolding with 7E instructional model could help students to understand biology concepts and minimize misconceptions better than the other instructional methods.

Introduction

One of the factors that affect the social, political and economic development of any nation is Education. However, there should be meaningful learning so as to education play its role. In teaching learning process for meaningful learning, the method of instruction (the pedagogical approach in teaching-learning process) is one of the important factors that affect students' learning (Hosseini, 2012; Munck, 2007). According to Kennedy (1998), students' learning with a conceptual understanding of science is dependent on how their teachers teach science. Therefore, the use of inappropriate instructional approaches by the teachers in a classroom is one of the reasons for students' ineffective science learning (Ganyaupfu, 2013; Munck, 2007; Orji & Ebele, 2006; Oloyede, 2010; Umar, 2011).

Until now, two types of instructional approaches in teaching-learning process which were emerged from behaviorism and constructivism learning theories dominated world education system. These are teacher-centered, (traditional approach) and learner-centered instructional approaches (active learning approach) respectively. Literature indicated that the traditional (teacher-centered) approach often promotes passive and superficial learning (Bransford et al., 2000). These weaknesses of the traditional approach resulted in the emergence of an alternative approach which is termed as learner-centered approach (Baeten et al., 2012). Different from the traditional one, learner-centered approach resulted in the students' active involvement in classroom teaching and change in the role of the teacher from transmitter of information to facilitator of the classroom practices and promoter of learners' involvement in the teaching and learning process (Meece, 2003, McCombs & Whisler, 1997; Schiller, 2009).

For effective implementation of learner – centered approaches, the learner needs to be self-directed, self-regulated and independent learners so as not to depend completely on teachers in knowledge acquisition as in the traditional teacher-centered approach. For this purpose, teaching them how to learn on their own is important (Saavedra & Opfer, 2012). Hence, metacognitive awareness of students is important. Metacognition is one's knowledge concerning cognitive processes and products, and one's actively monitoring and regulating that cognitive process (Flavell, 1979). In another word, metacognition has been defined as the ability to monitor, evaluate /asses, and make plans for one's learning understanding (Okoro & Chukwudi, 2011).

The students' abilities to control their own learning are vital for effective learning (Boekaerts et al., 2000). Unlike passive learners who do not control their own learning, active learners control their own learning because they know and use useful and best learning strategies and are effective in their schools. Metacognition helps the student to understand what they understand and adjust their learning strategies to improve their learning when they feel their understanding is incomplete (Samson, 2011). As indicated in literature, students who have well metacognitive awareness able to plan, monitor, and modify their cognition at different levels in their learning than those who have low metacognitive awareness (Zimmerman & Martinez-Pons, 1986).

In addition to methods of instruction and metacognitive awareness, prior knowledge of students is an important factor that influences students' effective learning (Grayson et al., 2001; von Glasersfeld, 1992). Before they come to the formal classroom instruction, students have some knowledge about the natural world and phenomena which may be constructed from their daily life experience that affects their learning (Teichert & Stacy, 2002). These students prior knowledge have given different names by scholars at a different time such as misconceptions (Lawson & Thompson, 1988; Nakhleh, 1992; Treagust, 1988), and alternative conceptions (Taber, 2001) to mention some. There are different sources of misconceptions from which students develop. According to Duit &Treagust (1995) and Harrison &Treagust (1996), some of the possible sources of misconceptions include textbooks; teachers; culture and language; mass media; daily usage of concepts; personal real-life experiences; lack of understandings from previous school courses. Moreover, innate structures of the brain (Duit, 1991) and traditional instruction (Kindfiled, 1991) were also reported as a source of misconceptions.

These previously perceived concepts about the natural world and phenomena in the mind of students affect the understanding of the new concepts (Schmidt et al., 2003). This is because misconceptions are an obstacle for meaningful learning and resistant to change especially through traditional instructional strategies and remain even after formal science instruction (Guzzetti, 2000; Stavy, 1991; Wandersee et al., 1994). When students come to the classroom and encountered a new knowledge, learning occurs as a result of assimilation and accommodation (Duit &Treagust, 2003; Posner et al., 1982). When students face new information, the prior knowledge serves as a background information on which the new information either fit with it through the process of assimilation or reorganized changing their schema through the process of accommodation as described by Piaget (1953).This type of learning process helps students to have a deep understanding of science concepts (Jonassen et al., 2005). Hence, in teaching toward understanding, an explicit confrontation between pre-knowledge and new knowledge is the critical element, as stated in the theory of conceptual change (Posner et al. 1982; Tanner & Allen, 2005). For meaningful learning to occur, students need to link new knowledge to previously perceived relevant concepts; otherwise, rote learning occurs (Ausubel, 1968).

Consequently, using appropriate strategies that actively involve and help students to become self-directed independent learners that are capable of monitoring their own learning and using their prior knowledge is crucial for learning science with understanding. Among different learner-centered methods and metacognitive strategies, 7E instructional models are useful to extract students' prior knowledge and misconceptions and to teach for conceptual understandings (Bybee et al., 2006; Eisenkraft, 2003) and planning, monitoring and evaluation metacognitive strategies are important for students to know how to learn and monitor their learning progress independently. Hence, in the current study, 7E instructional model with metacognitive scaffolding using metacognitive strategies of planning, monitoring and evaluation were used.

The 7E instructional model was extended from 5E instructional model by Eisenkraft (Eisenkraft, 2003) to make it more suitable than the previous one. It has 7 phases: Elicitation, Engagement, Exploration, Explanation, Elaboration, and Evaluation and Extension. In this newly developed learning cycle model, two more phases were added. These are the elicitation phase to examine prior knowledge of learners and extension phase for application of knowledge gained in daily life or to transfer learning in a new situation (Eisenkraft, 2003).

The first phase, Elicit, helps to reveal students prior knowledge with the concepts about to be studied, and pique their interest to know more (Tanner, 2010). Identifying students' prior knowledge to construct new scientific knowledge starts here in learning science (Eisenkraft, 2003). The second phase, Engagement, helps to focus students' attention on the phenomenon and stimulate curiosity. The third phase, Exploration, helps students to conduct exploration and formulate and test predictions, make observations, record data, and collaborate with peers to develop and test alternative solutions. The fourth phase, Explanation, helps students to review, analyze, and interpret their observations and data to make concepts, processes, or skills clear. The fifth phase, Elaboration, helps students to further experience or elaborates the concepts to deepen their conceptual understanding and broaden their understanding of science. The sixth phase, Evaluation, helps students to evaluate their understanding. The seventh phase, Extend, helps students to transfer their learning into new situations in their day to day life. This phase explicitly remind teachers the importance for students to practice the transfer of learning in a new context than simple elaboration (Eisenkraft, 2003 p. 59).

Metacognitive strategies include planning, monitoring and evaluation of thinking and learning processes (Chauhan & Singh, 2014; Schraw & Moshman, 1995; Schraw, 1998). Research suggests that those students that are aware of metacognitive strategies are more successful than the others in their learning (Caraway et al., 2003; Imani et al., 2011). According to Bransford, et al., (2000), metacognitive strategies assist students to manage their own learning through defining learning goals and monitoring their progress in order to achieve the stated goals. This, in turn, enables learners to ensure that their goals and tasks are properly understood and then successfully completed and enhanced their learning (Gourgey, 1998).

There are different strategies that can help learners to plan, monitor and evaluate to improve regulation of cognition. Some of them are self-questioning, concept map, journaling, modeling, think aloud, metacognitive prompts, **Know – Want to Know – Learned (**KWL) chart, regulatory checklists, etc (Blakey & Spence, 1990; King, 1991**;** Schraw, 1998). As described by Kumari and Jinto **(**2014) using these strategies in teaching-learning process by the teachers can help students to follow appropriate procedures in the process of learning.

Students can be equipped with these strategies through scaffolding. According to Hartman (2001) scaffolding is providing assistance to students on activities that they need guidance from others to make students independent, self-regulating thinkers, self-sufficient learners, and less teacher-dependent. Metacognitive scaffolding according to, Hannafin et al. (1999) enhances metacognitive thinking and metacognitive strategies of planning, monitoring, and evaluating.

After the development of the 7E instructional model, many studies have been conducted to see its effectiveness in learning science in different fields. The results of these studies revealed that 7E instructional model significantly improved students' critical thinking skills, conceptual understanding, retaining acquired knowledge, and promoting self-regulation, achievement (Gök, 2014; Polyiem et al., 2011).

Though, 7E learning cycle was proofed to be effective, few researches were conducted by combining 7E learning cycle with other strategies. For instance, a research conducted by Warliani et al. (2016) on effects of 7E learning cycle model using technology-based constructivist teaching shows that students in the experimental group performed better in understanding than the control group instructed with 7E learning cycle model alone. Similarly, research conducted by Bulbul (2010) shows the effectiveness of 7E learning cycle with computer animation on students' understanding. Students in this group performed better in the understanding of concepts in osmosis and diffusion. Moreover, a research conducted by Yerdelen-Damar and Eryilmaz (2016) on the effectiveness of metacognitive 7E learning cycle on the students' epistemological understandings revealed that students with in experimental group performed better. According to this study, metacognitive activities like the prompted small and whole group discussions, journal writings as homework, error analyses, and concept mapping were used with 7E learning cycle. They found that the group assigned with the metacognitive 7E learning cycle performed better than those taught with teacher-centered instruction. Similarly, a study conducted by Sornsakda et al. (2009) on the effect of using 7E instructional model with three metacognitive techniques of intelligibility, plausibility and wide – applicability found that the experimental groups performed better in learning achievement, integrated science process skills and critical thinking than control group. In the current study, however, metacognitive strategies of planning, monitoring and evaluation were used with 7E instructional model.

The current study focused on metacognitive scaffolding in which students were given supports to use metacognitive strategies of planning, monitoring and evaluation with training while learning through 7E instructional model. My study builds on what is reported in the literature by including metacognitive strategies planning, monitoring and evaluation in to the 7E instructional model. Using metacognitive strategies with 7E instructional model, however, makes this study somewhat different from the studies conducted so far and it will have its own knowledge contribution to the literature.

The other important issue in science education in the last decades was a gender issue. In most studies, it has been reported that there was a significant difference between males and females in science learning favoring males (Lee &Burkam, 1996). A research conducted by Amedu (2015) on the topic of microorganisms using the jigsaw method shows that males performed significantly better than females. However, other studies point out female students performed better than male students (Britner, 2008; Britner & Pajares, 2006). A research conducted by Filgona and Sababa (2017) on learning with mastery learning strategy revealed that female students performed better than their male counterparts. On the other hand, studies revealed that there was no significant difference between males and females. For instance, Sungur and Tekkaya (2003) reported that there was no difference between males and females in learning and attitude toward biology. According to Shaheen and Kayani (2015), there is no significant difference in the mean scores of boys and girls with respect to students' learning science. Therefore, the effectiveness of 7E instructional model supported with metacognitive strategies on Ethiopians 9th-grade students' conceptual understanding of biology concepts was investigated. Moreover, the effect of gender on conceptual understanding also examined.

Statement of the Problem

Though learners are expected to achieve the expected outcomes, results from national learning assessment in Ethiopia indicated that most students after completing each grade cycle are unable to fulfill the minimum learning competencies stated by the Ministry of Education. The Ethiopian baseline national learning assessments of Grades 10 and 12 students conducted in April 2009 indicated that students are unable to attain the required minimum competencies (NAE, 2010), less than the 50% achievement level set by the Education and Training Policy of Ethiopia (TGE, 1994, p.18). For instance, the national mean score of biology for Grade 10 was 40.3. The recent national learning assessment of Ethiopia also indicated that grade 10 students scored 46.96 (NEA and EA, 2014). According to Omolade (2008), in order for students to have high academic achievement, they must have deep understanding of basic concepts of the subject. The students' conceptual understanding of science, in turn, depends on how their teachers teach science (Kennedy, 1998).

Studies in Ethiopia shows that the practice of applying suitable learner centered methodology in biology classes were limited and traditional lecture methods are dominant in classrooms (Areaya, 2008; Bekele & Melesse, 2010; Berhe, 2006; Beyessa, 2014; Dufera, 2006; Teshome, 2012; Endawoke, 2004). This might be one of the reasons for low learning assessment result of students in biology. As we know, biology is one core component of the education system in Ethiopian. As part of scientific inquiry, it has special relevance to students as individuals, to the society and to the growth and development of Ethiopia at large. Biology education equips learners with the basic knowledge and skills that are essential in the study of fields such as medicines, pharmacy, nursing, agriculture, forestry and biotechnology. Moreover, many of the contemporary issues and problems such as nutrition, health, drug abuse, agriculture, pollution, rapid population growth, environmental degradation, global warming and conservation in the society are essentially biological in nature. In order to effectively deal with the relevance of biology and contemporary issues, an understanding of biological knowledge is required. Therefore, my study was mainly to investigate how the 7E instructional model with metacognitive strategies helps learners in conceptual understanding of biology concepts and minimizing of misconceptions in Ethiopian secondary school context.

Research Questions

1. Is there a significant mean score difference in the conceptual understanding of human biology concepts between groups?

2. Is there a significant mean score difference between males and females in the conceptual understanding of human biology concepts?

To what extent misconceptions in human biology exist among groups?

Research Method and Design

For this study, a quantitative research method was used. The design for this study was the nonequivalent pre-test, treatment, posttest control group quasi-experimental research design. The design has one comparison group and three treatment groups. Accordingly, TG1was with treatment of 7E instructional model (7EIM) (X_1), TG 2 was with treatment of 7E instructional model with metacognitive strategies (7EIMMS) (X_2), TG 3 was with conventional with metacognitive strategies (CIMS) (X_3) and CG was with conventional instruction (CI). Because of this, the research design for this study can be presented as follows:

Groups	Pre test	Treatment	Post test
Treatment Group1 (TG1)	O_1	X_1	O_2
Treatment Group2 (TG2)	O_1	X_2	O_2
Treatment Group3 (TG3)	O_1	X_3	O_2
Comparison Group (CG)	O_1		O_2

Sampling Technique

The study was conducted in Addis Ababa, Ethiopia, on grade nine students. Four schools were selected using purposive sampling based on school facilities, teachers' qualifications and experience and school effectiveness for the intervention. This is because the four schools should have to be in similar conditions. From each of the four schools, one well qualified and experienced biology teacher was purposely selected and one section of grade nine students from those selected teachers are teaching was randomly selected in each school and assigned as treatment and comparison groups randomly. Based on this, the study involved 164 9th grade students (64 boys and 100girls) in public secondary schools.

Data Gathering Instruments

In order to answer the research questions of this study, data were gathered using a human biology conceptual understanding test (HBCUT). HBCUT was a two-tier multiple choice diagnostic test. The two -tiers multiple-choice test contains content response (first tier) with two to four choices and a set of four to five possible multiple-choice reasoning response and one additional blank space (second tiers) that diagnose students' conceptual understanding and help to identify misconceptions held by students in science.

To develop the HBCUT, the procedure described by Haslam and Treagust (1987) and Treagust (1988, 1995) was used. The procedure includes three phases and 10 steps in which the first phase with four steps, the second phase with 3 steps and the third phase with 3 steps. The three phases with each step presented in the table below (Table 1). The final version of the HBCUT for assessing human biology conceptual understanding consisted of 18 items.

Table 1. Shows the three phases and 10 steps.

Phases	Title	Steps	
I	Defining the Content	1	Identify propositional knowledge statements.
		2	Develop a concept map.
		3	Relate propositional knowledge to the concept map.
		4	Content validation
II	Obtaining Alternative Conceptions	5	Review literature related
		6	Conduct interview
		7	Conduct multiple-choice content items with free response
III	Developing the Instrument	8	Develop two-tier items
		9	Design a specific grid.
		10	Refine test

Validity and Reliability

The content and face validity of instruments and the material prepared on 7E instructional model and metacognitive strategies were checked using experts' opinions. Finally, corrections were made by considering the feedbacks and recommendations obtained from the experts. A pilot study was conducted for item analysis of instruments and reliability checking. Based on the analysis of difficulty and discrimination power, some of the items improved and others were discarded. The reliability of HBCUT test was investigated by calculating an internal consistency measure of Kuder-Richardson 20 and it was found to be 0.70.

Intervention Procedure

First training on 7E instructional model was given to the teacher in TG 1 and TG 2. After giving a metacognitive inventory test to all groups, training on metacognitive strategies was given to teachers and students in TG 2and TG3. For the training of metacognitive strategies, KWHAL chart and Regulatory checklist were used. KWHAL refers to: **K** = What do I **k**now? **W** =**W**hat do I want to know? **H** = **H**ow will I know it? **A** = **A**m I learning well? **L** = What have I **L**earnt? Self Regulatory checklist was also used which are used to check whether they are on track or not using self questions like what is my goal? Do I have a clear understanding of what I am doing? Have I reached my goal? These two materials were given to all students in the TG 2 and TG3, taped on their desk, wall and exercise book during training and used during implementation of the intervention.

During implementation of the intervention which was lasted for 10 weeks, 4 times per week (45 minute each), teachers in TG 1 and 2 used 7E instructional model to teach the topics and design their lesson plan for each lesson indicating activities to be done, the role of the teachers and students under each phases of the 7E instructional model. In addition, teacher in TG 2 included metacogniitve strategies of planning, monitoring and evaluation in their lesson plan. Teachers in TG 3 and CG used conventional instruction, most commonly lecture method, to teach and design their lesson plan accordingly. In addition, teacher in TG 3 included metacognitive strategies. The unit taught was human biology which includes food and nutrition, the digestive systems, respiratory systems, cellular respiration and circulatory systems.

Second, pretest about HBCUT was given to the four sections taught by the four teachers. After completing these activities, implementation of intervention was started. Teachers and students were trained very well and several classroom observations were made during the intervention so as to monitor proper implementation of the intervention. After completing the implementation of the intervention, the conceptual understanding test was administered as post-test.

Analysis Methods

For analyzing the data, Statistical Package for Social Sciences (SPSS) software was used. After testing the assumptions parametric test, analysis of variance (ANOVA) was used. Moreover, data obtained from HBCUT were also categorized, analyzed and compared among the four groups in relation to sound understanding, partial understanding and misconceptions. In this regard, there are several studies on how to analyze two tiers multiple-choice items. Based on TarakciHatipoglu et al. (1999) and Ozkan et al. (2015) classification of students' understanding, the table below used to analyze the data obtained from the HBCUT. Misconceptions are considered significant and common if it is held at least 10% of the total sample of students (Chandrasegaran et al., 2007; Haslam &Treagust, 1987).

Table.2 Classification of understanding of students

First-tier	Second-tier	Classification
True	True	Sound understanding
True	False	Misconceptions
False	True	partial understanding
False	False	No understanding

Results

Pretest Scores Analysis

Before the implementation of the intervention begins, HBCUT was administered to all groups as a pretest. The purpose of administering the pretests was to compare whether students in the groups were different from each other in their understanding on human biology or not before the implementation of the intervention. Therefore, ANOVA was executed to investigate whether there was a significant mean difference between them or not in biology conceptual understanding. Before performing the analysis of pre-test scores, assumptions of ANOVA such as normality (skewness and kurtosis) and homogeneity of variance (Levene test) were checked and found were not violated.

After checking the assumption for ANOVA, descriptive statistics of the pre test scores were analyzed. The descriptive statistics result (table 3) revealed that the mean score of pre-HBCUT for TG 1, TG 2, TG 3 and CG were 12.47, 13.16, 10.34, and 10.72 respectively. The descriptive statistics of pre-HBCUT test scores of the groups were summarized below (Table 3).

Table 3. The descriptive statistics of pre-HBCUT scores of the groups

Variables	Groups											
	Treatment Group 1			Treatment group 2			Treatment group 3			Comparison group		
Pre-	N	M	SD	N	M	SD	N	M	SD	N	M	SD
HBCUT	41	12.47	7.74	38	13.16	5.39	43	10.34	5.63	42	10.72	6.18

From the results of descriptive statistics, the mean score of each of the groups looks somewhat different. Therefore, ANOVA was conducted to check whether there is a statistically significant difference between treatment and comparison groups on their pre-HBCUT test or not. The result from ANOVA analysis (Table 4) revealed that there was no statistically significant mean difference between the groups in pre-HBCUTF (3, 163) = 1.88, p = .14) for the groups. In summary, there was no statistically significant mean difference among groups. So, the change observed after intervention could not be attributed to treatment groups' difference before the implementation of the intervention. The ANOVA result is shown in the table below (Table 4).

Table 4.ANOVA result comparing groups in terms of pre-HBCUT

		Sum of Squares	df	Mean Square	F	p
Pre-HBCUT	Between Groups	224.51	3	74.84	1.88	.14
	Within Groups	6367.71	160	39.80		
	Total	6592.22	163			

Posttest Scores Analysis

After the implementation of the intervention, HBCUT was administered to all groups as a post test. After assumptions of ANOVA such as normality, homogeneity of variance and outliers were checked and found no serious violation of the assumptions, ANOVA was executed to investigate whether there was a significant mean difference between groups and between gender or not in biology conceptual understanding.

As it can be seen from Table 5, the mean scores of the TG 1, TG 2, TG 3 and CG on post-HBCUT test were different. The mean score of post-HBCUT for TG 1, TG 2, TG 3 and CG were 37.94, 44.44, 31.91, and 30.69 respectively. The mean score for TG 2 is higher than the other groups in post HBCUT followed by TG 1, TG 3 and CG consecutively.

Table 5. Descriptive statistics for post-HBCUT scores across groups

Variables	Groups											
	Treatment Group 1			Treatment group 2			Treatment group 3			Comparison group		
Post-	N	M	SD	N	M	SD	N	M	SD	N	M	SD
HBCUT	41	37.94	10.16	38	44.44	8.57	43	31.91	8.14	42	30.69	8.52

In addition to groups, the descriptive statistic of post test scores across gender also computed. As it can be seen from the table 6, the mean post-HBCUT score of females (40.67) was higher than males in TG 1 (33.68) and males in TG 3 (33.68)were higher than females (30.86) whereas score of males was almost similar with females in TG 2(44.79 and 44.19) and CG (30.90 and 30.56).

Table 6. Descriptive statistics for post-HBCUT scores across gender

Variables		Groups											
		Treatment Group 1			Treatment group 2			Treatment group 3			Comparison group		
		N	M	SD	N	M	SD	N	M	SD	N	M	SD
Post-	M	16	33.68	10.03	16	44.79	7.72	16	33.68	10.44	16	30.90	8.83
HBCUT	F	25	40.67	9.45	22	44.19	9.31	27	30.86	6.41	26	30.56	8.50

In order to check whether these differences across groups and gender statistically significant or not, inferential statistics were run and the results were presented below. As described above, the result of the descriptive statistics revealed that there was a mean score difference between groups and males and females in relation to post test scores of post-HBCUT test. To assess if there were statistically significant post- tests mean score differences between the four groups and males and females ANOVA was conducted. The ANOVA results revealed that there was a statistically significant difference between the four groups on posttest mean scores: post-HBCUTF (3, 163) = 20.17, p = 0.00).

Table 7. ANOVA result comparing groups in terms of post-HBCUT

		Sum of Squares	df	Mean Square	F	p
Post-HBCUT	Between Groups	4767.81	3	1589.27	20.17	.00
	Within Groups	12605.80	160	78.79		
	Total	17373.61	163			

However, there was no statistically significant difference between males and females on post test mean scores: post-HBCUTF (1,163) = .06, p = .81). The following table is the ANOVA result.

Table 8. ANOVA result comparing gender in terms of post-HBCUT

		Sum of Squares	df	Mean Square	F	p
Post-HBCUT	Between Groups	6.33	1	6.33	.06	.81
	Within Groups	17367.27	162	107.21		
	Total	17373.61	163			

Even though ANOVA result revealed that there was a significant difference between groups in post test mean scores, it did not show a significant difference among groups on the dependent variable. Therefore, post hoc analysis was conducted. The post hoc analysis result revealed that there was statistically significant mean difference between TG 1(M = 37.94) and TG 2 (M= 44.44), *p* = .01; between TG 1(M = 37.94) and TG 3 (M=31.91) *p*= .01; betweenTG 1(M = 37.94) and CG (M = 30.69), *p* = .00 in post-HBCUT. There was also statistically significant mean difference between TG 2(M =44.44) and TG 3 (M=31.91), *p* =.00; between TG 2(M =44.44) and CG (M = 30.69), *p*= .00 in post-HBCUT. Although there was a mean difference, the difference between TG 3 (M =31.91) and CG (M =30.69), *p*=.92 in post-HBCUT was no statistically significant. The table below shows post hoc multiple comparison result.

Table 9. Post hoc multiple comparison test result

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	p
Post-HBUT	TG 1	TG 2	-6.50*	1.99	.01
		TG 3	6.03*	1.94	.01
		CG	7.25*	1.95	.00
	TG 2	TG 3	12.53*	1.97	.00
		CG	13.76*	1.98	.00
	TG 3	CG	1.22	1.93	.92

Analysis of HBCUT Items and Misconceptions

In addition to significant result of ANOVA, percentages of students' responses to post HBCUT and misconceptions identified provided evidence of the difference between the groups after the treatment supporting the effectiveness of the intervention. At first, the percentages of students' responses and then the percentage of students' misconceptions for each item were calculated and analyzed.

Based on the categories of students response in to sound understanding (SU)- answering both two tiers; partial understanding (PU)-answering only the second tier; misconception (MC)-answering only first tiers, and no understanding (NU)-answering any other than correct first and correct second tier, each items were analyzed. In view of that, when we look at the percentage of students' responses the mean percentage of students' response in the table below (Table 10) showed that 37.21, 44.06, 31.26 and 30.47of the students for TG 1, TG 2, TG 3, and CG respectively have sound understanding on the concepts inhuman biology. On the other hand, 11.70, 11.62, 12.14 and 15.07 mean percentage of students' response showed that they have partially understood the concepts whereas 27.42, 25.02, 31.52 and 30.87% for TG 1, TG 2, TG 3, and CG have misconceptions about concepts in human biology. Moreover, 23.54, 19.30, 25.08 and 23.47 mean percentage of students' responses showed that they have no understanding of the concepts. Relatively higher mean percentage of misconceptions found from TG 3 and CG (31.52 and 30.87) respectively. The misconception held by students relatively lower in TG 2 (25.13) ensuring the effectiveness of 7E instructional model with metacognitive strategies than the others in minimizing misconceptions followed by TG 1 (27.65) with 7E instructional model alone. In relation to no understanding of concepts, TG 2 has a lower percentage of students followed by TG 1.

Furthermore, when each item was analyzed, students in TG 2 performed better in an understanding of the concept than students in TG 1, TG 3 and CG in 12 of the items (67%), in 14 of the items (78%) and in 16 of the items (89%) respectively. In relation to misconception, students in TG 2 hold less percentage of misconceptions in 11 of the items (61%) than the TG1 and in 12 of items (67%) than TG3 and in 13 items (72%) than CG. Similarly, students TG 1 better performed in understanding in 11 of the items (61%) than CG. Students in TG 1 hold less percentage of misconceptions in 12 of the items (67%) than TG 3 and in 11of the items (61%) than CG.

The percentage of students response in TG 2 was higher than the others followed by students in TG 1 in relation to sound understanding and lower in relation to misconceptions and no understanding indicating that 7Einstructional model with metacognitive strategies was superior to the other instructional methods followed by 7E instruction model alone in helping students understand the concept. This can be taken as an evidence that supports the ANOVA result.

Table 10. Percentages of the responses of students on post-HBCUT tests scores per categories

	Treatment Group1				Treatment Group 2				Treatment Group 3				Comparison Group			
Item	SU	PU	MC	NU	SU	PU	MC	NU	SU	PU	MC	NU	SU	PU	MC	NU
1	28.86	29.27	21.96	19.91	26.85	26.32	23.68	23.15	18.99	23.26	23.26	34.49	30.86	33.33	14.28	21.53
2	26.42	14.64	7.32	51.62	40.01	10.52	5.26	44.21	18.99	9.31	25.58	46.12	26.1	21.42	19.04	33.44
3	21.54	12.2	36.59	29.67	29.49	7.89	7.89	54.73	28.29	6.98	18.6	46.13	23.72	4.76	19.04	52.48
4	33.73	19.51	7.32	39.44	40.01	13.16	7.89	38.94	28.29	11.63	25.59	34.49	26.1	16.67	16.66	40.57
5	28.86	9.76	39.03	22.35	40.01	13.16	36.84	9.99	35.26	18.6	41.88	4.26	26.1	9.53	29.56	34.81
6	50.81	12.2	29.27	7.72	42.64	15.59	23.68	18.09	46.89	6.98	23.17	22.96	42.77	11.9	38.1	7.23
7	21.54	14.63	19.51	44.32	26.1	13.16	36.64	24.1	21.31	11.63	32.53	34.53	18.96	14.29	26.18	40.57
8	28.86	12.2	36.58	22.36	66.33	5.26	23.68	4.73	28.29	11.63	32.56	27.52	30.86	9.3	26.18	33.66
9	57.58	2.44	39.00	0.98	55.8	7.89	34.22	2.09	25.96	20.93	48.84	4.27	40.39	14.29	50.01	-4.69
10	50.81	0	50.22	1.02	40.01	7.89	42.11	9.99	35.26	9.3	41.86	13.58	28.48	9.52	45.24	16.76
11	70.32	4.88	9.76	15.04	74.22	5.26	7.89	12.63	35.26	9.31	18.61	36.82	59.44	7.14	28.57	4.85
12	31.29	4.88	17.08	46.75	50.54	15.78	18.42	15.26	30.61	16.28	25.58	27.53	23.72	26.19	33.33	16.76
13	31.29	2.44	41.47	24.8	55.8	0	42.1	2.1	25.96	2.33	58.13	13.58	33.25	4.76	54.76	7.23
14	54.76	9.76	24.4	11.08	42.64	13.16	28.95	15.25	30.61	11.63	44.18	13.58	30.86	7.14	28.56	33.44
15	36.17	9.76	31.72	22.35	53.17	23.68	7.89	15.26	39.92	9.13	39.54	11.41	26.1	19.05	21.42	33.43
16	28.86	12.2	26.84	32.1	32.12	5.26	50	12.62	39.92	9.31	30.23	20.54	23.72	16.66	26.18	33.44
17	45.93	13.07	40.9	0.01	45.28	14.68	40.11	.07	46.89	16.28	27.91	8.92	28.48	14.29	54.76	2.47
18	19.1	26.83	14.64	39.43	32.12	10.53	13.15	44.2	25.96	13.96	9.31	50.77	28.48	30.95	26.18	14.39
Mean	37.21	11.70	27.42	23.54	44.06	11.62	25.02	19.30	31.26	12.14	31.52	25.08	30.47	15.07	30.87	23.47

The analysis for the identification of misconception using the percentage of students' on each item was presented as follows with examples of items. The analysis was based on the categories of concepts in human biology such as food and nutrition; the digestive system; the respiratory system, cellular respiration and the circulatory system. Thirty misconceptions were identified from all items and groups most of them from comparison groups. For identification of misconceptions, responses of students to all items were analyzed but two examples (items 2 and 15) were presented below to show the process of the analysis and identification of misconceptions.

According to the percentage of correct first-tier and incorrect reason choice, it was found that a considerable percentage of students had misconceptions from item 2 about the purpose of converting food in to lipid and result of glucose test with Benedict solution. For this study, those correct first tier and incorrect second-tier reason responses above 10% were taken as major misconceptions (Haslam &Treagust, 1987). When we look at item 2, the result showed that only 26.42%, 40.01%, 18.99 % and 26.1%from TG1, TG2, TG3 and CG respectively have understood the reason for colour change in glucose test using Benedicts solution while considerable percentage of students in TG3 (25%) and CG (19%) have misconceptions compared to students in TG1(7%) and TG2 (5%). The relatively higher percentage of the students understood the concept from TG 2 (40.01%) followed by TG 1(26.42%). Considering correct first tier and incorrect second tier, students' responses with percentage of 14 from TG3 and 11.93from CG were taken as two misconceptions from item 2. Students in TG 3 and CG considered the change in colour during testing the presence of glucose with Benedict's solution is due to reduction of monosaccharide to disaccharides in the reaction andbecause when water boils it changes its colour**.** No misconceptions were identified from TG1 and TG2.This implies that 7EIM alone and 7EIMMS were effective in reducing misconceptions. However, 7EINMS was more effective than 7EIM because only 5.26% of students in TG 2 have misconceptions compared to 7.32% in TG 1. Responses of students for item 2 were analyzed as shown in the table below (Table 11).

Table 11.Percentage of students' responses to item no. 2

Item			TG1	TG2	TG3	CG
2	A grade 9 student conducted an experiment in the biology laboratory. First she put a sample of glucose powder and water in to a test tube. Then she added a few drops of Benedict's solution in to the test tube and placed it in boiling water. What was the most probable colour she observed within the test tube?					
	A	Blue	29.27	26.56	42.14	29.66
	B	Purple	30.73	23.84	11.62	27.28
	C	Black	7.32	5.26	2.33	7.14
	D	Orangey-red*	33.74	45.27	44.47	47.5
	The reason for my answer is					
	1	Copper(II) in the Benedict's solution is reduced to copper(I)*	26.42	40.01	18.99	26.1
	2	Copper(I) in the Benedict's solution is oxidized to copper(II)	2.44	5.26	2.33	7.14
	3	A monosaccharide is reduced in the reaction to disaccharides	0	0	9.3	**11.93**
	4	When water boils it changes its colour	4.88	0	**13.95**	2.38
	5	Other reason:	0	0	0	0

NB. Percentages under reasons are those only with correct first choice
* indicates correct combination of response

Similarly, result from item 15 showed that 36.17%, 50.87%, 39.92 and 23.8% from TG 1, TG 2, TG 3 and CG respectively have understood the concept of blood transfusion while others have misconceptions. The relatively higher percentage of students in the TG 2(50.87%) understood the concept. Responses with percentage of 12.2 (TG1), 11.63 and 13.95 (TG3) and 11.9 (CG) were taken as major misconceptions. No misconception was identified from TG 2. But three misconceptions were identified from this item in other groups. The first one is that students considered transfusion of blood from O type to A type is because O type has no antibody that reacts with antigen of the red blood cells of the person with blood type A. The second misconception is that O type has antigen AB that does not react with antibody in the red blood cells of the person with blood type A. The third misconception was O type has no antigen and antibody that reacts with the red blood of the person with blood type A. 7EIMMS was effective in minimizing misconceptions compared to the other groups. Responses of students for item 15 were analyzed as shown in the table below (Table 12).

Table 12.Percentage of students' responses to item no. 15

Item			TG1	TG2	TG3	CG
15	If someone with blood group "A" has got a car accident and lost a lot of blood. Therefore, he needs blood transfusion. Which of the following blood group is used during the transfusion?					
	A	B	9.76	5.26	13.95	14.28
	B	AB	22.03	34.62	6.98	40.14
	C	O*	67.73	60.71	79.36	47.52
	The reason for my answer is					
	1	It has no antibody that reacts with antigen of the red blood cells of the person.	9.76	7.89	**11.63**	4.76
	2	It has antigen AB that does not react with antibody in the red blood cells of the person.	9.76	2.63	**13.95**	**11.9**
	3	It has no antigen that reacts with antibody of the red blood cells of the person*	36.17	50.87	39.92	23.8
	4	It has no antigen and antibody that reacts with the red blood of the person.	**12.2**	0	**11.63**	4.76
	5	Other reason:			2.33	2.38

Discussion and Conclusion

In this section, the findings from the data analysis results on conceptual understanding were discussed in relation to findings from different related literature. As it is already mentioned, the aim of this study was mainly to investigate the effect of 7E instructional model with metacognitive strategies and gender on 9th grade students' conceptual understanding of concepts in human biology. The topics covered in this study include food and nutrition, the digestive systems, respiratory systems, cellular respiration and circulatory systems.

Accordingly, the first research question of the study was to investigate students' conceptual understanding of human biology concepts between groups. The findings showed that students in TG 2 who received 7EIMS outperformed than TG 1, TG3, and CG who received 7EIM alone, CIMS and CI alone in conceptual understanding. Similarly, students in TG 1 who received 7EIM alone outperformed thanTG3 and CG who received CIMS and CI alone. In other words, 7EIMMS has more significant effect on students' conceptual understanding than the other three types of instructional methods. Moreover, 7EIM alone also has more significant effect on students' conceptual understanding than the other two instructional methods. Therefore, since the groups were found similar in their pretest score, this difference between groups was due to the intervention.

However, the result revealed that, though the mean score was different, there was no statistically significant conceptual understanding means scores difference among TG 3 and CG. This means the effect of CIMS on students' conceptual understanding is not statistically different from conventional instruction. Students who received CIMS did not perform well than who instructed with CI in terms of the dependent variable.

In addition, to mean score analysis, each item of the HBCUT was analyzed in terms of percentages. The results of the analysis of each of the HBCUT item results also supported the findings of HBCUT mean score analysis result. Most students in TG 2 have sound understanding of the concept of human biology followed by students in TG 1 than students in TG 3 and CG. TG 2 students have a low percentage of students that did not understand the concept.

Analysis of each item indicated that, students in TG 2 performed better in the understanding of the concept in 12 of the items than TG 1, in 14 of the items than TG3 and in 16 of the items than CG. This means TG2 students have a better understanding in concepts of food and nutrition, digestive system, respiratory system, cellular respiration and cellular respiration. The difference can be explained by the method the teachers used which actively engages students in their learning. This indicates that 7EIMMA was relatively superior to the other instructional methods and 7EIM alone is also relatively superior to the two instructional methods in helping students understand the concept.

As indicated in literature, for learners to conceptually understand concepts, an explicit confrontation between pre-knowledge and new knowledge (Posner, et, al., 1982; Tanner & Allen; 2005) and active participation of students in discovery, reflection and critical thinking is the critical element in learning process (Santrock, 2001). In other words, for conceptual understanding to occur, there should be shifting and restructuring of pre-existing knowledge in to new knowledge through active involvement of students (Tanner & Allen, 2005). This type of learning, according to Posner et al. (1982), occurs through assimilation in which knowledge is incorporated into existing schemas and accommodation in which new knowledge conflicts with existing schemas. Moreover, according to Piaget (1953), children's mental structures (schema) which are basic for learning, are constructed through the process of assimilation and accommodation leading towards equilibrium. In other words, assimilation is using pre-existing knowledge to deal with new knowledge and accommodation is replacing and reorganizing preexisting knowledge to develop new knew knowledge. Moreover, for learning through assimilation and accommodation, there must be dissatisfaction with existing conceptions and the new conception must be intelligible, plausible and fruitful. It is this type of learning process helps students to have deep understanding of science concepts in their learning (Jonassen et al., 2005).

Research findings point out that the traditional instructional approach encourages memorization and recalling of facts which is gaining knowledge than conceptual understanding (Zakaria & Iksan, 2007). In this approach, students are passive listeners than active participants in learning. Similarly, Dhaaka (2012) also reported that this approach encourages students to memorize the content and reproduce the same to pass the examination without understanding the concept of the subject. Researchers indicated that students' learning cannot be determined by acquiring knowledge to pass the examination but rather by acquiring deep meaningful understanding of the materials presented to the students (Sakiyo & Waziri, 2015).

However, the modern constructivist approaches are found to be effective in helping students to learn science with conceptual understanding. The 7EIM, one of the constructivist approaches, found to be useful to actively engage students, extract students' prior knowledge and misconceptions, discover new knowledge leading to conceptual understandings (Byee et al., 2006; Eisenkraft, 2003).This study used 7E instructional model and metacognitive strategies to teach students. The 7E instructional model has 7 phases. These phases are elicit, engage, explore, explain, elaborate, evaluate and extend. The first phase enables students to brainstorm prior knowledge so as to know what students know and identify misconceptions. According to Piaget (1953), the prior knowledge serves as background information on which the new information either fit with it through the process of assimilation or reorganized changing their schema through the process of accommodation. The second phase actively engages students mentally in their learning through activities that focus their attention and curiosity (Bybee, et al., 2006). This creates a cognitive conflict and they try to either assimilate the new information with an existing mental structure or reorganize to develop new knowledge, accommodation. The third phase allows students to observe, explore, formulate hypotheses, test and record results and discuss with others. This leads to the process of equilibration between existing mental structures and new information either through assimilation or accommodation. The fourth phase allows students to present concepts, processes and skills briefly to the teacher and their classmates. In this phase, equilibration continues and misconceptions can be corrected. The fifth let students to further discuss the concepts. This helps them to understand concepts and minimize misconceptions. The six-phase give opportunity for students to assess their understanding and skills acquired with feedback from the teacher. The seventh phase provides students a chance to apply what they have learned in their day to day life. Hence, 7E instructional model is very useful to facilitate meaningful learning. The result obtained from this study provides evidence for its effectiveness.

Furthermore, in addition to instructional methods, literature reported that metacognition has an effect on students learning and performance because the learners' awareness about their learning and control of the way they are learning is important in meaningful learning (Azevedo, 2005; Efklides, 2006; Lin, 2001). This is because, according to Schraw et al. (2006), scientific inquiry requires metacognitive skills such as planning, monitoring, reflection, and self-evaluation of learning. Hence, the metacognitive strategies that students used in this study enabled learners to develop metacognitive skills of planning, monitoring and evaluation which are important skills in scientific inquiries. Therefore, students in this study benefited from the combined advantages of both 7E instructional model and metacognitive strategies so as to enhance their conceptual understanding. As a result, students taught by 7EIMMS outperformed in the understanding of concepts than students taught with 7EIM alone. Moreover, students instructed with 7EIM alone also performed better than those instructed with CI alone and CIMS.

Therefore, the use of the metacognitive strategies with the 7EIM contributed to the superiority of the 7EIMMS over 7EIM alone in improving students' conceptual understanding of concepts in biology. This is because in addition to providing opportunities for students to think and reflect what is in their mind (elicit), actively engage in investigations, explain and relate what they have learned with their day to day life, the method used in this study gave opportunities for students to plan ahead what they want to learn, monitor their learning progress while learning and to evaluate what they have learned before the actual assessment by the classroom teacher.

The use of MS with CI, however, was not effective in enhancing students learning. The reason might be in the CI most of the teachers use lecture method which didn't give an opportunity for students to actively engage in their learning because they are expected to listen to the teacher and take note at the same time. This, in turn, did not give an opportunity for students to use metacognitive strategies because they are busy so as not to miss what the teacher is writing and talking about.

Similarly, different studies conducted to compare the effectiveness of 7EIM with CI on students' conceptual understanding of concepts and reported significant results in favor of 7EIM (Gök, 2014; Polyiem et al., 2011; Shaheen & Kayani, 2015).The results of these studies revealed that 7EIM significantly improved students' conceptual understanding of concepts than CI.

Even though, 7EIM was found to be effective in enhancing students'learning, few researches have been conducted by combining 7E learning cycle with other strategies. For instance, a research conducted by Bulbul (2010) shows the effectiveness of 7E learning cycle with computer animation on students' conceptual understanding. Students in this group performed better in understanding of concepts in osmosis and diffusion. Another research conducted by Warliani, Muslim and Setiawan (2016) on effects of 7EIM using technology-based constructivist teaching shows that students in experimental group performed better in understanding than control group instructed with 7EIM alone in physics.

Nevertheless, few studies have been conducted on the effect of 7EIM with metacognitive strategies on students' conceptual understanding reported significant results in favor of the 7EIM with MS. For instance, a research conducted by Sornsakda et al. (2009) on the effect of using 7EIM with three metacognitive techniques of intelligibility, plausibility and wide – applicability in environmental education found that the experimental groups performed better in learning achievement, integrated science process skills and critical thinking than control group. The other research conducted by Yerdelen-Damar & Eryilmaz (2016) on the effectiveness of metacognitive 7EIMusing metacognitive activities on the students' epistemological understandings in physics revealed that students with an experimental group performed better. They found that the group assigned with metacognitive 7EIM performed better than those taught with teacher-centered instruction. However, this study used metacognitive strategies differently than they used. Unlike these studies, metacognitive strategies of planning, monitoring and evaluation were used n this study.

Generally, the findings of this study supported the previous research findings that revealed 7EIM with technology and metacognitive strategies is more effective than the other approaches to enhance students' biology conceptual understanding of concepts and extended the previous findings because this study used different approaches. Moreover, the results provide further empirical support for the studies reported significant results about the effectiveness of 7EIM alone over CI on students' understandings of biology concepts. The finding ensures that using 7EIM alone is important in enhancing students learning but supporting the 7EIM with MS is even better to increase students learning than using 7EIM alone.

The second research question of this study was whether there is a significant mean score difference across gender in the conceptual understanding of human biology concepts or not. In this study, therefore, the variable was also investigated in relation to gender. In relation to the dependent variable, after the implementation of the intervention, there was a mean score difference between males and female students. The ANOVA results of this study, however, revealed that there was no significant mean difference between male and female students in conceptual understanding of human biology concepts. Therefore, it can be said that male and female students gained similar benefits from the implementation of the intervention.

The results of this study is consistent with the studies investigated the effectiveness of learning cycle across gender. Several studies indicated no significant difference between males and females with respect to science learning (Cakiroglu, 2006; Ugwu & Soyibo, 2004; Thompson & Soyibo, 2002). For example, Ugwu and Soyibo (2004) indicated that there is no significant gender difference in performance on nutrition and plant reproduction concepts among 8th-grade students. The third research question was the extent of misconceptions held by students among groups. Therefore, one of the purposes of this study was to identify misconceptions in human biology concepts and compare the effects of the instructional methods with respect to misconceptions in relation to conceptual understanding of concepts. Hence, this study investigated misconceptions held by students' in human biology concepts from HBCUT. So, in this study, all the misconceptions in human biology concepts were identified and a list of misconceptions was developed.

According to the findings of this study, 7EIMMS was effective than other instructional methods in terms of conceptual understanding of human biology concepts and the reduction of misconceptions. The analysis of students' post-HBCUT scores showed that students taught by 7EIMMS understood the concepts well and reduced misconceptions compare to students instructed with 7EIM alone, CI alone and CIMS (Table 10). Relatively higher mean percentage of misconceptions found from TG 3 and CG. Here again, misconception held by students relatively lower in TG 2 ensuring the effectiveness of 7EIMMS than the others in minimizing misconceptions followed by TG 1 with 7EIM alone.

When we examine each item of HBCUT in relation to misconception, students in TG 2 hold less percentage of misconceptions in most of the items than TG 1, TG 3 and CG. This is because students instructed by 7EIMMS elicit their prior knowledge, engaged in exploration of concepts by their own and used metacognitive strategies of planning, monitoring and evaluation. Even if the students assigned with 7EIMMS understood the concepts better and reduced misconceptions than the other instructional methods, still there are misconceptions held by students in the groups. Analysis of post HBCUT result revealed that students' in all treatments and comparison groups hold some misconceptions though the extent of the percentage of the misconceptions held varies between groups. For example, from an analysis of HBCUT, two major misconceptions were identified from TG 3 and CG in concepts of food and nutrition.

One of the misconceptions was when we add Benedict solution to glucose, orange red colour was formed due to when water boils (TG 3) and due to monosaccharide is reduced in the reaction to disaccharides (CG). The correct conception is that the formation of orange red colour is due to the reduction of copper II to copper I compound during the reaction. The reason for the development of the misconception may be due to the reason that this concept was presented in the form of activity in the textbook but most of the time teachers did not give emphasis for activities in the textbook because of lack of materials and they think that it takes time to do the activities which in turn affects their pace to complete the course on time at the end of the academic year.

From the digestive system category, students know that mechanical digestion breaks food in to smaller soluble once but they considered that mechanical digestion releases enzymes from glands and involves enzyme action to break large food substances. These misconceptions were obtained from TG 3 and CG respectively. The correct conception is that mechanical digestion breaks dawn food in to smaller pieces by teeth bite and chewing and muscular tubes so as to increase the surface area for enzymes action. Enzymes are involved in chemical digestion.

From the circulatory system, the misconception identified was about the reason behind the transfer of blood from one person to another person. Although students know that blood type O is universal donor, they have misconceptions in that this is because of the reason that blood type O has no antibody that reacts with antigen of the red blood cells of the person; blood type O has antigen AB that does not react with antibody in the red blood cells of the person and blood type O has no antigen and antibody that reacts with the red blood of the person. The correct conception is that a person with blood type A can receive blood from blood type O because blood type O has no antigen that reacts with antibody of the red blood cells of the person with blood type A. This helps the blood type O not to be recognized by other cells. The reason may be due to the word antigen and antibody which is somewhat difficult to differentiate because of their similarity.

Misconceptions can be barrier for learning since knowledge construction occur based on already existing understandings (Guzzetti, 2000, Stavy, 1991; Wandersee et al., 1994). Therefore, identifying and finding way of minimizing misconceptions is very important for meaningful learning. Being aware of the students' misconceptions is very important for teachers to designing their instruction to remedy these misconceptions and overcome the difficulties of students in learning concepts.

According to Duit & Treagust (1995) and Harrison &Treagust (1996) sources of misconceptions includes the textbooks; the teachers; the culture and language; the mass media; daily usage of concepts; personal real-life experiences and lack of understandings from previous school courses. Moreover, innate structures of the brain (Duit, 1991) and traditional instruction (Kindfiled, 1991) were also reported as a source of misconceptions. So, the misconception identified in this study may be caused by such different sources of misconceptions.

Even though misconceptions can be minimized, there are several evidences as students had misconceptions after instruction (Guzzetti, 2000; Kaynar et al., 2009; Stavy, 1991; Wandersee et al., 1994). However, according to Marek et al. (1994) using learning cycle is useful to minimize misconceptions and to help students understand the concepts. For instance, the results obtained from the research conducted on the effectiveness of 5E learning cycle shows that students' misconceptions reduced after the instruction of 5E instructional model (Ajaja, 2013; Artun & Coştu, 2012; Cakiroglu, 2006; Nuhoglu & Yalcin, 2006; Sadi & Çakiroğlu, 2010). However, it is difficult to completely eliminate misconceptions because there are various misconceptions (Duit & Treagust, 1995; Harrison & Treagust, 1996).

In this study, students assigned with 7EIMMS engaged in the exploration of concepts on their own and they planned monitored and evaluated themselves using metacognitive strategies with the help of the teacher. Therefore, students taught with 7 EIMMS able to minimize misconceptions than students taught with 7EIM alone and CI alone and CIMS. Students taught with 7EIM alone also able to understand human biology better than the two groups taught with CI alone and CIMS and minimized misconceptions.

From the finding of this study, it can be concluded that metacognitive scaffolding while learning with 7EIM helped students to learn biology concepts better than learning with only 7EIM alone. When students are supported with metacognitive strategies of planning, monitoring and evaluation, they benefited much from 7EIM in understanding of concepts and minimizing of misconceptions. Moreover, students benefited more from 7EIM alone than CIMS and CI to learn biology concepts. Since the 7EIMMS helped students to conceptually understood concepts better than the other instructional methods, the percentage of misconceptions held by students also reduced among this group followed by students taught with 7EIM alone. However, students in all groups continued to hold some misconceptions in relation to human biology concepts due to the persistent nature of some misconceptions. Gender has no any significant effect on students learning.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Examining of Preservice Science Teachers' Conceptions of Learning Science: A Q Method Study

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Abstract

The purpose of this study is to examine the pre-service science teachers' views about learning science. Learning science means to use specialized conceptual language in reading and writing, reasoning and problem solving, daily life, and leading practical actions in the laboratory. This study was designed using Q-method. Ten pre-service science teachers voluntarily participated in this study. Data were collected by using 'The Conceptions of Learning Science' (COLS) questionnaire. The significance of the factors was demonstrated by using the 'Graphical Rotation' and 'Varimax Rotation' analysis in the PQmethod software. According to the results of Q analysis, participants thought that learning science is not related to science achievement or getting high scores from exams, but they stated that learning science means explaining nature and the topics related the nature. They also believed that science should be learned not by memorizing, that should be learned by experimenting, and by integrating it into daily life. It has not been found any relationship between participants' views of learning science and their understanding of nature of science. It is recommended that empirical studies might be conducted in future studies to improve the understanding of pre-service and in-service teachers about learning science.

Introduction

Learning science means learning to use specialized conceptual language in reading and writing, reasoning and problem solving, daily life, and leading practical actions in the laboratory. This might be expressed in the sense of learning to communicate in the language of science and to act as a member of the community of people who do this (Lemke, 1990). According to Lee et al. (2008), learning science means memorizing definitions, laws, formulas and special terms; being successful in science tests or getting high scores in exams; applying a number of calculations or tutorial problems; increasing knowledge through learning and scientific knowledge; understanding how to use knowledge and skills; acquiring scientific knowledge to gain a new perspective for the creation of integrated and theoretically consistent information structures in science. On the other hand, international reform documents have stated that learning science is more than accumulation of knowledge and it includes the development of skills and attitudes (AAAS, 1990, 1993; MoNE, 2018; National Research Center, 2012; NGSS Lead States, 2013).

The studies have also revealed the relationship between learning science and nature of science (NOS), which is accepted as an important component of science literacy, and it is thought that science teachers might have difficult to teach scientific concepts to students without having informed knowledge of NOS (Murcia & Schibeci, 1999). Morgil et al. (2009) stated that when science teachers have a clear understanding of NOS, their decisions in their teaching will be in a way to further support scientific literacy. It is also noteworthy that teachers acquire the above knowledge about NOS during their undergraduate years. Having an informed understanding of scientific knowledge for pre-service teachers is important in raising individuals who are scientifically literate. Considering that epistemological beliefs, learning approaches, and learning concepts are important factors in the formation of science concepts teaching (Şahin et al., 2016). As a result, developing positive attitudes towards science, scientists, and learning science is gradually more of a concern (Osborne et al., 2003). Therefore, teachers are the only people who can eliminate this concern.

Teachers' opinions about learning science have been frequently examined in the literature. The first studies on the concept of learning were done by Saljo (1979) (Marshall et al., 1999). When Saljo asked the study group what it means of learning, he identified 5 qualitatively different, hierarchically related learning concepts from the analysis of the data. These include (1) increasing knowledge, (2) memorizing, (3) obtaining facts or procedures that can be kept or used in practice, (4) abstraction of meaning, (5) understanding of reality.

Tsai (2009) investigated the 83 Taiwanese undergraduate students' conceptions about Web-based learning. Using the phenomenographic method to analyze students' interview transcripts, various categories about the concept of learning and web-based learning have been revealed. Analysis of interview results showed that web-based learning concepts are more complex than learning. For example, it has been found that many students conceptualize learning in a web-based context as a quest to see in a new way than real understanding and learning in general.

In Turkey, although there are not enough studies in which focus on in-service or pre-service teachers' conceptions about learning science, there are some studies partially focus on this issue. Sadi and Lee (2018), comparing Taiwan and Turkish high school students' biology learning concepts, found that there was a significant difference between students' mean scores in four learning concepts such as memorization, calculation and practice, increasing their knowledge and seeing them in a new way. Duarte (2007), in his study, tried to determine the Portuguese university students' conceptions of learning and learning approaches. Pre-service teachers responded open ended questions about the meaning, process, and context of learning. The results from content analysis repeated most of the learning concepts defined by phenomenographic research (e.g., the distinction between learning as memorization and learning as understanding). Moreover, new variants of known learning conceptions have emerged (e.g., learning; exploratory practice; learning to learn; motivation) and a seemingly new understanding (e.g., learning as understanding and practice).

Şahin et al. (2016), who investigated the extent to which Turkish pre-service teachers' orientations towards science teaching can be explained with their epistemological beliefs, learning concepts and approaches to science learning, determined that developing student-centered/orientation towards science teaching was mostly explained by constructivist learning approaches in science.

This study is theoretically based on six conceptions of learning science, which were identified in recent studies (Bahcivan & Kapucu, 2014; Tsai, 2004). These six conceptions are learning science means as memorizing, as preparing for tests, as calculating and practicing tutorial problems, as increasing of knowledge, as applying, and as understanding and seeing in a new way (Tsai, 2004). Teachers' conceptions about learning science are examined in these frameworks.

Purpose of the Study and Research Questions

There are few studies that reveal the pre-service teachers' conceptions related to learning science in Turkey. While some researchers focus on the attitudes of teachers (e.g., Akbaş, 2010; Nuhoğlu, 2008), some focus only on their beliefs (e.g., Erdem, 2008; Özkan & Tekkaya, 2011). This study might also have a potential value in terms of its unique research method for examining pre-service teachers' conceptions about learning science. The aim of this study is to examine the pre-service science teachers' views about learning science which focuses on the different perspectives of the participants and the underlying causes of these conceptions. Therefore, this study makes it possible to obtain more in-depth findings regarding the pre-service teachers' views about learning science based on their own expressions. The following research question guides the study:

> What are the pre-service science teachers' conceptions about learning science?

Method

This study was designed using Q-method (Stephenson, 1955), which is known as a mixed method. In studies conducted using the Q-method, the data are collected and analyzed quantitatively, but the results are mostly interpreted qualitatively (Ramlo & Newman, 2011). The Q method is defined as the measurement of subjectivity by William Stephenson (Stephenson, 1955). The Q-method allows participants express their feelings, thoughts, and beliefs about a topic, usually by sorting the statements. Selected expressions are called Q samples. Despite its mathematical structure, the purpose of the Q-method is to reveal its subjective structures, attitudes, and perspectives from the viewpoint of the person or people have been observed (Brown, 1996).

Participants

Ten pre-service science teachers (6 females; 4 males with an average age of 20) voluntarily participated in this study at a traditional four-year education faculty in a Turkish state university on their third year. Participants have a similar educational background and have taken general physics, chemistry and biology courses. Besides, they are currently taking education psychology and science method courses. In a Q study, the aim was to define typical representations of different perspectives and to demonstrate how different perspectives are represented, rather than finding the proportion of individuals with specific perspectives (Akhtar-Danesh et al., 2008; Simons, 2013). Although it is generally recommended to be between 12-20 participants in Q studies (Cairns, 2012; Webler et al., 2009), the use of fewer participants does not pose a major disadvantage. (McKeown & Thomas, 1988; Valenta & Wigger, 1997).

Data Collection Source

Data were collected by using "The Conceptions of Learning Science" (COLS) questionnaire (Lee et al., 2008). The questionnaire has been mostly used a five-point Likert scale from strongly disagree to strongly agree. The questionnaire consists of thirty-one items and six factors. The factors were named based on the Tsai's (2004) study, and these are (a) memorizing, (b) preparing for tests, (c) calculating and practicing tutorial problems, (d) increasing of knowledge, (e) applying, and (f) understanding and seeing in a new way (Tsai, 2004). The reliability (Cronbach's alpha) coefficients of COLS questionnaire for those factors were respectively found 0.85, 0.91, 0.89, 0.90, 0.84 and 0.91 in exploratory factor analysis (Lee et al., 2008). Adaptation of COLS questionnaire to Turkish language was done by Bahçivan and Kapucu (2014), and the reliability (Cronbach's alpha) coefficients of these factors were found very similar to recent findings.

Data Collection Procedure

In this study, each pre-service science teacher was asked to sort the Q samples (31 learning science statements in the COLS questionnaire (Lee et al., 2008), as shown in the Figure 1, from the statement they mostly agreed (+4) to the statement they least agreed (-4).

-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**
25	29	21	17	26	4	22	2	6
	28	19	10	13	3	30	20	
		16	8	14	11	23		
		27	9	7	12	18		
			31	15	5			
				1				
				24				

Figure 1. Example of classification scheme for a Q method with 31 statements

The Q set consisting of 31 statements in the COLS questionnaire was given to pre-service science teachers as randomly numbered cards. Firstly, the pre-service teachers divided the random cards into three groups as "I agree", "I disagree" and "I am neutral", and then they ranked the statements in each group from the least agreed to most agreed. As a result of these sequences, a distribution like Figure 1 was obtained. During the ranking process, the participants were reminded that they were free to change their rankings at every stage of the process. In this way, pre-service teachers made changes in their rankings with their reasons of explanations. While the pre-service teachers sorted the statements, the participants were asked to explain the statement they put in each range and tried to reveal the underlying reason(s) of this sort by asking why the statement was included in that order. All the interviews were audio recorded for further analysis.

Data Analysis

Q sort data for all participants were entered into PQMethod (version 2.35) (Schmolck, 2014), a program specifically designed for Q analysis. All data were sent to factor analysis. Principle component analysis (PCA) was performed for the sorts in this study, but there was no statistically significant aggregation. The factors were obtained by using the centroid factor analysis (CFA) method, which is a factor extraction method frequently used in Q method studies (Akhtar-Danesh, 2017; Brown, 1980; Schmolck, 2008; Stephenson, 1955). The significance of the factors was demonstrated by using the 'Graphical Rotation' and 'Varimax Rotation' analysis. As a result of the analyzes, a series of tables were created for each factor. Among these tables, there is a representative Q sort for each factor. In these tables, the extent to which the pre-service teachers in the relevant factor, Q ranking values (columns indicated by Q) refer to the corresponding item within the range of -4 (strongly disagree) and +4 (strongly agree); Z-score values (columns indicated by Z) refer to standardized score of the respective Q values.

In addition, the proportion of representing consensus and disagreement statements between factors was reported in the outputs of Q analysis (values expressed in the variance of explanation (%) in Table 1 and Table 2 (Brown, 1980; McKeown & Thomas, 1988). Each factor obtained in the Q method represents a specific perspective within the group. Although each Q sort is subjective, the factors identified in Q are based on concrete behavior and are typically reliable and reproducible (Brown, 1980). The interview transcriptions were analyzed in Hype-research qualitative program as a content analysis for supporting to results obtained from the Q analysis. The validity and reliability of a Q method study, as a mixed method, is considered different from quantitative research methods. There is no external criterion for evaluating the individual's perspective (Friedman & Wyatt, 1997). The rankings made by each individual are accepted as a valid expression of their views (Brown, 1996).

Results and Discussion

According to the results of Q analysis, a single factor called comprehensive factor was created by Graphical Rotation, the factors determined as a result of the centroid factor analysis within 10 pre-service science teachers, 31 items (sample Q) and 9 intervals (between -4, +4). As shown in Table 1, 9 out of 10 participants (excluding a pre-service teacher coded Selim) were included in this factor in a meaningful way. It was seen that the comprehensive factor explained the 63% of pre-service science teachers' common learning science views (Table 1).

Table 1. Factor matrix with an X indicating a defining sort for graphical rotation

Participants	Comprehensive Factor
Emir	0.7200 **X**
Merve	0.8472 **X**
Lale	0.7692 **X**
Beril	0.8493 **X**
Murat	0.8921 **X**
Gamze	0.8747 **X**
Seda	0.8346 **X**
Zafer	0.7096 **X**
Melis	0.7611 **X**
Selim	0.6740
% expl.Var.	63

Mean: .00; St. Dev: 1.915

Table 2. Factor matrix with an X indicating a defining sort for varimax rotation

	Factors			
Participants	1	2	3	4
Emir	0.8466 **X**	-0.0115	0.3338	0.2184
Merve	0.6634 **X**	0.5009	0.0291	0.3915
Lale	0.2945	0.3008	0.0301	0.8300 **X**
Beril	0.5468 **X**	0.3070	0.4376	0.4109
Murat	0.6954 **X**	0.5072	0.1363	0.3589
Gamze	0.5003	0.6952 **X**	0.3053	0.2377
Seda	0.3780	0.3846	0.3477	0.5565 **X**
Zafer	0.2423	0.2562	0.8795 **X**	0.2061
Melis	0.2268	0.1227	0.4109	0.7824 **X**
Selim	0.0612	0.8956 **X**	0.1999	0.2186
% expl.Var.	25	22	19	23

Mean: .00; St. Dev: 1.915

When the factors obtained as a result of centroid factor analysis are rotated in the Varimax rotation, a model has been created in which the participants are distributed among 4 factors. The four factors that emerged at the end of the Varimax rotation reflect the science learning beliefs expressions in which pre-service teachers have accumulated in a statistically significant way. These factors explain 25%, 22%, 15%, and 23% of the common science learning belief views of all pre-service teachers, respectively (Table 2). As a result of this rotation, 4 pre-service teachers were loaded in factor 1; 2 pre-service teachers were loaded in factor 2; 1 pre-service teachers were loaded in factor 3; and 3 pre-service teachers were loaded in factor 4 (Table 2).

Graphical Rotation: Comprehensive Factor

According to graphical rotation, nine pre-service science teachers who were statistically loaded in this factor, believed that learning science does not mean that getting high scores in the exams or being successful in the school via memorizing definitions, formulas, or laws in the textbook. They thought that learning science enables individual to understand natural phenomena or topics related to nature, and thus people can find a better way to make sense of natural life. Table 3 shows the most and least agreed to statements by all nine pre-service science teachers.

Table 3. Comprehensive factor: Three most and least agreed to statements by all participants

Item	Statement	Q Sort Value	Z-score
28	Learning science helps me view natural phenomena and topics related to nature in new ways.	+4	1.960
29	Learning science means changing my way of viewing natural phenomena and topics related to nature.	+3	1.462
30	Learning science means finding a better way to view natural phenomena or topics related to nature	+3	1.333
...	....	...	...
1	Learning science means memorizing the definitions, formulae, and laws found in a science textbook.	-3	-1.459
8	There are no benefits to learning science other than getting high scores on examinations. In fact, I can get along well without knowing many scientific facts	-3	-1.550
6	Learning science means getting high scores on examinations.	-4	-1.688

Gamze: Learning science is not related to school success or getting high scores on exams. Learning science is learning nature, natural phenomena, and developing new perspectives to the natural life.

Murat: Science is not just something that is taught or learned in schools. For centuries, people have been learning and using scientific knowledge for their needs. Many of these people didn’t even go to school. It should not be thought that science is something only for school success or getting high scores on exams. That is not learning science but memorizing it briefly and keeping it in mind.

Merve: Science means nature. It means to understand and explain nature and things related to nature. For this reason, we learn science in order to understand and explain nature with a wide perspective, and to discover new ways.

Varimax Rotation: Factor 1, 2, and 3.

Table 4. Factor 1: Three most and least agreed to statements by Emir, Merve, Beril, and Murat

Item	COLS Statements	Q Sort Value	Z-score
24	We learn science to improve the quality of our lives.	+4	1.778
20	Learning science helps me acquire more facts about nature.	+3	1.639
19	Learning science means acquiring more knowledge about natural phenomena and topics related to nature.	+3	1.355
...	....	...	...
1	Learning science means memorizing the definitions, formulae, and laws found in a science textbook.	-3	-1.164
2	Learning science means memorizing the important concepts found in a science textbook.	-3	-1.670
6	Learning science means getting high scores on examinations.	-4	-1.889

Factor 1: Utilitarian & Against Memorization

According to Varimax rotation, four pre-service science teachers (Emir, Beril, Merve, and Murat), who were statistically loaded in factor 1, believed that learning science is not something highly related to be successful in school, or memorizing scientific concepts found in a textbook. Unlike the comprehensive factor, these pre-service science teachers thought that the most important goal of learning science is improving the quality of human beings' lives, as well as attempting to understand natural phenomena and topics related to nature. Table 4 shows the most and least agreed to statements by four pre-service science teachers.

> Beril: Before anything else, a person who learns science, a science literate individual, can make own life easier and improve the quality of it. For example, someone who knows science can know how to make his house lighter with much less cost, or when we think more globally, learning science will cause its technology to develop and our quality of life will increase.

> Emir: Learning science means learning and understanding nature. Science education is not just about getting high scores from exams or memorizing formulas in books. The routine education based on memorizing that has been imposed on us for years causes the generation who are afraid of science more than learning science.

> Murat: Human beings' curiosity of learning and understanding science and nature has been on-going efforts for centuries. The biggest goal here is to have a better quality of life. Looking at scientific developments, science has had vital goals such as survival, hunting, sheltering, comfortable living, using technology for the benefit of the human being, as well as understanding nature and responding to the humorous sense of curiosity.

The statements that distinguish the pre-service teachers included in this factor from the participants loaded in the other factors are shown in Table 5. According to this, it was seen that the participants in this factor were strongly agree to the statement "We learn science to improve the quality of our lives", in which the pre-service teachers, who loaded in the other factors, were disagree or partly agree. In addition, it was seen that the pre-service science teachers in this factor, had undecided view in the statement of "Learning science involves a series of calculations and problem-solving", that the participants in the second factor did not agree, while other participants in the 3rd and 4th factors agreed on this statement.

Table 5. Distinguishing statements for Factor 1

		Factor 1		Factor 2		Factor 3		Factor 4	
Item	COLS Statements	Q-sv	Z-scr	Q-sv	Z-scr	Q-sv	Z-Scr	Q-sv	Z-scr
24	We learn science to improve the quality of our lives.	+4	1.78*	0	0.18	-2	-0.73	0	0.25
12	Learning science involves a series of calculations and problem-solving.	0	0.00	-2	-0.85	+3	1.57	+2	1.14

($p < .05$; Asterisk (*) indicates significance at $p < .01$)
Q-Sort Value (Q-sv) and the Z-Score (Z-scr) are shown in Table

> Merve: The quality of life of someone who learns science and applies it to her life improves both philosophically and physically. At least I learn science for myself for this reason, because everything I learned about science improves my quality of life.

> Murat: While learning science sometimes involves calculations or problem solving, sometimes we do not include any calculations, for example biology, we do not encounter any calculation or problem solving. I am undecided about this.

Factor 2: Increasing and Applying Knowledge & Against Examinations

According to Varimax rotation, two pre-service science teachers (Gamze, and Selim), who were statistically loaded in factor 2, thought that learning science refers to understand scientific knowledge and to learn how to apply this knowledge in a new situation. Like in the comprehensive factor, these pre-service teachers believed that learning science does not mean to get high scores on the examinations or science- related tests. Table 6 shows the most and least agreed to statements by two pre-service science teachers.

Table 6. Factor 2: Three most and least agreed to statements by Gamze and Selim

Item	COLS Statements	Q Sort Value	Z-score
23	Learning science means learning how to apply knowledge and skills I already know to unknown problems.	+4	1.956
17	Learning science means acquiring knowledge that I did not know before.	+3	1.530
26	Learning science means understanding scientific knowledge.	+3	1.404
...	....	...	...
10	I learn science so that I can do well on science-related tests.	-3	-1.404
6	Learning science means getting high scores on examinations.	-3	-1.784
8	There are no benefits to learning science other than getting high scores on examinations. In fact, I can get along well without knowing many scientific facts.	-4	-1.956

Selim: Science literacy does not mean getting a high score on exams. Getting high scores on exams is perhaps the most irrelevant benefit of learning science. We learn science to learn new things and to apply these new things in our daily life.

Gamze: Learning and implementing things I never seen before is my most important goal in learning science. When I become a teacher in the future, I will try to teach my students science with this logic, not to get higher scores on the exams.

Selim: Getting a high score on the exam does not mean that science is learned, learning science means understanding scientific knowledge and applying it in our daily life. This means already in science literacy.

The below statement that distinguishes the pre-service teachers included in this factor from the participants loaded in the other factors is shown in Table 7. According to this, the pre-service teachers, who were loaded in this factor, were strongly disagree on the statement "Learning science involves a series of calculations and problem-solving", while the other participants in the other factors, were mostly agree or undecided.

Table 7. Distinguishing statements for Factor 2

		Factor 1		Factor 2		Factor 3		Factor 4	
Item	COLS Statements	Q-sv	Z-scr	Q-sv	Z-scr	Q-sv	Z-Scr	Q-sv	Z-scr
12	Learning science involves a series of calculations and problem-solving.	0	0.00	-2	-0.85	+3	1.57	+2	1.14

($p < .05$; Asterisk (*) indicates significance at $p < .01$)
Q-Sort Value (Q-sv) and the Z-Score (Z-scr) are shown in Table

Selim: Learning science is not just about calculations, it is based on many applications, especially in primary school level, and it is learned by using it in daily life."

Gamze: We learn science by criticizing, explaining and practicing, not by calculating or solving problems.

Selim, who was not statistically in the comprehensive factor, thought a little differently than other participants about learning science through memorizing.

Selim: Scientific concepts do not need to be memorized especially in elementary school level, but as science is divided into different fields, like chemistry, biology, and physics in higher levels, scientific concepts and definitions need to be memorized, so I have been undecided view in such statements.

Selim: I think that learning will not be without memorization, but of course I believe that everything should be practiced more than memorization for learning science.

Factor 3. Problem Solving & Against Examinations

According to Varimax rotation, a pre-service science teacher (Zafer), who was statistically loaded in factor 3, believed that learning science means acquiring knowledge and solving unknown questions. Unlike the comprehensive factor, this pre-service science teacher thought that learning science involves a series of calculations and problem-solving. As stated in comprehensive factor, this participant also believed that learning science does not mean getting high scores on exams or memorizing some conceptions in the science textbooks. Table 8 shows the most and least agreed to statements by one pre-service science teacher.

Table 8. Factor 3: Three most and least agreed to statements by Zafer

Item	COLS Statements	Q Sort Value	Z-score
17	Learning science means acquiring knowledge that I did not know before.	+4	2.089
12	Learning science involves a series of calculations and problem-solving.	+3	1.567
25	Learning science means solving or explaining unknown questions and phenomena.	+3	1.567
...	....	...	...
6	Learning science means getting high scores on examinations.	-3	-1.567
2	Learning science means memorizing the important concepts found in a science textbook.	-3	-1.567
8	There are no benefits to learning science other than getting high scores on examinations. In fact, I can get along well without knowing many scientific facts.	-4	-2.089

Zafer: I think learning science involves learning the knowledge of unknown things, and solving problems. To learn science, calculations must be made and a problem must be solved.

Zafer: I am against a memorizing education. Unfortunately, in our country, exams are accepted as the fundamental criteria of success, and the level of the exams forces students to memorize scientific concepts. That's why we just memorize it, and when we pass the exam, we suddenly forget it. That's why I am against to the memorizing-based science education. This way there is no learning. Learning happens by understanding, inquiring, and solving our daily problem.

The below statement that distinguishes the pre-service teacher included in this factor from the participants loaded in the other factors is shown in Table 9. It was seen that the pre-service teacher in this factor, was disagree on the statement of "We learn science to improve the quality of our lives", while other participants, who were loaded in other factors, were mostly agree on it.

Table 9. Distinguishing statements for Factor 3

		Factor 1		Factor 2		Factor 3		Factor 4	
Item	COLS Statements	Q-sv	Z-scr	Q-sv	Z-scr	Q-sv	Z-Scr	Q-sv	Z-scr
24	We learn science to improve the quality of our lives.	+4	1.78	0	0.18	-2	-1.04*	0	0.25

($p < .05$; Asterisk (*) indicates significance at $p < .01$)
Q-Sort Value (Q-sv) and the Z-Score (Z-scr) are shown in Table

Zafer: I think learning science for a purpose is not necessary. Science seeks to answer what we wonder, to learn what we do not know, to access scientific knowledge. Increasing our quality of life should not be our primary aim. It might be a byproduct resulting from science.

Factor 4. Understanding Nature & Against Memorizing

According to Varimax rotation, three pre-service science teachers (Lale, Seda, and Melis), who were statistically loaded in factor 4, thought that learning science means getting more knowledge about natural phenomena and topics related to nature as well as applying this knowledge into a problem in daily life. As parallel to comprehensive factor and other three factors, the pre-service science teachers, who were loaded in factor 4, believed that learning science does not mean memorizing the definitions, formulae, or scientific conceptions. They thought that learning science refers to understanding, internalizing, and applying scientific knowledge in our daily life. Table 10 shows the most and least agreed to statements by three pre-service science teachers.

Table 10. Factor 4: Three most and least agreed to statements by Lale, Seda, and Melis

Item	COLS Statements	Q Sort Value	Z-score
28	Learning science helps me view natural phenomena and topics related to nature in new ways.	+4	1.794
19	Learning science means acquiring more knowledge about natural phenomena and topics related to nature.	+3	1.714
23	Learning science means learning how to apply knowledge and skills I already know to unknown problems.	+3	1.310
...	....	...	...
1	Learning science means memorizing the definitions, formulae, and laws found in a science textbook.	-3	-1.714
5	Learning science means memorizing scientific symbols, scientific concepts, and facts.	-3	-1.794
3	Learning science means memorizing the proper nouns found in a science textbook that can help solve the teacher’s questions.	-4	-1.960

Melis: Learning science is the understanding of scientific information and its application in daily life problems.

Lale: Learning science is an effort to understand nature. If we learn science, we better understand nature and things we do not know and bring logical explanations.

Seda: Science learning is not something that related to memorizing scientific concepts, definitions and formulas. Science education brings scientific explanations to the difficulties and problems we encounter in daily life, and it makes a better understanding of nature.

The below statement that distinguishes the pre-service teachers included in this factor from the participants loaded in the other factors is shown in Table 11. According to this, even it is not statistically meaningful, it was seen that the participants in this factor were definitely not involved in the statement “Learning science means memorizing scientific symbols, scientific concepts, and facts", while other participants were also disagreed with this statement.

Table 11. Distinguishing statements for Factor 4

		Factor 1		Factor 2		Factor 3		Factor 4	
Item	COLS Statements	Q-sv	Z-scr	Q-sv	Z-scr	Q-sv	Z-Scr	Q-sv	Z-scr
5	Learning science means memorizing scientific symbols, scientific concepts, and facts.	0	-0.27	-1	-0.43	-1	-0.52	-3	-1.79

($p< .05$; Asterisk (*) indicates significance at $p< .01$)
Q-Sort Value (Q-sv) and the Z-Score (Z-scr) are shown in Table

Discussion, Conclusion, and Implications

In this study, which attempts to examine pre-service science teachers’ conceptions on learning science using the Q method, it was found that pre-service teachers, in general, thought that learning science is not related to science achievement or getting high scores from exams, but they stated that learning science means explaining nature and the topics related the nature. These findings differ from the findings of Saljo (1979), and are similar to the study of Sadi and Lee (2018). By using the Q method, each participant's profile was formed based on the participants' responses towards to learning science statements. Among the factors revealed in Tsai's (2004) study, it was shown in which factors the participants were loaded most and how they sort the statements. In this context, parallel to the study of Lee et al. (2008), it was concluded that in this study, science should be learned not by memorizing, that should be learned by experimenting, and by integrating it into daily life. Although some pre-service teachers thought that memorizing was a necessary step for learning, they mostly emphasized the disadvantages of a completely memorized science education. It has been concluded that a science education based on memorization only benefits the students in a short time but not performs a meaningful learning. Thus, students are generally afraid of science lessons and do not like science. the pre-service science teachers in this study mostly pointed out the importance of helping students in early ages to love science with hands-on activities, and inquiry-based learning.

According to Q analysis, some pre-service teachers thought that science should be learned in order to benefit humanity, while some thought that science should be learned for solving out the problems in our daily life. Also, in this study, it was observed that the gender factor did not have a significant effect on pre-service teachers' conceptions of learning science. It was observed that there was no statistically significant difference in the factors involving male and female participants. When the distinguishing statements for each factor are examined, it is seen that pre-service teachers have different conceptions especially regarding the aims of learning science. As well as those who stated that the importance of the relationship between science and daily life and said that science facilitates our lives and increases our welfare level, there were also pre-service teachers who argued the importance of learning the subject content knowledge and calculations in science. This Q study differs from other quantitative studies related to learning science by revealing the reasons for the views of pre-service teachers. For this reason, it is recommended to use Q method in other samples to understand and improve the conceptions of teachers and pre-service teachers about learning science.

Despite mentioning the relationship between learning science and NOS in the literature (Morgil et al., 1999), in this study, it has not been found any relation between learning science and NOS. Exploring the pre-service science teachers' NOS views and the level of development can reveal the relationship between their understanding on learning science and the aspects of NOS. Thus, it is suggested that new studies should be carried out to understand the relationship between teachers' NOS views and their conceptions of learning science, and also to improve the pre-service teachers' understanding about learning science, just like the studies have been performed on developing learners' NOS views.

Another important feature of this study is its unique methodology. It is possible to come across applications of this method, which is not very common in science education, especially in recent years (e.g., Jason et al., 2008; Mesci & Cobern, 2020). The q method, as a mixed method, serves to reveal the subjective views of the participants based on their personal worldview, viewpoint, socio-economic, and educational background. In this way, it provides a great opportunity for researchers especially in socio-scientific subjects and educational sciences. In this q study, it was focused on pre-service science teachers' subjective worldviews, and revealed their responses to statements about learning science. For this reason, it is recommended to increase the applications of this method and to gain literature in both science education and other educational studies.

It is thought that this study might contribute to science education literature and teacher development programs since there are a few studies in Turkey that reveal the conceptions of teachers and pre-service teachers about learning science. The problems that are brought by memorization in science education where most pre-service teachers draw attention should be emphasized, and this awareness should be developed in both in-service and pre-service teachers by revising the goals of new programs such as making science lessons more enjoyable and making students love it, not only being successful in lessons, but also seeking ways to integrate science in daily life. In this context, revealing the pre-service teachers' opinions about learning science with q method is important for the construction of new science education programs.

This study is limited with the pre-service teachers participating in the study. It has been previously stated that there are no disadvantages using small sample sizes in Q studies, the size of the sample chosen in the study might be a limitation of this study. Therefore, it is recommended that similar studies should be carried out in larger and different samples. In addition, it is suggested that empirical studies might be conducted in future studies to improve the understanding of pre-service and in-service teachers about learning science, focusing on the factors underlying their views.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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The Effect of Augmented Reality Applications in Science Education on Academic Achievement and Retention of 6th Grade Students

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Abstract

The role of technology literacy in education, which is one of the 21st century skills that students should have, is very important. This study examines the effect of augmented reality (AR) applications, which is a new technology, on students' academic achievement and the level of recalling the learned knowledge. In this study, quasi-experimental design with pretest-posttest control group, one of the quantitative research methods, was used. The study was carried out with a total of 50 students, 24 in control and 26 in experimental groups, studying in the 6th grade of a secondary school in the Odunpazarı district of Eskisehir. The study lasted for 9 weeks, covering the Solar System and Eclipses unit and the Systems in Our Body unit of the 6th grade Science curriculum. During the process, the lessons instructed in the experimental group (EG) were supported by AR applications, whereas only the textbook was used in the control group (CG). The tools used in data collection were "the Solar System and the Systems in Our Body achievement test", developed by the researcher and a semi-structured interview form for AR applications. Independent samples t-test, covariance analysis (ANCOVA) and descriptive analysis were used in the analysis of the data obtained from the achievement test. Content analysis was used in the analysis of the data obtained from the interview form. As a result of the research, it was observed that the use of AR applications in the processing of the course was effective in increasing the academic success of the students in the EG and in the permanence of the information they learned compared to the students in the CG, who only used the textbook. In addition the following findings were revealed: students have not used AR applications before, these applications were effective in increasing the academic success of the students, the knowledge that they have learned was permanent mostly because of the 3D feature of the technology, the applications worked smoothly and it may be useful to use them in other courses. Based on these results, it is suggested to use AR applications more frequently and actively in all topics of science and in all grade levels of secondary school.

Introduction

Today, where the greatest power is knowledge, societies are shaped on the use, production and teaching of knowledge, which is a product of science. Knowledge obtained as a result of scientific studies creates new perspectives and new horizons. Technology is the biggest supporter of scientific studies. Science and technology, which constantly interact by contributing to each other, continue their development at full speed. In the 21st century, creative, innovative, entrepreneurial, flexible, responsible, information and technology literate individuals are needed. Partnership for 21st Century Skills [P21], 2013 classified 21st century skills under three headings: learning and innovation skills (creativity and innovation, critical thinking and problem solving, communication and social interaction), life and career awareness (flexibility and adaptability, entrepreneurship and self-management, social and intercultural skills, leadership and responsibility), and information media and technology skills (information literacy, media literacy, and information and communication technologies). Information, media and technology literacy are the prominent skills of this study. When it comes to raising 21st century people, we cannot think of education separately from technology. Science and technology which determine the level of development of societies (Karasar, 2004) are an integral part of education. The countries developed in the fields of science and technology are known to be developed in education systems as well. Hence, many countries, especially developed countries, have conducted studies on the use of technology and projects in education (Pamuk et al., 2013).

The inclusion of technology in education and being used by teachers and students provides better quality learning (Cakir & Yildirim, 2009). As it is known, the realization of learning in classical classroom settings is very difficult. With the contribution of technology, these difficulties in learning environments disappear to a large extent, if not completely eliminated. In order to provide more effective learning environments, new teaching strategies, methods, techniques, tools, materials or technologies that activate student, prevent distraction, make the topics interesting and fun are needed (Arici, 2013).

New technologies that we encounter as virtual reality (VR) and augmented reality (AR) are used in learning-teaching settings in education. These technologies emerge as a topic that attracts attention in education, becoming widespread and accepted. Computers, mobile phones, interactive whiteboards, videos, multimedia applications, educational games and learning platforms, simulations, VR, Internet and Web 2.0 applications are some examples of technology that are effectively used by teachers and students in educational settings (Dror, 2008). AR technology is one of the new educational technologies. AR is one of these new technologies, which has been increasingly used with the development of technology, and whose impact on education is widely discussed (Kucuk et al., 2014). The advantage of this new technology is creating a realistic simulation and experimental setting (Abdusselam, 2014). According to Azuma (1997), AR is a derivative of VR. He describes it as the settings built on the real world and supported by VR, rather than a purely virtual environment. More generally, AR is the interpretation and presentation of virtual objects placed in predetermined places on the image of the real world taken by camera by the computer programs (Yilmaz, 2014). Technology, which goes into every area of our daily life, is becoming more and more indispensable with a new development every day. AR, which is one of the new products of technology, also appears in new areas day by day. According to Azuma (1997), AR technology consists of at least six classes: medical imaging, maintenance and repair, explanation, robot route planning, entertainment, military aircraft navigation and targeting. Today, new fields, such as architecture, tourism and education, are added to these fields. Thanks to the rapid information transfer it provides, AR gains considerable potential in the areas it is used. Considering this knowledge transfer in the field of education, it will have a very positive contribution to education. AR technology will eliminate many obstacles in education with the opportunity to interact with virtual objects on the real world that it provides to its users. It is undoubtedly accepted that the application of technological innovations in education will increase the quality of education. Regarding the recent years in the Horizon reports, which are published regularly every year, AR technology is stated to be beneficial in education. AR technology provides diversity and makes it possible to interact on it. However, the use, acceptance and dissemination of educational technologies are more difficult and time consuming than other methods (Parker & Heywood, 1998). Therefore, the development of guiding materials to teachers for the use of programs such as AR it is important (Aktamis & Arici, 2013). AR is also very effective in developing some features expected from students, such as problem solving, group work, multi-faceted evaluation and understanding of different perspectives (Sahin, 2017). At the same time, it increases the academic achievement of students by extending their focus time (Abdusselam & Karal, 2012). At this point, the development of AR applications that have an important potential and apply them in education will be beneficial (Somyurek, 2014).

The use of educational technologies in addition to teaching materials in science lessons was reported to help students to relate the knowledge they have learned to daily life and to learn technology (Akpinar et al., 2005). The role of technology in science education is bigger than other fields. Technology can be used effectively in other fields as well but regarding the role of AR in science education, it can be said that it has an important potential thanks to its ability to concretize abstract concepts. AR applications not only concretize abstract concepts, but also provide an opportunity to experience the settings that are difficult to access or cannot be created on the world. From this point of view, the effects of AR technology on students in science class are wondered. Educational technologies provide in-depth learning by concretizing abstract concepts especially for primary school-age children since they have difficulties in learning abstract concepts (Akpinar et al., 2005). For this reason, this study targeted the students who are at lower grades of education. On the other hand, the literature review revealed many studies on AR, the majority of them measuring the academic success of students and their attitude towards science course. In this study, it is aimed to investigate the effect of AR applications in science education on the level of recalling the learned knowledge of 6^{th} grade students. For this purpose, the following questions were addressed.

- Is there a significant difference between experimental group (EG) students' pretest and posttest achievement test scores?
- Is there a significant difference between control group (CG) students' pretest and posttest achievement test scores?
- Is there a significant difference between EG and CG students' average posttest scores adjusted according to pretest scores?

- Is there a significant difference between EG and CG students' average recall test scores adjusted according to posttest scores?
- What are the opinions of the EG students about AR applications?

Method

Research Model

In this study, quasi-experimental design with pretest-posttest control group, which is one of the quantitative research methods, was used to determine the effect of AR applications in science teaching on the level of recalling the knowledge. Fraenkel et al. (2012) summarized the main idea of all experimental research as "try something and systematically observe what is happening". The objective of the experimental studies is to test the cause-effect relationship between the variables (Buyukozturk et al., 2009). Experimental patterns can be divided into two, as multi-subject patterns and single-subject patterns (Buyukozturk et al., 2009). Fraenkel et al. (2012) divided the multi-subject designs into four as weak experimental designs, real experimental designs, quasi-experimental designs and factorial designs. Quasi-experimental design is the preferred experimental design in educational studies, when it is impossible to control all variables (Cohen et al., 2007). In this study, quasi-experimental design was used because all variables could not be controlled.

Study Group

The research was carried out with a total of 50 students, 22 girls and 28 boys, who were attending 6th grade of a secondary school in Eskisehir city center during the fall semester of the 2019-2020 academic year. In order to provide speed and convenience to the research, the sample was selected according to easily accessible criterion. In order to prevent the ongoing education process from being interrupted, control and experimental groups were not created artificially but were formed from existing students. While determining the control and experimental groups, the two classes which are academically similar among the 6th grades, with the most skillful class teacher in terms of using technology and which are more enthusiastic about working together, were chosen. The parental consent of a total of 7 students, 5 from the EG and 2 from the CG, could not be granted. These students are included in the study process in order not to violate their educational rights, but the data collected from these 7 students were not included in the data set.

Research Process

The research was planned to include the first two units of the 6th grade; the Solar System and Eclipses, and the Systems in Our Body units. The gains and concepts that cannot be acquired through AR applications are excluded from the study. After the necessary permissions were obtained from the Provincial Directorate of National Education and the Ethics Committee, the study was initiated with a total of 50 students, 22 girls and 28 boys, in the fall semester of the 2019-2020 academic years. At the beginning, the pretest was administered on both the control and experimental groups that we randomly determined. The study was planned according to the time intervals of the gains covered in the 6th grade science curriculum that are suitable for the study and lasted for a total of nine weeks. Two weeks of these nine weeks were involving the filling of the pre-test, post-test and interview forms. “The Solar System and the Systems in Our Body Achievement Test” was administered on the control and experimental groups as the pretest. During the study, Space 4D, Space 4D +, Virtual Teacher 4D, Our Body 4D, Luke AR, and Human Anatomy 4D AR applications and cards were used in the EG. During the study process, the researcher installed AR applications on the phone and tablet and actively used them. In addition, students who have a smartphone or tablet were asked to bring their devices to the lesson and AR applications were installed on the devices and made ready for the lesson.

Regarding the Solar System and Eclipses unit, two activities were carried out in the EG. The topics and concepts of this unit related to solar system, planets, meteor, blue stone, and asteroid were instructed using AR applications such as Space4D +, Uzay 4D, Sanal Ogretmen 4D. These activities targeted the following gains: "compares the planets in the solar system with each other." and “creates a model by sorting the planets in the solar system according to their proximity to the Sun”. Visuals related to the activities in the Solar System and Eclipses unit are presented in Figure 1 and 2.

Figure 1. Solar System

Figure 2. Planet Sorting

Six activities were carried out for the Systems in Our Body unit. The topics and concepts of this unit related to cartilage, bone and bone types, joint and joint types, muscles and muscle types; the structure and organs that constitute the digestive system, physical and chemical digestion, enzymes, the function of the liver, pancreas, and pancreas in digestion; structures and organs that constitute the circulatory system, structure and function of the heart, blood vessels, systemic circulation and microcirculation, blood types, blood donation, circulatory system; structures and organs that constitute the respiratory system, lungs were instructed using AR applications such as Vucudumuz 4D, Human Anatomy 4D, Luke AR. These activities targeted the following gains "Explains the structures of the musculoskeletal system with examples", "Explains the functions of the structures and organs that constitute the digestive system using models", "Explains the functions of auxiliary organs in digestion", "Explains the functions of the structures and organs that constitute the circulatory system using models", "Examines the systemic circulation and microcirculation on the scheme and explains their functions" and “Explains the functions of the structures and organs that constitute the respiratory system using models”. Visuals related to the activities in the Systems in Our Body unit are presented in Figure 3-4-5-6.

Figure 3. Skeleton System

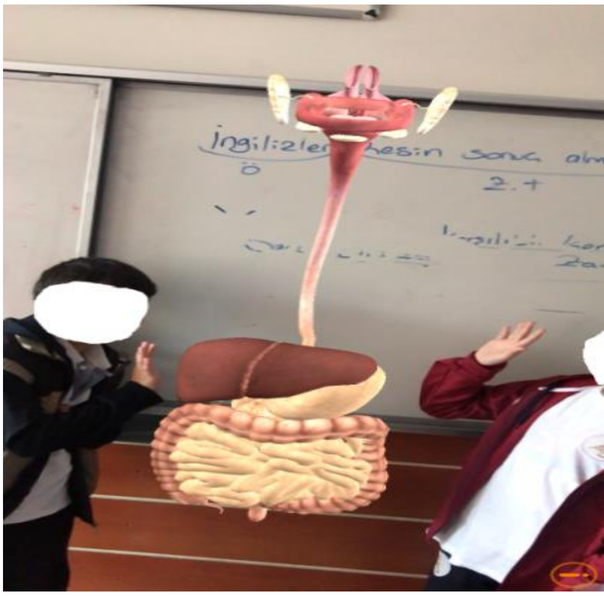

Figure 4. Digestion System

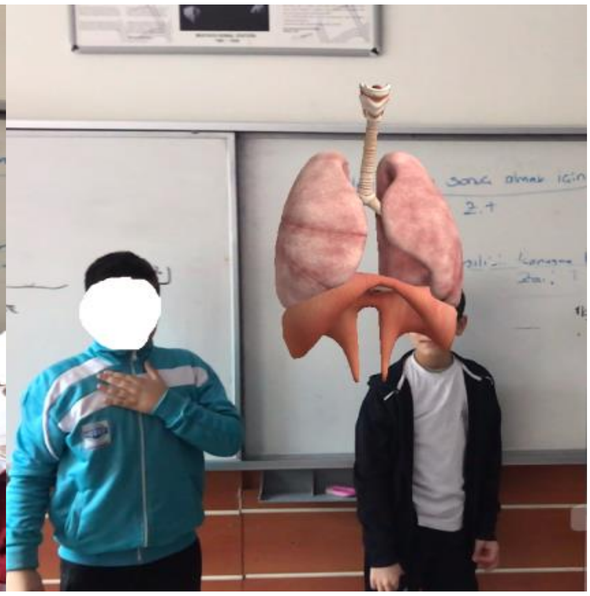

Figure 5. Respiratory System

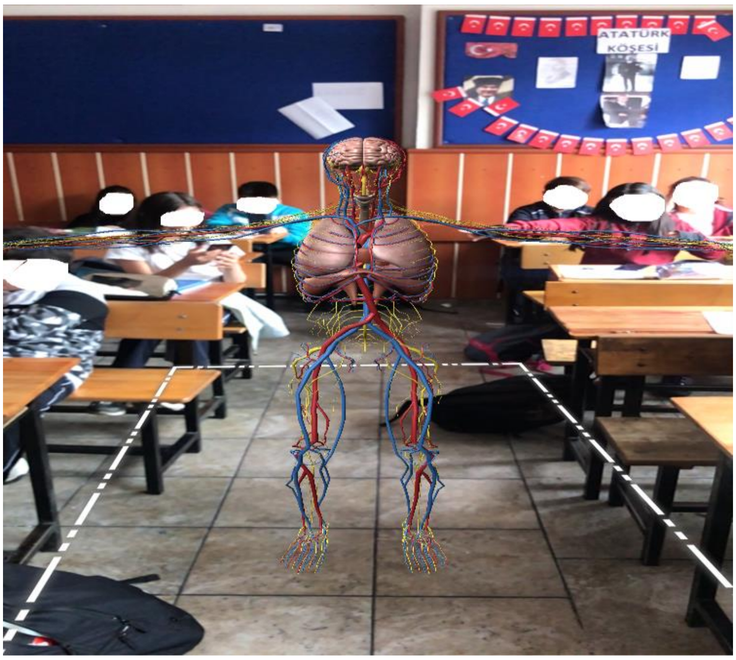

Figure 6. Circulatory System

Teacher-centered traditional teaching method was used in the CG, by sticking to the curriculum and textbook. Teacher-centered traditional teaching is the instruction where the teacher is active and the student is passive in the classroom and activities (Aydede & Matyar, 2009). Following the application process, the posttest and the semi-structured interview form were administered on the EG to determine their opinion on AR technology, whereas only the posttest was administered on the CG. One month after the post-test application, the recall test, which is exactly the same as the post-test, was administered on both experimental and control groups to measure the permanence of the learning.

Data Collection Tools

In order to determine the students' level of recalling, the Solar System and the Systems in Our Body Achievement Test, developed by the researcher, was used. A semi-structured interview form prepared by the researcher was used for collecting students' opinions on AR applications.

The Solar System and the Systems in Our Body achievement test

The Solar System and the Systems in Our Body Achievement Test, developed by the researcher, was used in the study to determine the students' level of recalling the knowledge. The gains included in the achievement test prepared for the "Solar System and Eclipses" and the "Systems in Our Body" units, which are the first and second units of 6^{th} grade Science curriculum, were specified according to 2018 science curriculum (MEB, 2018). Item analysis was performed for the validity of the 45-question test prepared for 9 gains. Malformed items were detected upon the item analysis and difficulty and discrimination level of the items were confirmed (Buyukozturk et al., 2016). A total of 402 students have participated in the pre-pilot application. In item analysis, the focus was on item discrimination and item difficulty. Regarding the reference values of the item discrimination indexes, items with a discrimination index of 0.40 and above are considered to be very good, and items between 0.30-0.39 are quite good. Items with a discrimination index of 0.20-0.29 can be revised and modified, and items with a value of 0.19 or less should be removed from the test (Crocker & Algina, 1986). Regarding item difficulty, the reference value ranges between 1 and 0. As this value approach to 1, the item becomes easier and vice versa (Buyukozturk et al., 2016). Following the analysis, 18 items with a discrimination index of 0.19 and below were removed from the test. The test, whose number of items was reduced to 27, get ready for pilot implementation. Regarding the item analysis of the data obtained from the pilot application conducted with 43 girls and 45 boys, item difficulty and discrimination indices were found to be within the reference values. The reliability coefficient of the developed test was calculated as KR20 (Alpha) 0.85.

Semi-structured interview form

Interview is the preferred method in most of the qualitative studies (King et al., 2019). After the implementation process and the measurement of academic achievements in the study, an eight-question semi-structured interview form developed by the researcher was used to determine the opinions and thoughts of the students in the EG about this experience. The questions were prepared under three themes: thoughts on AR technologies, experiences on AR technology and the contribution of AR technology to learning. The interview form was administered on 26 students in the EG. 40 minutes were given to answer the questions in the form. Two faculty members who are experts in science education and measurement and evaluation were consulted during the preparation of the questions. In addition, opinions of two science teachers, one working in the science, arts and education center affiliated to the Ministry of National Education and the other in a secondary school, were asked. In order to test the comprehensibility of the questions, a preliminary interview was held with 10 students attending 6^{th} grade. The interview form was finalized upon the corrections made according to the given feedback.

Data Analysis

While analyzing the quantitative data, TAP (Test Analysis Program) was used in the preparation of the achievement test, and SPSS 20 software was used to compare the data obtained from the pretest, posttest and recall test. In order to make the raw data obtained during the study usable, numerical values were given to each answer and they were entered into the databases of the programs.

Descriptive analysis was performed on the data collected from the control and experimental groups, and the arithmetic mean, standard deviation, maximum and minimum values, skewness, kurtosis and Shapiro-Wilk values were calculated. Regarding the normality check of the score distribution, Buyukozturk (2005) suggested to use Shapiro-Wilk normality test if the group size is less than 50, and Kolmogrov-Smirnov normality test if the group size is greater than 50. Regarding the p value calculated as a result of these tests, the values smaller than 0.05 are interpreted as the scores deviate significantly from the normal distribution, that is, the normality condition is violated (Buyukozturk, 2005). In this study, Shapiro-Wilk normality test was administered because the sample size was less than 50. Another parameter that indicates normality is skewness and kurtosis. In particular, the skewness is more useful than the kurtosis. Having a skewness of zero ("0") is an indicator of normal distribution, but it is extremely difficult to collect data with normal distribution in the implementation (Coskun et al., 2015). If the skewness is between +1 and -1, it is assumed that there is no significant deviation from the normal distribution (Buyukozturk, 2005).

Dependent groups t-test was performed to determine whether the difference between the mean scores of the dependent groups in the study was significant or not, whereas independent samples t-test was used to determine the significance of the difference between the mean scores of independent groups (Buyukozturk, 2005). Normal distribution of data is required in all parametric tests, while in some tests such as t-test, this condition is not required. They can be used safely up to a certain deviation from normal distribution (Coskun et al., 2015). Covariance analysis (ANCOVA) was used to test whether the group means adjusted according to the common variable associated with the dependent variable differ significantly from each other (Buyukozturk, 2015). The covariance analysis, which is a parametric test, gives strong results if the assumptions are met, and variance analysis and regression analysis are used together to calculate the difference between the means of the groups (Kalayci, 2010).

Content analysis was used to analyze the data obtained from semi-structured interview form administered on the students of the EG. The objective of preferring content analysis is to reach the concepts and relationships that explain collected data. The process carried out in this analysis is to group the data within the framework of certain concepts and interpret the themes in a way that the reader can understand (Yildirim & Simsek, 2016). The analysis process was completed in three stages, namely data processing, visualization of the data, and inference and confirmation (Miles & Huberman, 1994). In the first stage, the data were examined. In the second stage, codes and categories were specified and grouped under three themes. The third stage tries to summarize the data in an understandable way. In order to comprehend the data obtained from the semi-structured interview form more clearly, the answers collected from the students were classified under the themes suitable for the objectives of the study. Similar data obtained from the form were grouped under a common theme and students' answers were supported with quotations to ensure the internal validity of the research. Each student was given a code name (P1-P), so that their identity was kept confidential. In order to ensure external validity, all stages of the research have been examined in detail. In order to ensure the reliability of the research, the data were analyzed independently by the researchers and then compared. The two researchers analyzed the data obtained from the interview forms at different times. Also, during the research, researchers often came together and decided on the themes, categories and codes to be used in the study. The analysis of the data obtained from the interview form was done by two independent evaluators. No calculation was made in this process, only a few codes differing among the evaluators were discussed and agreed on. A harmony was observed among the coding of the evaluators.

Findings

This section includes the findings obtained in line with the objectives and sub-objectives of the research. Firstly, the distributions of the data obtained from achievement test administered on control and experimental groups were analyzed. Table 1 shows the student numbers of the groups, the average scores obtained from the achievement test, standard deviations, skewness, kurtosis, mid-range minimum, maximum and Shapiro-Wilk normality test results.

Table 1. Descriptive Statistics of the pretest, posttest and recall test scores from Achievement test

Tests	Groups	N	$\bar{X}$	sd	Skew.	Kurt.	Mid-range	Min	Max	Shapiro-Wilk
Pretest	Exp.	26	10.34	2.79	-.54	.65	12	4	16	.31
	Control	24	10.83	2.20	-.30	-.65	8	6	14	.27
Posttest	Exp.	26	22.69	2.61	-.37	-.34	10	17	27	.50
	Control	24	20.08	2.81	.49	.53	12	15	27	.59
Recall test	Exp.	26	22.26	2.47	-.12	-.47	10	17	27	.48
	Control	24	17.54	3.72	.19	-.15	15	10	25	.88

Regarding Table 1, mean pre-test score of the CG ($\bar{X}$ = 10.83) and EG ($\bar{X}$ = 10.34) were observed to be quite close to each other, and accordingly the achievement level of the groups was concluded to be similar before the application. Regarding skewness, kurtosis and Shapiro-Wilk normality values of the pretest, posttest and recall test, the scores obtained from all tests exhibited normal distribution ($p>.05$)

Comparison of experimental and control group students' pretest and posttest scores

In order to answer, "Is there a significant difference between EG / CG students' pretest and posttest achievement test scores?" questions, experimental and control groups' pre-test and post-test scores were tested. Since the scores of both tests were normally distributed, the significance of the difference between the mean scores was tested by "dependent groups t-test".

Table 2. t-test results of control and experimental groups' pretest and posttest scores

	Test	*N*	$\bar{X}$	*SD*	*sd*	*t*	*p*
Experiment	Posttest	26	22.69	2.61	25	24.43	.000*
	Pretest	26	10.34	2.79			
Control	Posttest	24	20.08	2.81	23	14.19	.000*
	Pretest	24	10.83	2.20			

*p<.05

Regarding table 2, a significant difference was observed between pretest and posttest scores of the EG students ($t(25)=24.43$, $p<.05$). The average score of the EG increased from 10.34 to 22.69, which corresponds to an increase of approximately 53%. This finding is higher than CG's achievement increase. A significant difference was also observed between pretest and posttest scores of the CG students ($t(23)=14.19$, $p<.05$). The average score of the CG increased from 10.83 to 20.08, which corresponds to an increase of approximately 46%.

Comparison of experimental and control group students' posttest scores

In order to answer, "Is there a significant difference between EG and CG students' average posttest scores adjusted according to pretest scores?" question, the significance of the difference between experimental and control groups' average pretest scores was tested first. Regarding independent samples t-test results, no statistically significant difference was observed between the average pretest scores of the EG and CG students ($t = -.68$; $p>.05$). Then, the significance of the difference between experimental and control groups' average posttest scores was tested by independent samples t-test. The result of independent samples t-test is given in Table 3.

Table 3. t-test results of control and experimental groups' posttest scores

Group	$\bar{X}$	SD	sd	t	p	η2
Control	20.08	2.81	48	3.39	.001*	0.193
Experimental	22.69	2.61				

*p<.05

Regarding Table 3, the average posttest score of the EG was observed to be higher than the CG. Accordingly, a statistically significant difference was observed between EG and CG students' posttest scores ($t = 3.39$; $p< .05$). When the effect size was calculated, the large effect size ($\eta2$ =.193) (Cohen, 1988) demonstrated a significant difference between the groups.

Comparison of experimental and control group students' recall test scores

In order to answer, "Is there a significant difference between EG and CG students' average recall test scores adjusted according to posttest scores?" question, the significance of the difference between experimental and control groups' average posttest scores was tested first. In table 3, a statistically significant difference was observed between EG and CG students' posttest scores ($t = 3.39$; $p<.05$). Therefore, covariance analysis (ANCOVA) was performed for experimental and control groups' posttest and recall test scores.

Before performing the covariance analysis, certain assumptions were checked and the covariant was specified. In this sub-problem, the covariant was specified as the scores that the groups received from Posttest. The assumptions of the covariance analysis, namely whether the scores of the groups show normal distribution, whether there is a linear relationship (correlation) between the common variable (covariant) and the dependent variable, and the homogeneity of the regression curves and the group variances were checked. For normality assumption, Skewness, Kurtosis and Shapiro-Wilk normality test results of Table 1 were reviewed, and it was concluded that the scores did not deviate excessively from the normal distribution.

The relationship between the dependent variable and the covariant was examined by Pearson correlation analysis. The results showed that the relationship between the dependent variable (recall test scores) and the covariant (posttest scores) is significant and high for both the EG ($r =.87$; $p <.01$) and CG ($r =.84$; $p <.01$), therefore a linear relationship was observed between them. In order to check the assumption of homogeneity of regression curves within groups, the difference between the slopes of regression lines was examined by "Group x Posttest" joint effect test. The results of the analysis are given in Table 4.

Table 4. “Group x Posttest” joint effect test outcomes

Dependent Variable	Source	Sum of Squares	sd	Mean of Squares	F	p	η2
Recall Test	Adjusted Model	621.52[a]	3	207.17	73.03	.00	,826
	Constant	.30	1	.30	.10	.74	,002
	Groups	13.52	1	13.52	4.76	.03	,094
	Posttest	331.80	1	331.80	116.97	.00	,718
	Groups *Posttest	7.58	1	7.58	2.67	.10	,055
	Error	130.47	46	2.83			
	Total	20752.00	50				
	Adjusted Total	752.00	49				

Regarding Table 4, it was concluded that the difference between the slopes of the regression lines is not significant, in other words the regression curves are homogeneous (F (1.46) = 2.67, p>.05). When the effect size was calculated, it was estimated that the effect size was η2 =, 055. Accordingly, this value is interpreted as a medium effect size (Cohen, 1988). The results of the Levene test performed to check the equality of variances assumption also showed that the variances of the groups were homogeneous (F = 3,01, p>.05). As a result of these analyzes, all assumptions of ANCOVA are provided, showing that the significance of the difference between the experimental and control groups’ average recall test scores adjusted according to the posttest scores can be analyzed by ANCOVA. The results of the covariance analysis are given in Table 5.

Table 5. ANCOVA results of experimental and control groups’ recall test scores

Dependent Variable	Source	Sum of Squares	sd	Mean of Squares	F	p	η2
Recall Test	Adjusted Model	613.94[a]	2	306.97	104.50	.00	.81
	Constant	.64	1	.64	.21	.64	.00
	Posttest	335.01	1	335.01	114.05	.00	.70
	Groups	48.13	1	48.13	16.38	.00	.25
	Error	138.06	47	2.93			
	Total	20752.00	50				
	Adjusted Total	752.00	49				

Regarding Table 5, a statistically significant difference was observed between EG and CG students’ recall test scores adjusted according to the posttest scores (F(1,47)= 16,38, p<.05). The effect size of the difference was calculated as η2 =.25. Regarding this effect size, we can say that independent variable has a small effect on the dependent variable. In other words, 25.9% of the change in the dependent variable results from the applied method. The results of the Bonferroni comparison test between the adjusted averages of the groups are given in Table 6. Regarding Table 6, a statistically significant difference was observed between experimental and control groups’ adjusted recall test scores (p <.05), in favor of the EG.

Table 6. Bonferroni Comparison Test Results of the Groups’ Adjusted Recall Test Scores

Group	Difference in Means	Standard Error	p	Source of the Difference
Experimental Control	2.18	.54	.00	Experimental >Control

Opinions of experimental group students on AR **technology**

This part of the study includes the findings obtained from the semi-structured interview form consisting of eight questions in which the opinions of the students in the EG about the AR technology are taken. The interview form was administered on the 26 students of the EG. The answers given to the eight questions in this form were analyzed. For a clearer understanding of the data obtained from the interview form, the answers given by the students were classified under themes suitable for the objective of the study. These analysis results were also supported with quotations from student opinions. Theme, category, code and frequency values created for AR practices are presented in Table 7.

Table 7. Theme, category, code and frequency table for AR applications

Theme	Category	Code	*f*
Thoughts on AR Technologies	Description of AR	3D image	19
		Phone app	5
		Feeling like you're there	1
		Examination	1
	The remarkable features of the applications	Being 3D/4D	16
		Moving images	4
		Visible on the phone	2
		Having a voice narration	2
		Being fun	1
		Effective on the retention of the knowledge	1
		Having card feature	1
	Suggestions for other courses	Social Sciences	17
		Mathematics	8
		English	2
		Turkish	1
		Science	1
		Physical education	1
	Topics suggestions	History	11
		Sets	1
		Our place in the world	1
		Life on earth	1
		Individual and society	1
		Parallel and meridian	1
		Dodgeball	1
Experiences on AR Technologies	Previous use of AR applications	I have not used	18
		I don't remember the name	5
		Uzay 4D	3
		Vucudumuz 4D	2
		Anatomy 4D	1
	Problems experienced	Some	2
		None	24
The Contribution of AR Technology to Learning	The topics and concepts learned	The Solar System	16
		Systems in Our Body	15
		Topics and concepts in Science	3
		The concept of prejudice	1
	Helping them to understand the topic	Yes	24
		No	1
		Somehow	1
	How it helped them to understand the topic	Repetitions	13
		Visuals	7
		Being fun	1
		Audio	1
	Effect on the permanence of what was learned	Effective with the visuals	17
		Effective by being repetitive	3
		Effective by being fun	3
		Not effective	2
		Not fully effective	1

Students' answers regarding AR applications were grouped under three themes: thoughts on AR technologies, experiences on AR technology and the contribution of AR technology to learning (Table 7). There are four categories under the theme of thoughts on AR technologies: description of AR, remarkable features of the applications, suggestions for other courses and topic suggestions. The code mostly mentioned under the description of AR category is 3D image. A student on this subject said, “Seeing an item from all sides, seeing it as 4D or 3D. (P-1)”, whereas another similar opinion was “We can see objects in three dimensions (P-17)”. The other codes mentioned under this category were phone app, feeling like you’re there and examination. The code mostly mentioned under the remarkable features of the applications category is being 3D/4D. A student on this subject stated her opinion as “Being 3D/4D attracted my attention (P-27)”. Another similar opinion was "Being 3- or 4-dimensional drew my attention (P-19)". The other codes mentioned under this category were the presence of moving images, being visible on the phone, having fun, having a voice narration, being effective in the retention of the knowledge, and having a card feature. The mostly repeated code under the category of suggestions for other courses is social sciences. A student on this subject expressed his opinion as “the first Turkish states in social sciences (P-5)”. Another similar view was "Social Sciences, Anatolia Homeland of the Turks (P-7)". Other codes mentioned under this category were mathematics, English, Turkish, science and physical education. The most frequently mentioned code under the category of topic suggestions is history. A student on this subject expressed her opinion as "I would like to see it in Social Sciences course and on the topic of History (P-14)". Another similar opinion was "Social Sciences History (P-13)". Other codes mentioned under this category were sets, our place in the world, life on earth, individual and society, parallel and meridian, and dodgeball.

There are two categories under the theme of experiences on AR technology: previous AR applications and problems experienced. The code mostly mentioned under previous AR applications category was I have not used. A student said, “I did not use it (P-15)” on this subject. Another similar opinion was, “I have not used such an application before. (P-10)”. The other codes mentioned under this category were, I don't remember the name, uzay 4D, vucudumuz 4D, anatomy 4D. None is the code that was mostly repeated under the category of problems experienced. A student on this subject expressed his opinion as "No, there was not (P-25)". Another similar view was "no problem occurred (P-20)". The other code specified under this category is some problems. A student on this subject expressed her opinion as “yes, my phone's camera has warmed up (P-1)”. Another similar opinion was “There was a problem with the application. It was closing immediately. (P-13)”.

The theme of the contribution of AR technology to learning is presented under four categories: the topics and concepts learned, helping them understand the topic, how it helped them to understand the topic and its effect on the permanence of what was learned. The most frequently mentioned code under the category of topics and concepts learned is The Solar System. A student on this subject expresses her opinion as "I learned a lot about the Solar System (P-3)". Another frequently repeated code is Systems in Our Body. A student stated on this subject that “Yes, I learned the topic of our body better (P-9)”. Other codes mentioned under this category are topics and concepts in Science and prejudice. The code mostly mentioned under the category of helping them understand the topic is yes. A student on this subject said, “Yes, I learned through these applications. It made us understand the topics better. (P-21)”. Another similar view was, “Yes, it helped me to learn. I saw it more closely. (P-12)”. The other codes mentioned under this category are no and somehow. The most mentioned code under the category of how it helped them understand the topic was repetitions. A student on this subject expressed his opinion as "I have repeated the topic and it was reinforced (P-23)". The other codes mentioned under this category are visuals, being fun, audio. The code mostly repeated under the category of effect on the permanence of what was learned is effective with the visuals. A student on this subject expressed his opinion as “yes, because 3D is better at learning (P-22)”. Another similar opinion was “it helped. In particular, when there was something I forgot in the exam, the images in AR came in my mind (P-8)”. The other codes mentioned under this category effective by being repetitive, effective by being to fun, not effective, not fully effective.

Discussion and Conclusion

This study aims to investigate the effect of AR applications in science education on the level of recalling the learned knowledge of 6^{th} grade students. For this purpose, the data obtained from “The Solar System and Systems in Our Body Achievement test” developed by the researcher and the semi-structured interview form were analyzed and the effect of AR applications on the academic achievement of 6^{th} grade students and their level of recalling the learned knowledge in science course was determined. More consistent results were obtained by supporting these quantitative analyzes with the qualitative findings obtained from the semi-structured interview form.

Regarding the findings obtained by comparing pretest and posttest scores of experiment and CG students, a significant difference was observed between them. The increase rate of the EG is higher than that of the CG, which shows us that the application in the EG was more effective than the application in the CG. Regarding the findings obtained from the comparison of experiment and CG students’ posttest scores, a statistically significant difference was observed between them ($t = 3.397$; $p > .05$). This finding shows that the science lesson instructed using AR applications has a positive effect on students' academic achievement compared to the science lesson instructed only by sticking to the textbook. These results of the research are similar to the results of other studies in the literature (Abdusselam & Karal, 2012; Ates, 2018; Chiang, Yang, & Hwang, 2014; Demirel, 2017;

Demirel, 2019; Eroglu, 2018; Fidan, 2018; Fleck & Simon, 2013; Gungordu, 2018; Kul, 2019; Ozarslan, 2013; Shelton & Hedley, 2002; Sirakaya, 2015; Sin & Badioze-Zaman, 2010; Sahin 2017; Senturk, 2018; Yildirim, 2018). However, there are some studies in the literature showing that AR applications did not have a positive effect on academic achievement. Erbas (2016) reported that the use of AR did not create a positive difference on the academic achievement of students in the practice carried out within the scope of biology lesson. Gun & Atasoy (2017) reported that their AR applications performed within the scope of mathematics lesson did not make a positive difference in students' academic achievements. Yen et al. (2013) reported that no positive difference occurred on students' academic achievement as a result of using AR applications on university students' in the phases of the moon topic. The results of these studies do not overlap with the results of this study.

The findings obtained by comparing EG and CG students' recall test scores showed that science lesson instructed with AR applications had a positive effect on students' level of recalling the learned knowledge compared to the lesson instructed by sticking to the textbook only. The literature review revealed that there are few studies measuring the level of recalling the knowledge learned through AR applications. Fidan (2018) reported that AR applications applied with problem-based activities within the scope of force and energy unit had a positive effect on students' level of recalling the knowledge. In the study examining the effect of AR applications on academic achievement within the scope of the "particle structure of matter and pure substances" topic of 7th grade science course, Ates (2018) reported that instruction supported by AR applications positively affected the permanence of the knowledge. The following features of AR technology may have been effective in achieving these results; AR is a new technology, thus it may have attracted the attention and interests of the students who faced with this technology for the first time, which affected their motivation and increased their achievement. Similar results are seen in the literature (Delello, 2014; Di Serio, Ibáñez, & Kloos, 2013; Gun, 2014; Korucu et al., 2016; Kucuk, 2015; Sahin, 2017; Senturk, 2018; Sirakaya, 2015; Tomi & Rambli, 2013; Yen et al., 2013). The realistic image quality of AR applications may have been effective in attracting students' attention. Students can perceive three-dimensional objects appearing on AR application cards as magic (Billinghurst et al., 2001). In this way, a fun learning can be realized (Erbas, 2016; Senturk, 2018). Students do not have the chance to make observation on every subject of The Solar System and Systems in Our Body units, and AR applications allowed them to make observation with their realistic images, thus it is expected to attract students' attention. Textbooks are also insufficient in this sense. The literature also contains studies reporting that AR applications concretize abstract concepts that cannot be observed via 3-D visuals and present complex topics in a comprehensible way (Cetin, 2019; Gun, 2014; Gungordu, 2018; Klopfer & Squire, 2008; Senturk, 2018; Shelton & Hedley 2002; Wu, Lee et al., 2013).

The opinions of the students in the EG on AR technology were taken and they were grouped under three themes: thoughts on AR technologies, experiences on AR technology, and the contribution of AR technology to learning. The results reached under the theme of thoughts on AR technologies have shown that students have reached the level of describing AR technology even though they have not used any AR applications before. Another result has shown that three-dimensional visuals in AR applications attracted students' attention. There are studies in the literature achieving similar results (Cetin, 2019; Erbas, 2016; Fidan, 2018; Gungordu, 2018). Another result showed that students want to use AR applications in different courses and topics. There are studies in the literature achieving similar results (Ates, 2018; Cetin, 2019; Demirel, 2019; Erbas, 2016; Fidan, 2018; Gun, 2014; Gungordu, 2018; Kul, 2019; Ozarslan, 2013; Sirakaya, 2015). The results obtained under the theme of experiences on AR technology showed that students have not used AR application before, and they met AR applications with this study. Even though the students were using AR applications for the first time, the growth of the new generation intertwined with technology provided an advantage in terms of harmony. There are studies in the literature achieving similar results (Erbas, 2016; Kucuk, 2015; Senturk, 2018; Yildirim, 2018). Another outcome showed that the students had no problems in using the applications during the research. There are studies in the literature showing similar results (Gun, 2014; Gungordu, 2018; Kul, 2019; Ozarslan, 2013). Although no problems occurred in this study, there are several studies in the literature, reporting problems in using AR applications. Cetin (2019) reported that students were distracted because of some technical problems in the hardware and software. Senturk (2018) reported that problems arising from external factors such as light, output and image quality can be experienced. Gun (2014) reported difficulties related to lighting and image blur due to camera. The resulting difference may be due to the use of different and diverse applications in this study. The results achieved under the theme of the contribution of AR technology to learning showed that AR applications played an active role in sustaining students' academic achievement and the learned knowledge, that is, improving the recall levels, and this is mainly due to the 3D visuals used by the applications. There are studies in the literature indicating similar results (Ates, 2018; Cetin 2019; Fidan, 2018; Gun, 2014; Gungordu, 2018; Shelton & Hedley, 2002; Sahin, 2017; Senturk, 2018; Sirakaya, 2015; Tomi & Rambli, 2013; Yildirim, 2018).

As a result, the academic achievement of the EG, in which AR applications were actively used by the students in the science course, was found to be higher than the academic success of the CG, where the course was instructed only by sticking to the book. The analysis of the mean scores of the recall tests administered to measure how much the experiment and CG recall the knowledge they learned, in other words the permanence of their knowledge, EG students were found to be statistically significantly more successful. More generally, the use of AR applications in science class has a positive effect on 6^{th} grade students' level of recalling the learned knowledge. The review of the studies in the literature showed that they are in line with the results this study (Ates, 2018; Barmaki et al., 2019; Fidan 2018; Huang et al., 2019; Lu et al., 2014; Pérez-López & Contero, 2013).

Recommendations

In line with the results obtained from this study, the following suggestions were developed: It is recommended to use AR applications actively and regularly in science lessons. Similar studies can be conducted with different samples, at different grade levels. This study involved The Solar System and The Systems in Our Body units in science curriculum. The effect of AR technology on different topics can be examined by focusing on different units, especially on teaching abstract concepts. Both this study and similar studies focused on the effect of AR applications on academic achievement, attitude and motivation. Further studies analyzing the effect of AR technology on different skills and variables such as 21^{st} century skills, life skills, and thinking skills, may be conducted. Very few problems occurred with the AR applications used in this study. The AR applications used have attracted students' attention with their image quality and entertaining content and motivated them towards the course. While conducting similar studies, more attention may be paid to the selection of applications; applications that are more entertaining in terms of content, materials and software, and that can run in all operating systems can be preferred. In addition, these applications were carried out through the phone. The researchers were advised to be procured in terms of phones or tablets in order to avoid problems during the applications.

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Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Discussing Socio-Scientific Issues on Twitter: The Quality of Pre-Service Science Teachers' Arguments

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Abstract

The purpose of this study is to determine pre-service science teachers' (PSTs') argument qualities in the process of discussing some SSIs on Twitter. In this respect, firstly, sources that PSTs use to reach information and ranking of these sources as they access information were taken. The study is designed as a case study and the participants were 13 PSTs (11 females, 2 males). Data were collected through arguments written on Twitter and after classroom discussions, and field notes taken by the researchers. The findings showed that PSTs use Internet, books and social media tools as they try to reach information and spend at least 1 to 5 hours in social media during the day. The findings also showed that online discussions on Twitter developed their argumentation qualities. This may indicate that as PSTs become familiar with writing arguments and realize that they need to consider the elements of arguments, they produce better arguments. It is therefore recommended to the researchers and teachers to provide students with environments where they can be active and conduct informal discussions about SSIs. Social media tools (Facebook, Instagram, YouTube, etc.), at this point, may provide with a useful option.

Introduction

Socio-scientific issues (SSIs), are scientific issues that require decision making by leaving individuals in dilemmas (Zeidler & Nichols, 2009) and have potentially large impacts on societies and individuals' lives (Sadler, 2004). SSIs have some special features: they do not have absolute solutions, they are usually ill structured, and people are likely to confront them in their daily lives (Kolstø, 2001). These issues require consideration of many dimensions such as ethical/moral, economic, political, social/cultural or environmental issues (Chang Rundgren & Rundgren, 2010; Holbrook & Rannikmae 2009; Nuangchalerm 2010). Integration of scientific issues and scientific processes is needed for inquiry and decision making about these issues (Sadler et al., 2007). According to Zeidler and Nichols (2009), the use of SSI in education is addressed as contemporary social-related issues that not only require scientific knowledge to make informed decisions but also promote students' active participation and develop students' argumentation skills. Combining scientific concepts with the challenging problems of SSI has been shown to be an effective way of engaging students in discussions and developing students' skills in decision-making and critical thinking (e.g., Chang Rundgren & Rundgren 2010; Klosterman & Sadler, 2010). The reasoning process of SSIs is consistent with argumentation method. In other words, SSIs constitute an important context for the argumentation method (Dawson & Venville, 2013; Ekborg et al., 2013). Argumentation is a process in which scientific claims are justified based on experimental or theoretical evidence (Erduran & Jiménez-Aleixandre, 2007). While discussing their opinions about a SSI that is open to debate, individuals employ the process of reasoning that requires consideration of elements such as, claims, evidence and reason (Sadler et al., 2007). Carrying the argumentation process out of formal learning environments is important for scientific literacy. Scientific literacy requires students to understand complex scientific issues and make decisions based on their own knowledge. The inevitability of individuals to be exposed to SSIs in informal learning environments shows that addressing these issues is important for scientific literacy (Zeidler, 2007). As being issues concerning the society, carrying SSIs into the classroom environment is thought to be effective in making interpretations about these issues in informal environments and improving scientific literacy. For such reasons, it is important that science teachers, as well as science teacher candidates, should have the related training for carrying SSIs into their classes.

It is known that SSIs frequently take place in media and create dilemmas because of their relation to society. In this respect, individuals refer to media elements as they want to learn, reason or make decisions about SSIs. (Boyd & Ellison, 2007; Dimopoulos & Koulaidis, 2003; Kachan et al., 2006; Klosterman et al., 2012). In the 21st century, individuals often use social media tools like Twitter, Facebook, Instagram and WhatsApp

(Klosterman et al., 2012). Sharing SSIs in social media environments and reflecting the argumentation process on these sharing will contribute to the development of scientific literacy and the quality of arguments. In this context, in the current study, a number of socio-scientific issues (farm chicken consumption, influenza vaccines, sugar intake during pregnancy, raw/processed milk consumption, vaccination of children and homeotherapy) were discussed through Twitter – a popular social media platform. The study was structured on the basis of the opinions expressed by the PSTs during their discussions about the SSIs on Twitter and their written and verbal arguments stated throughout the process. In the related literature, there are studies on the discussion of SSIs in the classroom (Cansız, 2014; Öztürk & Yenilmez Türkoğlu, 2018), however, it is hoped that, the current study will contribute to the literature in terms of providing an alternative informal environment that makes PSTs feel comfortable and express their arguments freely.

Socio-Scientific Issues and Argumentation

An argument is an assertion with supporting information or, alternatively, a claim with reasons to support the claim (Dawson & Carson, 2017). Argumentation, on the other hand, is expressed as a complex process defined as an artefact with the statements that individuals use to support their claims or refute the counterclaims as they put forward their arguments about an issue (Sampson & Clark, 2008). Argumentation was first introduced by Toulmin (1958) with its elements. The Toulmin's Argument Model contains the elements of claim, grounds, warrant, backing, qualifier and rebuttal (Toulmin, 1958). Based on Toulmin's Argument Model, several researchers have expanded or changed the argument elements to determine argument levels /qualities (Erduran et al., 2004; Lin & Mintzes, 2010; Sadler & Fowler, 2006).

Argumentation in science education is an effective process in which scientific claims are based on beliefs and experimental evidence (Driver et al., 2000; Erduran, & Jiménez-Aleixandre, 2007). The use of argumentation process is considered as an important method in addressing the SSIs that require students to produce arguments, reason and make decisions (Acar et al., 2010; Dawson & Venville, 2013; Ekborg et al., 2013; Kolstø, 2001). A number of studies in the literature also indicate that SSIs are suitable for determining teacher candidates' argument qualities and their developmental processes (Dawson & Venville 2010; Osborne et al., 2004; Wu & Tsai, 2007; Zohar & Nemet, 2002).

It is obvious that the skills acquired during the argumentation process are important for evaluating the views about the SSIs that are open to discussion and arriving at a final decision (Sadler et al., 2007). Argumentation skills are seen as important skills that people should have in modern societies when they need to make decisions on SSIs they face (Chang, 2007; Chang & Chiu, 2008; Osborne et al., 2004; Chang Rundgren & Rundgren, 2010; Chang Rundgren, 2011; Sadler, 2004). Argumentation on a SSI, together with argument writing skills, can provide important contributions to scientific thinking skills and decision-making skills of individuals (Chang & Chiu, 2008; Sadler & Zeidler, 2005b; Zohar & Nemet, 2002). In the related literature, it is seen that the number of studies examining students' argument qualities of SSIs is limited (e.g. Topçu et al., 2010; Sadler & Zeidler, 2005a; Sadler & Donnelly, 2006; Isbilir et al., 2014).

Argumentation can be carried out in the classroom, as well as in informal spaces like online environments. Online argumentation is the process where the discussion takes place in computer and internet environment and teachers and students interact with each other online (Çelik et al., 2017). In informal learning environments opportunities should be provided to students for experiencing SSIs (Zeidler, 2007). By this way, students will be able to understand complex scientific issues in the society, interpret the information and make decisions about the issues by using their own knowledge (Zeidler, 2007). There are studies in the related literature that point out an increase in argumentation levels/quality of students as a result of online discussions (Lin et al., 2012; Isbilir et al., 2014). Lin et al. (2012) reported that there was a positive development in physics students' quality of arguments after online discussions and that the students performed better in the online discussion environment. In another study, Isbilir et al. (2014) investigated PSTs' argument qualities on four different SSIs and concluded that PSTs produced high level arguments in online discussion environments.

Socio-Scientific Issues and Media

Teachers and students most likely use media as the source of information about popular SSIs that are discussed in the society (Kachan et al., 2006). The popular media, or the mass media in other words, remain as an important source of communication in modern societies. While newspapers and radios gained an important place as news and entertainment sources of individuals in the nineteenth century, internet-based technologies such as Facebook, Twitter, etc. have frequently taken place in the community agenda in the 21st century (Klosterman et al., 2012). Media/social media tools that occupy a significant part of daily life in recent years, can be used as an important source in science education. Media, with various areas of use, is an important source of choice especially in teaching practices of SSIs (Dimopoulos & Koulaidis, 2003; Kachan et al., 2006; Öztürk, Eş, & Turgut, 2017; Türköz & Öztürk, 2019). Klosterman et al. (2012) concluded that media was effective in teaching SSIs and that teacher and students reached the information about SSIs through media. Dimopoulos and Koulaidis (2003) pointed out in their study that media is frequently used to form opinions about the contemporary SSIs and the social impacts of science and technology. Öztürk et al. (2017) in their study with talented students, used YouTube videos about a SSI, and took students' claims and grounds about the issue.

Use of Twitter in Education and SSIs

The widespread use of mobile phones and internet increases the demand for social media to provide easy access to social media from mobile phones. According to the most up-to-date Internet usage statistics report published by We Are Social and Hootsuite (2018), 3.81 billion people (51% of the world's population) were internet users, while 3.02 billion (37% of the world's population) were social media users in 2017. In 2018, on the other hand, 53% of the world's population, which consists of 4.02 billion, were internet users, while 42% of the world's population (3.19 billion) is said to be a social media user. Even in the last two years, the increase in the use of social media makes it important to use these environments for educational purposes. In several studies, it is seen that social media tools such as Facebook and Twitter are used for students to communicate with each other and for learning activities (Junco et al., 2010; McArthur & Bostedo-Conway, 2012; Veletsianos, 2012).

Moreover, there are also studies indicating that educators also use social media for communicating with each other and making sharing to support their professional development (Ebner et al., 2010; Mills, 2014; Rankin, 2009; Schroeder et al., 2010). People use Twitter for several purposes like communicating, asking questions, making recommendations, putting their opinions on agenda-related issues, commenting and discussing. Carpenter and Krutka (2014), in their extensive research on how Twitter is used by educators, draws attention to the fact that it is mostly used for professional development and communication, but less for classroom applications; and they recommend to do extensive research on the use of Twitter for educational purposes. The current study focuses on the sharing of arguments on SSIs in Twitter as a popular social media tool.

The purpose of this study

The purpose of this study is to determine PSTs' argument qualities in the process of discussing SSIs on Twitter.

Method

This study is designed as a case study. The case study is a qualitative approach in which detailed and in-depth information is gathered by using a variety of sources such as observation, audio-visual materials, interviews, documents and reports within a certain period of time (Creswell, 2013). In this context, in accordance with the study group and the scope of the study, it was decided to conduct the study in an elective course named "Media Literacy".

Participants

The participants of the study were 13 PSTs (11 females, 2 males) attending the Science Education Program at state university in Turkey. They were selected conveniently from the university where the researchers were working, for the purpose of being easily accessible to them. The participants were questioned for their use of social media tools and it was found that they are using Instagram (f=11), Facebook (f=10), WhatsApp (f=8), Twitter (f=5), Snapchat (f=2), Tumblr (f=2), YouTube (f=2) and Swarm (f=1). Moreover, it was determined that they are either spending 5 or more hours (f=5), 3 to 5 hours (f=3), 1 to 3 hours (f=4) or less than 1 hour (f=2) on social media. All PSTs participated in this study used social media tools and typically allocated a certain period to social media usage during the day.

Procedure

The "Media Literacy" course is a 2-hour-per-week elective course. At the end of this course, students are expected to recognize the mass media, and discuss the relationships between media, society and culture, media and economy, media and ethics, and science-society-media and socio-scientific issues. The current study was carried out at 10 weeks. It consists of two stages. Detailed information about the process is presented in Figure 1.

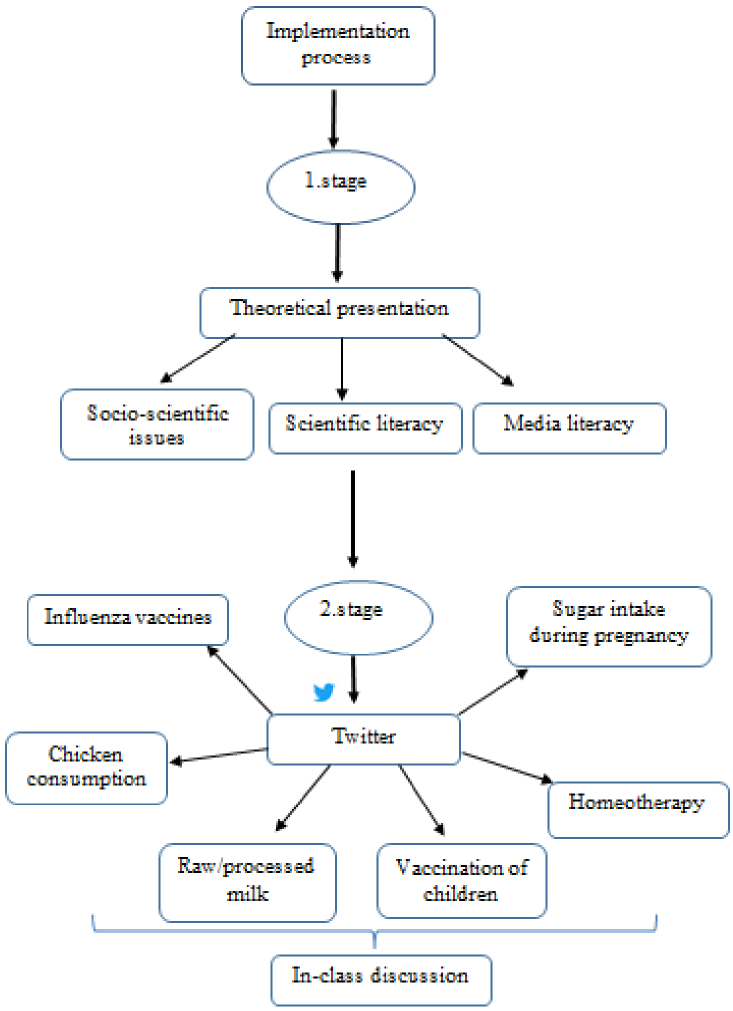

Figure 1. The procedure of the study

In the first 3 weeks of the 10-week period, theoretical presentations were done by the researchers of this study. The presentations were about scientific literacy and its relationship with SSIs, science curriculum and SSIs, argumentation and its elements, media literacy, and SSIs in the context of scientific literacy and media literacy. The PSTs have already taken theoretical and practical courses on argumentation and argumentation elements during their past education. The issues of chicken consumption, flu shot, sugar intake during pregnancy, raw/processed milk consumption, vaccination of children and homeotherapy were discussed respectively during the study. Online discussions were carried out on Twitter together with the researchers and the participants of the study, once a week (Sundays) between 20:00 and 23:00. The selected SSIs were brought up for discussion by the researchers based on some scientific research findings, news from newspapers, supportive/non-supportive blog shares, YouTube videos, pictures, etc. For example, some YouTube videos covering two different opinions about farm chicken consumption were shared by the researchers and left for discussion by the PSTs. Videos taking 1-5 minutes were specifically selected in order to take the remaining time for the discussion of the issues.

After watching the videos, the PSTs initially stated their claims about the issue (as supporting / not supporting / undecided) under the sharing. Each PST, then, tried to support his/her claim through information from different sources (such as, newspapers, YouTube videos, research findings). The PSTs searched the sources during twitter writings. The periods of 3-hour discussions were thought to be sufficient for searching and screening the issues since access to information through internet is very fast. Students were also directed to search on the issues before coming to the class discussions.

The points that they paid attention to in accordance with the instructions given by the researchers were the (i) claims, (ii) data, (iii) warrants and (iv) backings and the rebuttals used to disprove the counter ideas. The researchers participated in the discussion process occasionally through probing questions. For example, upon a statement like "I don't support farm chicken consumption, I find it harmful", the researchers responded as "So, why don't you support and find it harmful?" and oriented the PSTs to create more detailed and qualified arguments. No limitation has been imposed on the use of resources by researchers, however, they directed questions like "Do you think this source is reliable? Can you reference it? How would you know that this is correct?" etc. After a few weeks, resources were questioned by the PSTs before making a decision. Since there is a character limitation on Twitter (140 characters), the entries of PSTs were listed as +, ++, +++, or 1,2,3...
After discussing the SSIs on Twitter, each week, the related issue was discussed in the classroom, as well. Since there are six SSIs covered in this study, the discussion process took a total of 6 weeks. After completing the discussions, PSTs were asked to write their arguments about each SSI. The arguments written on Twitter and at the end of the discussions were taken and examined in respect to the purpose of this study.

Data Collection and Analysis

Data were collected through arguments written on Twitter and at the end of the classroom discussions, and the field notes taken by the researchers of the study during the classroom discussions. The written arguments on Twitter were transcribed and compared with the classroom discussion-end-of-written arguments for the purpose of determining whether there are any differences in the argument elements.

Together with the written arguments and filed notes, demographic data about participants' habits of social media use and access to information were also taken for the purpose of defining the participants. A sample coding list for the sources that PSTs use as they try to access information is given in Table 1.

Table 1**.** A sample coding list for the sources that PSTs use as they try to access information

Theme	Code	Sample expression
Media	Social media	*"*The easiest way to access information nowadays is the social media. I mostly use Instagram…*"* (PST-5)
	TV	*"*I like TV shows most. Especially the talk shows…" (PST-11)
	Newspapers	"… I mean, I hang out more on the internet, but I also check the newspapers. The same news may be given differently in different newspapers…*"* (PST-7)
	Magazines	*"*I love scientific- technical magazines. There are more accurate and up-to-date information in them; so I'm trying to get them occasionally… *"* (PST-8)

Written arguments were analyzed based on content and continuous comparative analysis techniques. According to Patton (2002), content analysis is defined as scanning the text for repeated words or themes. The analysis was done according to the criteria proposed by Erduran et al. (2004) based on Toulmin's Argument Model. Erduran et al. (2004) proposed 5 argumentation levels. If the argument consists of a simple claim or a counter-claim, this is defined as Level 1 argumentation. Level 2 argumentation, on the other hand, has arguments consisting of a claim versus a claim with either data, warrants, or backings but do not contain any rebuttals. In Level 3 argumentation, there are arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak rebuttal. Level 4 argumentation shows arguments with a claim with a clearly identifiable rebuttal and these arguments may have several claims and counter-claims. Finally, Level 5 argumentation displays an extended argument with more than one rebuttals.

PSTs' qualities of arguments were evaluated based on the criteria given above. In order to increase the reliability, data analyses were triangulated by three researchers. Two researchers analyzed the transcripts independently and the results were presented to the third researcher for consideration. Through this triple evaluation process, the reliability of the data was tried to be provided. The analyses provided by the two researchers and the consideration of the third researcher was compared until a consensus was reached between the researchers and the argument levels of the PSTs were then finalized. For the purpose of clarifying the analysis process, one of the PSTs' (PST-12) argument evaluation is presented in Table 2.

Table 2. Sample argument analyzing scheme for PST-12

Level	Explanation	Sample excerpt
1	Argument consists of a simple claim or a counter-claim	"I support the use of village chicken, do not support the store chicken."
2	Argument consists of a claim versus a claim with either data, warrants, or backings but do not contain any rebuttals	"…I was against the flu vaccine, but I changed my mind upon the discourse of experts shared in Twitter. I support it because of the health benefits for people, as written in the news named 'You should be vaccinated'."
3	Argument consists of a series of claims or counter-claims with either data, warrants, or backings with an occasional weak rebuttal	"I'm against sugar loading. Because, giving 50 g sugar to a pregnant woman can result in dangerous outcomes. The speech of the expert impressed me. I can say that the data she showed affected my decision. If I experience such a situation, I can think about it if only there is data supporting that it is not harmful, otherwise I am determined…"
4	Argument consists of a claim with a clearly identifiable rebuttal or may have several claims and counter-claims	"I think that raw milk is more useful. Because I agree with the ideas of the expert (shared in Twitter) and the opinions of the experts who make such sharing. Processed milk is undergoing many treatments and many useful things within the milk are killed. Just think! It doesn't go bad for long, and this makes me think. I think, the data defending processed milk is insufficient. Maybe if the data were clear and sufficient, I may be confused.…"
5	An extended argument with more than one rebuttals	"I don't agree with my friends. Children should be vaccinated. Because they may have diseases like measles, chicken pox, and vaccines protect them. Many experts also have made supporting explanations; even the Ministry of Health. Babies may die if the vaccine is not given. So if the baby could only be protected by breast milk without vaccination, there would be no need for vaccination, would it? Vaccination is an important invention that affects children's health…"

As seen in Table 2, PST-12 presented a claim with the statement:

> I support the consumption of village chicken.

She presented a claim and a warrant by saying:

> I support it because of the health benefits for people, as written in the news named "You should be vaccinated"

PST-12 stated a claim by saying:

> I'm against sugar loading

and data by

> …giving 50 g sugar to a pregnant woman…

and a warrant by

> …can result in dangerous outcomes.

Regarding raw/processed milk consumption, she presented a claim by saying:

> I think that raw milk is more useful

data and a warrant by

> Processed milk is undergoing many treatments and many useful things within the milk are killed,

backings by

> Because I agree with the ideas of the expert (shared in Twitter) and the opinions of the experts who make such sharing

and rebuttals by

> …if the data were clear and sufficient….

Finally, regarding the vaccination of children, PST-12 stated a claim by saying:

> Children should be vaccine,

data and a warrant by

> Because they may have diseases like measles, chicken pox, and vaccines protect them,

backings by

> Many experts also have made supporting explanations; even the Ministry of Health,

and clear rebuttals by

> Babies may die if the vaccine is not given. So if the baby could only be protected by breast milk without vaccination, there would be no need for vaccination, would it?

Results

One of the purposes of the current study was to examine the kinds of sources that PSTs use as they try to reach information. For this purpose, the sources they use to reach information, the ranking of these sources as they access information, the reliability of the information and their opinions about the decision making process were taken before the SSIs were discussed. In this respect, the findings related to the sources they use in reaching the information are presented in Table 3.

Table 3. PSTs' views on the sources they use to reach information

Category	Code	f
Internet	Internet	13
Media	Social media (Facebook, Instagram, etc.)	5
	TV	3
	Newspapers	2
Library	Books	8
	Magazines	2
	Articles	1
	Theses	1
	Encyclopedia	1

As seen in Table 3, all of the PSTs (f = 13) mentioned that they use Internet as they try to reach information, while most of them (f = 8) also reach information from books and some (f = 5) from social media tools such as, Facebook, Instagram and Twitter. When they are asked to rank the sources with respect to their use in reaching information, seven of them stated that Internet was the first one that they use to reach information, while five stated that books led them more, and one PST gave the first place to the theses done in the field. PSTs showed different attitudes as they were asked about the reliability of the knowledge and the criteria by which they decide on the reliable information. Sample responses are as follows:

> I do research from other sources. I ask people around me and get ideas. I act according to the majority (PST1).

> Of course, I do not stick to a single web page or book. I try to confirm information by looking at different web pages or books, and I decide by majority (PST3).

If I have seen or heard the same information from many sources, I can trust and decide (PST8).

First of all I do research from different sources and examine the opinions and ideas on the issue. If there are common news everywhere, I consult experts. Of course, people may have been influenced elsewhere in the media. It is therefore best to find the primary source (PST9).

I reach information through my own experiences. I consult my family, my friends, my social environment, and sometimes internet (PST5).

It can be observed that many of the PSTs commonly reached knowledge by searching from different sources. While PST1 is concerned with different sources of information, PST9 emphasized the expert factor and PST5 considered the environmental factor.

Besides examining the kinds of sources that PSTs use as they try to reach information, in the current study, a number of socio-scientific issues (farm chicken consumption, influenza vaccines, sugar intake during pregnancy, raw/processed milk consumption, vaccination of children and homeotherapy) were discussed through Twitter and PSTs' argument qualities related to these issues were also examined in this study. PSTs argumentation levels about the SSIs before and after discussions are given in Table 4.

Table 4. PSTs' argumentation levels with respect to SSIs

Pre-service science teachers	Chicken C.		Influenza vaccines		Sugar Intake		Raw/Proc. M.		Vacc. of Children		Homeother.	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
PST1	1	2	1	2	2	2	2	3	3	3	3	3
PST2	1	1	2	3	2	3	3	3	3	3	3	4
PST3	2	2	3	3	3	3	3	3	3	3	3	3
PST4	1	2	2	3	3	3	3	3	4	4	4	4
PST5	1	2	1	2	2	3	2	3	2	3	3	3
PST6	3	3	3	3	4	4	4	4	3	3	1	3
PST7	2	2	2	2	2	3	3	3	3	3	3	3
PST8	1	2	2	2	2	3	3	3	3	3	3	4
PST9	2	3	2	3	3	3	3	3	3	3	4	4
PST10	3	3	3	3	4	4	4	4	3	4	4	4
PST11	1	2	2	3	2	3	4	4	4	4	5	5
PST12	1	2	2	3	3	3	4	4	5	5	5	5
PST13	1	2	2	3	2	3	3	4	4	4	4	4

Table 4 shows 13 PSTs' argumentation levels for each SSI determined before discussions (-pre) and during-and-after (-post) discussions. The first SSI discussed on Twitter was Farm Chicken Consumption. Before this issue was discussed, it was observed that most of the PSTs (n=8) stated simply a claim (level 1), three of them stated a claim, data, warrant or backing, and two stated a claim, data, warrant, backing and a weak rebuttal. In response to researchers' questions like:

Why do you (or, don't you) support the consumption of farm chicken?

they said:

That's just what I think. I think so (PST1).

or

I think, we should consume village chicken (PST8),

and did not present any data or warrant. In the second week, on the other hand, most of the PSTs (f = 8) wrote their arguments at level 2 and presented their claims with data, warrants or backings. Three PSTs wrote arguments at level 3 and two PSTs at level 1. In response to the questions like:

Why would (or, would not) you prefer to have Influenza vaccine?

they replied like:

> Influenza vaccine should not be given because in the article written by the expert it was noted that there is aluminum and mercury in the vaccine (PST3).

Another PST replied this response as:

> So, you decide only based on the opinion of the expert? Then, another expert mentioned that it (vaccine) was important for health! (PST5).

The researchers had been actively involved in the discussion and triggered the discussion with questions like:

> What are your arguments to refute the counter-argument on this issue? What are your data?

In the third week, it was found that most of the PSTs (f=7) still wrote their arguments at level 2, while four at level 3 and two at level 4. In the fourth and fifth weeks, however, most PSTs (f=7, f=8, respectively) improved to level 3. As Table 4 suggests, there is no PST at level 1, that is proposing just a claim or counter-claim, starting from the third SSI - sugar loading during pregnancy. In the last week of the study, it is observed that many of the PSTs (f = 6) were at level 3, while four were at level 4 and two at level 5. One of the PSTs (that is, PST6) had an unstable attitude towards the issue (homeotherapy) and considered to be at level 1.

In general, in the written arguments taken at the end of the discussions, it was determined that the argumentation levels of the PSTs were similar and also the levels were developed towards the end when compared to the arguments discussed in Twitter in the first weeks. For example, nine PSTs' (PST1, PST2, PST4, PST5, PST8, PST9, PST11, PST12, PST13) low levels of argument qualities in the first and second weeks significantly developed at the end of the discussions (see Table 4). It was determined that the six PSTs in the third week, three PSTs in the fourth week, two PSTs in the fifth week and three PSTs in the sixth week were observed to develop. This development can be interpreted as the reflection of knowledge and experience acquired during the discussions on Twitter on PSTs' written arguments taken at the end of the process. For example, PST4 stated his/her idea about the consumption of raw/processed milk on Twitter as:

> I prefer to consume raw milk.

Through probing questions like:

> Why do you prefer so?

the PST was asked to think about the issue and encouraged to state data and justifications for his/her arguments; and through directing questions like:

> There are opposing ideas; PST10 for example, how would you refute this argument?

s/he was encouraged to use backings and rebuttals, as well.

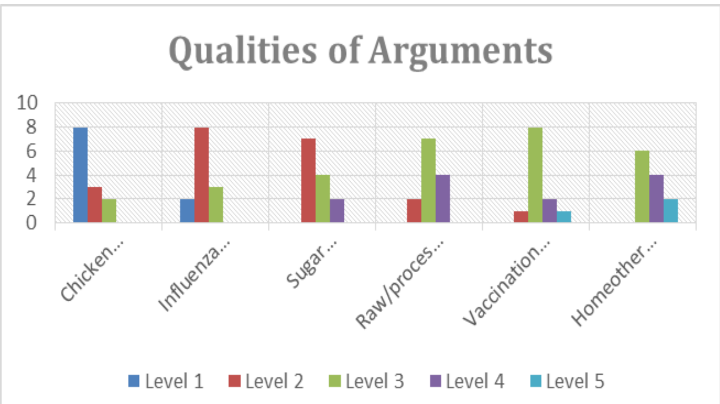

Figure 2. Frequencies of argument qualities for the SSIs

As seen in Table 4, the quality of arguments improved as the SSIs were discussed on Twitter. The field notes taken by the researchers also show that PSTs possessing level 1 argumentation in the prior SSIs showed higher levels of argumentation at the end of the process. For example, it was observed that while PST13 put only claims forward about the first SSI in the discussion process on Twitter (level 1), s/he included the elements of argument like data and justification at the end. It can be said that this improvement indicates a positive development in PSTs' argument qualities. The improvement of the qualities of arguments related to the issues discussed in this study are presented in Figure 2.

When Figure 1 is examined, it is seen that most of the PSTs' arguments were at level 1 about farm chicken consumption (f=8), level 2 about influenza vaccines (f=8) and sugar intake during pregnancy (f=7), and level 3 about raw/processed milk consumption (f=7), vaccination of children (f=8) and homeotherapy (f=6). It is observed that PSTs are able to produce arguments at level 3 in all SSIs, that is, they produce arguments consisting of a series of claims or counter-claims with either data, warrants, or backings with an occasional weak rebuttal. From the third SSI (sugar intake during pregnancy) level 1 arguments disappear while level 4 arguments start to appear. In the last SSI, there are no arguments at level 1 and level 2 but PSTs were able to write arguments at level 5, that is, they could produce extended arguments with more than one rebuttals.

Data obtained from researchers' field notes showed that PSTs were satisfied with the discussions on Twitter; they were usually motivated to the argumentation process every week, and tried to make the best decision by searching different resources about the issues and use the argument elements in forming their decisions. For example, PST6 stated his/her satisfaction as:

> That was a very useful application for us.

PST7, on the other hand, showed his/her willingness by saying:

> …every Sunday I willingly participated in the discussion. I realized that it was both fun and instructive for us to discuss the issue together on Twitter.

Some PSTs referred to the contributions of the discussions. For example, PST9 said:

> There is information pollution on the internet. I noticed that we never questioned this case. Now I am more careful.

Similarly, PST12 said:

> The discussion on Twitter continued at school. We argued about everything. I enjoyed it very much. And, that contributed us a lot.

and PST6 said:

> I learned that I should not decide on a single source. We're going to be teachers, how we decide is very important. Some sharing of our friends, for example, with supportive arguments inevitably motivated me.

Besides the discussion process itself, researchers'' probing questions like:

> Why did you refer to that source? Why didn't you join your friend's words? How would you convince your friend who has an opposing idea?

students were asked to question their decisions and re-evaluate the arguments they wrote. In addition, during the class discussions, PSTs were encouraged to feel the development in their own decisions. For example, in response to PST12's word:

> …that contributed us a lot,

the researchers asked:

> How did the process contribute to you? What skills do you think you have developed?

Finally, observing their willingness to present their ideas about the issues and providing arguments to defend their decisions, it is possible to say that the implementation conducted in this study would result in a continuous behavior of PSTs.

Results, Discussion and Recommendations

The purpose of this study is to determine PSTs' argument qualities in the process of discussing a number of SSIs on Twitter. In this respect, firstly, the sources that PSTs use to reach information, the ranking of these sources as they access information, the reliability of the information and their opinions about the decision making process were taken before the SSIs were discussed. It was found that all of the PSTs use the Internet as they try to reach information, many of them use books and some of them reach information from social media tools such as Facebook, Instagram and Twitter. Considering the findings of 'We Are Social and Hootsuite' in 2017 and 2018 about the dissemination of social media usage, it is expected that teacher candidates would use social media widely. According to Muntinga et al. (2011), social media tools such as Facebook, YouTube and Twitter provide Internet users with opportunities to interact, share, and create content on an unlimited range of imaginative sharing networks. The general profiles of PSTs on media use also support this situation. It is found in this study that PSTs spend time in social media for at least 1 hour and a maximum of 5 hours during the day. Seven PSTs mentioned that the Internet is the first source they use as they rank the sources they use to access information. While five of the PSTs stated that books led themselves more in the first place, one PST gave the first place to the theses made in the field. It was also determined that PSTs decided according to criteria such as family, environment, internet, media sources, book and expert opinion.

For the purpose of this study, PSTs' argument qualities on the issues of farm chicken consumption, influenza vaccines, sugar intake during pregnancy, raw/processed milk consumption, vaccination of children and homeotherapy were evaluated as level 1 to level 5 based on Toulmin's Argument Model. It was found that PSTs possess differing argument qualities for different SSIs even at the lowest level. It was determined that PSTs who produce arguments at the levels of 4 and 5 consider scientific sources, expert opinions on the issue and refer to these elements in particular as they provide backings or warrants for their claims. It was also found that most PSTs, who possess levels of 1, 2 or 3, had limited elements in their arguments and referred mostly to their personal experiences and knowledge. Christenson et al. (2014) stated that supporting arguments with scientific knowledge and data influence the quality of the argument. In line with the findings of the current study, Karışan et al. (2017) stated that prospective teachers cannot provide sufficient scientific evidence in presenting their arguments, rather they usually refer to their personal opinions. Similarly, Albe (2008) determined that prospective teachers could produce arguments with personal opinions rather than scientific data. The findings of this study, in general, showed that starting from the third SSI discussed on Twitter (that is, sugar intake in pregnancy), PSTs were able to reveal the argument elements based on scientific data and resources rather than their personal experiences.

During the discussions on Twitter, it was observed that most of the PSTs possessed level 1 arguments in the first week's SSI (that is, farm chicken consumption) by simply claiming, while they possessed level 2 arguments on the second week (influenza vaccines) and presented their claims with data, warrants or backings. In the third week (sugar intake during pregnancy), it was determined that most PSTs wrote their arguments in level 2, and in the fourth week (raw/processed milk consumption) in level 3. According to the findings of the study, in short, the argumentation levels tended to improve. This finding may indicate that as PSTs become familiar with writing arguments and realize that they need to consider the elements of arguments, they produce better arguments. PSTs gained awareness about the SSIs and were able to present different arguments about these issues. The findings of this study, in which the argumentation process itself improved the quality of the arguments, are consistent with the related research findings (Akbaş & Çetin, 2018; Isbilir et al., 2014; Karışan et al. 2017; Sadler & Donnelly, 2006; Topcu et al., 2010). However, in this study, it is thought that the realization of the argumentation process in an online informal environment motivated the PSTs to the process and ensured effective discussion within the boundlessness of sharing. Similar to this research, Isbilir, et al. (2014) conducted a research in an online environment and took PSTs' written arguments on climate change, nuclear energy, genetically modified foods and the human genome project. They determined that PSTs' produced high level arguments about the SSIs and the online discussion environment where the SSIs were discussed was effective in producing arguments. Lin et al. (2012) stated that there was a positive development in the quality of arguments after online discussions with students of physics department and they showed better performance in online discussion environment.

The findings of this study showed that online discussions on Twitter developed PSTs' argumentation qualities. Several researchers point out that social media tools such as Facebook and Twitter provide students with environments for communicating with others or for learning activities (Junco et al., 2010; McArthur & Bostedo-Conway, 2012; Veletsianos, 2012). In addition, educators also use social media in order to communicate with each other and to make sharing that support their professional development (Ebner et al., 2010; Mills, 2014; Rankin, 2009; Schroeder et al., 2010). Considering that social media is widely used for several purposes and users feel comfortable to express their ideas in such environments, together with the results of this research, it can be concluded that Twitter is a suitable environment where SSIs can be discussed.

Considering the findings of this research, it is recommended to the researchers and teachers to provide students with environments where they can be active and can conduct informal discussions about SSIs. To do this, they can use different social media tools (Facebook, Instagram, YouTube, etc.) that occupy most of a day's time period, in the teaching process, so that they can use the time for learning. Considering that the popular media play an important role in the teaching of SSIs, it is thought that pre-service teachers will experience with such practices or activities before they begin their work and develop their knowledge, and gain different perspectives in local, regional or social decision-making processes.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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