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Investigated effects of guided inquiry-based learning approach on students’ conceptual change and durability

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Abstract

This study aims to investigate the effect of guided inquiry-based learning approach on conceptual change and durability of sixth-grade middle school students regarding density concept. In this study, qualitative research methods were used. The study group consisted of 26 students studying in the sixth grade of a state middle school in the western part of Turkey. The data collection tool Test of Conceptual Understanding of Density (TCUD), including three open-ended questions, was used. TCUD was administered to the students in the study group before, immediately after, 6 weeks after and 24 weeks after the instruction. The results showed that the rate of giving scientific answers about the density concept of increased, whereas the rate of misconceptions decreased. It was also determined that the students were able to preserve scientific knowledge 6 and 24 weeks after the instruction, even if it was not the same as after the instruction. The effect of the course content which was prepared by following the guided inquiry-based learning approach on students' conceptual change and durability regarding the concept of density was discussed within the scope of the relevant literature and suggestions were made for further studies.

Keywords: Conceptual change, conceptual durability, guided inquiry, middle school students

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1. Introduction

The idea of using inquiry as a teaching method dates back to the mid-20th century. In particular, the inquiry-based learning approach emphasises learning process rather than the outcome. Within this scope, it is important to develop research skills rather than being concerned about creating a product (Lim, 2001). The inquiry-based learning is a student-centered approach that encourages learners to focus on asking questions, researching, critical thinking and problem solving by involving students in scientific thinking processes. In science education, inquiry-based learning is an effective method for students' conceptual understanding of scientific facts (Minner, Levy & Century, 2010).

There are different types of the inquiry-based learning approach. According to NRC (2000) and Colburn (2000), inquiry-based learning can be divided into three groups as *structured inquiry*, *guided inquiry* and *open inquiry*.

As one of the inquiry levels, in structured inquiry, the teacher gives the research problem to the students and manages the process, and the students are expected to achieve the outcomes based on the activities performed in the process (Bell, Smetana & Binns, 2005). In a guided inquiry, however, the teacher only reveals the problem and provides necessary materials. Students, on the other hand, design the process required to reach a solution (Hansen, 2002). The task of the teacher is to guide the students. Within this scope, the teacher does not provide students with the answer or questioning steps but gives tips to follow the necessary steps (Koksal & Berberoglu, 2014). In this respect, it differs from the structured inquiry. Guided inquiry encourages students' ability to ask questions, analyse and interpret evidence and choose the best solution to the problem (Lee, 2012). The guided inquiry may prevent time loss and reduce the frustration and fears of students due to failure (Furtak, Seidel, Iverson & Briggs, 2012). In their study, Jiang and McComas (2015) stated that the highest student success is achieved when the research questions are asked and inquiry is designed by the teacher. Guided inquiry-based learning has been found to affect students' conceptual understanding (Bunterm et al., 2014; Fang, et al., 2016; Stender, Schwichow, Zimmerman & Hartig, 2018). Thus, it is necessary to discuss the change in non-scientific ideas of students about the concept learned through inquiry-based learning and the durability of scientific answers.

Students may bring various misconceptions to the classroom environment that contradict scientific knowledge (Driver & Oldham, 1986; Osborne & Freyberg, 1985). These misconceptions may hinder the learning of scientific knowledge (Driver, 1989a). Teachers should not only reveal students' misconceptions but also ensure that these ideas change towards scientific ideas during teaching (Jones & Brader-Araje, 2002). However, misconceptions of the students are very resistant to change (Driver, 1989b). Many theories have been developed regarding the conceptual change process of students' ideas. At the heart of conceptual change studies, the content-specific nature of learning is being (Flynn & Hardman, 2019). Hewson (1992) states that the change in students' ideas is resistant to traditional teaching methods. According to Vosniadou and Ioannides (1998), the content of teaching is effective in the change of students' ideas. In another study, Vosniadou and Ioannides (1998) divide the types of conceptual change into two as spontaneous- and instruction-based changes. Teaching should ensure a change of ideas that are incompatible with scientific knowledge among the ideas that students acquire during their experiences. To be able to claim that the students change their ideas, it is necessary to look at the long-term changes in the students. Thus, several studies investigating the durability of students' ideas as well as the conceptual change have been conducted.

Determining whether the conceptual change occurs in students after a long period of instruction may give an idea about the effectiveness of instruction (Kucukozer, 2013). Georgides (2000) defines the term conceptual durability as the students' ability to maintain the newly learned scientific concepts even after a long time. In the studies regarding the conceptual durability, the ideas of students that they have after a certain time following the instruction are revealed, not the ideas after the instruction. For this reason, studies investigating long-term conceptual durability can be guiding in revealing the basic ideas of students (Bostan-Sarıoglan & Kucukozer, 2017). Trundle and Bell (2010) mention that there are not many studies investigating conceptual durability and pointed out the gap in the literature. In their study, Trundle, Atwood and Christopher (2007) state that some pre-service teachers have their misconceptions again long after the instruction. In this case, it will be difficult to explain whether a conceptual change occurs in students. However, the existence of the scientific concept in the mind of the student after a certain time is essential in durable conceptual change (Sackes & Trundle, 2017). Therefore, it is important to investigate whether the conceptual change that occurs after instruction is durable after a long time and to discuss the effect of instruction on these concepts.

Understanding the concept of density is important for comprehending concepts regarding both physics and chemistry. Therefore, many studies have been found in the literature on the concept of density. Some of these studies are given below. Almuntasheri, Gillies and Wright (2016) investigated the effect of guided inquiry-based instruction on sixth-grade students' learning of the concept of density with 6 teachers and 107 students. It was stated that guided research inquiry-based instruction was effective in explaining students' concept of density and developing conceptual understanding compared to teacher-centered instruction. In his study, Joung (2009) aimed to reveal mental models of students who did not have any knowledge about floating and sinking concepts and found that the vast majority of students first thought about the depth of water and the width of the object about floating and sinking. Scherr (2003) stated that inquiry-based instruction was more effective in students' learning about mass, volume and density than traditional instructional methods.

1.1. Purpose and Significance of the Study

In this study, instruction in which guided inquiry-based learning approach was used to change the ideas of students about the concept of density to be learnt for the first time was designed. At the same time, the effect of this instruction not only on the change in students' ideas after instruction but also on the durability of their ideas after long periods was investigated. From this point of view, this study aims to investigate the effect of guided inquiry-based learning approach on conceptual change and durability processes of sixth-grade middle school students regarding density concept.

An increasing number of studies in recent years have shown that an inquiry-based learning approach in science teaching serves the purpose of raising science-literate individuals. Many studies conducted on the concept of instruction when it was understood that students had some prejudice, intuition and non-scientific explanations before coming to the classes (Duit, 2009). If the misconceptions are not eliminated, the learning process and learning of science concepts can be seriously hindered. It is difficult to perform such a study with students who have never taken responsibility and do not know how to conduct scientific research. Teachers should carefully plan lessons and assign specific tasks to each student to take responsibility.

Considering the studies, no applied research investigating the effect of guided inquiry-based teaching approach on the concept of density has been found at the middle school sixth-grade level. Within this scope, it is thought that this study will contribute to the literature. It is important to show how inquiry-based learning activities can be applied in classrooms and the effect of this method on learning the subject. It is also considered that the guided inquiry-based learning approach used in this study will contribute to the literature by following appropriate processes. For this reason, it is thought that investigating the effect of guided inquiry-based instruction on the conceptual change and durability processes of sixth-grade students regarding the concept of density will contribute to the literature.

2. Method

In this study, a qualitative approach was used to understand and describe students' conceptions about density concept before instruction, immediately after instruction and 24 weeks after instruction since qualitative methods could provide detailed data that offered the possibility of better understanding and describing students' comprehension of concepts.

2.1. Participants

The study group included 26 students (12 girls and 14 boys in the age group of 12) studying in the sixth grade of a secondary level state school in the western region of Turkey. Qualitative studies try to reveal in-depth information. Additionally, they can be carried out in detail with a small sample, sometimes even with a single sample (Patton, 2014). In this research method, random sampling is not compulsory since it is not necessary and sometimes unlikely to reach generalisable results.

2.2. Data Collection and Analysis

Test of Conceptual Understanding of Density (TCUD), prepared by researchers, was used to determine students' conceptual understanding of density. TCUD was piloted to a total of 70 nonparticipant students. As a result of the pilot study, corrections were made for the questions that were not understood by the students and two questions were removed from the test. Two science education experts were asked for opinions regarding the remaining questions in terms of the suitability for the curriculum and grade level, content and adequacy in measuring relevant achievements. According to the feedback from the experts, the test consisting of three open-ended questions was finalised. The questions in TCUD were asked for the following purposes: TCUD was applied to the students in the study group to examine conceptual change and durability before instruction (BI) and immediately after instruction (AI), 6 weeks after instruction, first conceptual durability test (1st CDT) and 24 weeks after instruction, second conceptual durability test (2nd CDT) were completed.

In the analysis of TCUD, the answers given by the students were first examined in detail and descriptive analysis was performed by classifying the answers into four categories. In the category of fully correct answers, students answered the question correctly and explained the reasons for their answers. In the category of partially correct answers, students gave correct answers but could not explain the reasons for their answers. In the category of unacceptable answers, students' scientifically unacceptable answers and misconceptions about the subject were included. In the noncoding answer category, students' responses that are not related to the subject were included. The students who did not comment on the questions were placed in the category of no answers.

To ensure the reliability of the data obtained from TCUD, students' responses were analysed independently by two researchers. After the independent evaluations of both researchers, the results of the analysis of the answers were compared with each other. In the analysis, the formula suggested by Miles and Huberman (1994) was used to calculate reliability and inter-rater reliability which was found as 85%.

2.3. Instruction Process

This study was carried out in a total of 8 hours of instruction related to teaching the concept of density. In the study, the instruction was prepared and applied according to the 5E learning cycle model of guided inquiry-based learning approach. The 5E learning cycle model appears as a teaching model that supports inquiry-based learning (Campbell, 2006). The teacher was involved in the process by meeting the needs of the groups and guiding them through the activities.

3. Results

In the first question of TCUD, it was asked which one would be carried more easily while carrying sand and water with the same size fire buckets. The results obtained are given in Table 1.

Table 1. Results obtained from the analysis of the first question

Question 1	BI		AI		1st CDT		2nd CDT	
Types of responses	*n*	%	*n*	%	*n*	%	*n*	%
1. FULLY CORRECT ANSWER								
It depends on the mass of the substances. The one with more mass is more dense	1	4	12	46	9	35	12	46
2. PARTIALLY CORRECT ANSWER								
It is more difficult to carry the bucket with sand	1	4	3	12	1	4	4	15
TOTAL	**2**	**8**	**15**	**58**	**10**	***38***	**16**	***62***
B. UNACCEPTABLE ANSWER								
Depends on the space between particles in the substance	*12*	*46*	*6*	*23*	*13*	*50*	*6*	*23*
The solid one is heavier	*3*	*12*	*1*	*4*	*2*	*8*	*1*	*4*
TOTAL	**15**	**58**	**7**	**27**	**15**	**58**	**7**	**27**
C. NONCODING	9	35	2	8	0	0	3	12
D. NO ANSWER	0	0	2	8	1	4	0	0
TOTAL	**26**	**100**	**26**	**100**	**26**	**100**	**26**	**100**

In the first question, the correct answer was determined as 'It depends on the mass of the substances. The one with more mass is denser'. Accordingly, the number of students responding correctly was 4% before the instruction, it increased to 46% after the instruction, it decreased to 35% in the 1st CDT and it increased to 46% in the 2nd CDT. The partially correct answer was determined as 'It is more difficult to carry the bucket with sand'. While the number of students who respond partially correctly was 4% before the instruction, it increased to 12% after the instruction. It decreased to 4% in the 1st CDT whereas it increased to 15% in the 2nd CDT. It was seen that the number of students who gave scientifically correct answers increased after the instruction. While there was a decrease in the scientifically correct answers in the 1st CDT, compared to the postinstruction, there was an increase in the scientifically correct answers in the 2nd CDT, which was similar to the postinstruction.

In the section regarding unacceptable answers, it was determined that the students confused the density of the substances with the space between particles in the substance. While the number of students responding to the space between particles in the substance was 46% before the instruction, it decreased to 23% after the instruction. In addition, the number of students increased to 58% in the 1st CDT, while it decreased to 27% in the 2nd CDT. While the frequency of encountering this misconception decreased after the instruction, it was encountered more frequently in the 1st CDT than that of before the instruction. The frequency of encountering this misconception decreased to a level that was close to the preinstruction in the 2nd CDT. It was seen that the number of students responding as 'The solid one is heavier' decreased from 12% before the instruction to 4% after the instruction, the number of students increased to 8% in the 1st CDT, while it decreased to 4% in the 2nd CDT. The most common misconception of students was that 'when the substance changes, its mass can also change'.

While the number of students responding to the question as noncoding before the instruction was 35%, it decreased to 8% after the instruction. In addition, answers in this category were not encountered after the 1st CDT, while it was 12% after the 2nd CDT. While there were no students who did not answer before the instruction, the rate increased to 8% after the instruction. Moreover, it decreased to 4% in the 1st CDT whereas there were no students in the 2nd CDT.

In the second question of TCUD, students were asked to calculate the density of an object in the form of a rectangular prism, whose mass and edge lengths were given, and to write its unit. The results obtained from the analysis are given in Table 2.

Table 2. Results obtained from the analysis of the second question

Question 2	BI		AI		1stCDT		2ndCDT	
Types of responses	n	%	n	%	n	%	n	%
1. FULLY CORRECT ANSWER								
Mass / Volume process is performed correctly and the unit is written	*0*	*0*	*8*	*31*	*11*	*42*	*10*	*38*
2. PARTIALLY CORRECT ANSWER								
mass / volume process is performed correctly, but the unit is not written "	*1*	*4*	*8*	*31*	*2*	*8*	*0*	*0*
TOTAL	**1**	**4**	**16**	**62**	**13**	***50***	**10**	***38***
B. UNACCEPTABLE ANSWER								
Miscalculation or wrong calculation of density	*0*	*0*	*2*	*8*	*2*	*8*	*0*	*0*
TOTAL	**0**	**0**	**2**	**8**	**2**	**8**	**0**	**0**

C. NONCODING	10	38	6	23	6	23	5	19
D. NO ANSWER	15	58	2	8	5	19	11	42
TOTAL	**26**	**100**	**26**	**100**	**26**	**100**	**26**	**100**

In the second question of TCUD, the correct answer was accepted as 'mass/volume process is performed correctly and the unit is written'. While no student who gave the correct answer was found before the instruction, the rate increased to 31% after the instruction. Additionally, it increased to 42% in the 1st CDT, while it decreased to 38% in the 2nd CDT. In the partially correct answer category, there were responses 'the mass/volume process is performed but the unit is not written'. While the number of students responding to this category was 4% before the instruction, it increased to 31% after the instruction. In addition, it decreased to 8% in the 1st CDT, whereas there were no students in this category in the 2nd CDT. It was seen that there was an increase in scientifically correct answers after the instruction. However, there was a slight decrease in scientifically correct responses in the 1st CDT, the decrease continued in the 2nd CDT. However, in all three tests, scientifically correct answers were found at a higher rate than before the instruction.

In the category of unacceptable answers, there were answers to students who could not calculate or miscalculate the density of substances. Students in this category could not grasp the relationship between the concept of density and mass and volume. It was observed that there were no students who could not calculate or miscalculate the density of substances before the instruction, the rate increased to 8% after the instruction. In addition, it remained 8% in the 1st CDT, while there were no students in the 2nd CDT, i.e., the students were not able to calculate the density or express any ideas about this subject before the instruction as they did not have information about the relationship between density and mass and volume. In addition, they had difficulty in understanding the relationship between density and mass and volume after the instruction.

While the number of students responding to the question in the noncoding category was 38%, it decreased to 23% after the instruction. Additionally, it remained 23% after the 1st CDT, whereas it decreased to 19% after the 2nd CDT. While the number of students who did not answer the question before the instruction was 58%, it decreased to 8% after the instruction. Moreover, it increased to 19% in the 1st CDT and 42% in the 2nd CDT.

In the third question of TCUD, the students were explained that some liquids that do not mix each other are put in a glass container (honey, spirit and soap, respectively), and informed that the spirit is at the top. The results obtained from the analysis of the students' answers are given in Table 3.

Table 3. Results obtained from the analysis of the third question

Question 3	BI		AI		1stCDT		2ndCDT	
Types of responses	n	%	n	%	n	%	n	%
1. FULLY CORRECT ANSWER								
Although the container is inverted, the liquid with low density remains above the others.	*0*	*0*	*22*	*85*	*18*	*69*	*16*	*62*
2. PARTIALLY CORRECT ANSWER								
	0	*0*	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL	**0**	**0**	**22**	**85**	**18**	***69***	**16**	***62***

UNACCEPTABLE ANSWER								
Honey remains at the bottom as it is solid	*2*	*8*	*0*	*0*	*0*	*0*	*2*	*8*
The one with high density remains on top	*3*	*12*	*2*	*8*	*1*	*4*	*3*	*12*
It is due to the shape of the container	*3*	*12*	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL	**8**	**31**	**2**	**8**	**1**	**4**	**5**	**19**
C. NONCODING	11	42	2	8	2	8	3	12
D. NO ANSWER	7	27	0	0	5	19	2	8
TOTAL	**26**	**100**	**26**	**100**	**26**	**100**	**26**	**100**

In the third question of TCUD, the correct answer was that the liquid, which has a low density, remains above the others over time, even though the container is inverted. While no students who gave the correct answer was found before the instruction, the number increased to 85% after the instruction. Additionally, it decreased slightly to 69% in the 1st CDT, and decreased to 62% in the 2nd CDT. In this question, some students gave partially correct answers. It was found that the scientifically correct answers given by the students increased after the instruction, and that rate decreased slightly in the conceptual durability tests, but it was quite high compared to the preinstruction.

The number of students in the category of unacceptable answers who responded that honey remains at the bottom as it is solid was 8% before the instruction, but this misconception was not encountered in the students after the instruction. In addition, there were no students who had this misconception in the 1st CDT, while the number was 8% in the 2nd CDT, which was similar to the preinstruction. It was seen that the number of students with the misconception that the one with high density remains on top was 12% before the instruction and it decreased to 8% after the instruction. It was observed that the frequency of encountering this misconception decreased to 4% in the 1st CDT whereas it increased to 12% in the 2nd CDT. While the number of students who had the misconception that it is due to the shape of the container was 12% before the instruction, this misconception was not encountered in the first and second implementation of conceptual durability tests.

While the number of students in the noncoding answers category before the instruction was 42%, it decreased to 8% after the instruction. Additionally, it remained at 8% after the 1st CDT, while it increased to 12% after the 2nd CDT. Although the number of students who gave the noncoding answers after the instruction decreased, there was some increase in the 2nd CDT. The number of students who did not answer the question before the instruction was 27%, while there were no students after the instruction, 19% in the 1st CDT and 8% in the 2nd CDT.

4. Discussion and Conclusion

In this study, the effect of guided inquiry-based instruction on the change and durability in the ideas of middle school students about density concept was investigated. For this reason, TCUD was applied to determine the conceptual durability levels of students 6 weeks after and 24 weeks after the instruction. In the first question interrogating the understanding of the relationship between density and mass, the rate of correct answers before the instruction was quite low, while almost half of the students understood the relationship between mass and density after the instruction. In the 1st CDT, it was seen that the rate of correct answers decreased slightly compared to the postinstruction period. In the 2nd CDT, the rate of correct answers increased, which was the same rate as after the instruction. Similarly, in his study, Georgides (2000) encountered a slightly higher rate of correct answers about open/closed circuits and burnt bulb concepts 8 months after the instruction, which was slightly higher than a week after the instruction. In this question, two types of misconceptions were encountered in students. While nearly half of the students had the misconception that the space between particles in the substance affects the mass before the instruction, the rate halved after the instruction. In the 1st CDT, the frequency of encountering this misconception increased and it was encountered in half of the students. In the 2nd CDT, the frequency of encountering this misconception decreased and it was the same rate as after the instruction. The frequency of encountering this misconception varied in durability tests, and it was less in the 2nd CDT than the 1st CDT. The reasons for the increase in the frequency of this misconception should be examined in more detail. The frequency of the misconception that the solid substances are heavier decreased after the instruction, one student showed an increase in the 1st CDT compared to the postinstruction and the same rate was observed in the 2nd CDT as in postinstruction.

In the second question of TCUD, the students were asked to calculate the density of a substance whose mass is known and volume can be calculated, and they were expected to write its unit. While the number of students who answered correctly for this question was very low before the instruction, the frequency of correct answers after the instruction increased. As for conceptual durability tests, half of the students responded correctly in the 1st CDT, whereas the rate of correct answers in the 2nd CDT slightly decreased. While the frequency of scientifically correct answers was the lowest before the instruction, the rate of scientifically correct answers was the highest after the instruction. The frequency of scientifically correct answers showed some decrease in conceptual durability tests. In a similar study, Kucukozer (2013) has obtained the result that the frequency of correct answers decreased 22 months after the instruction. While there were no students who miscalculated or could not calculate the density before the instruction, a slight increase was found in the postinstruction and 1st CDT. This may be due to the instruction. Samples that are used to explain a concept in the classroom can convey a completely different meaning and may lead to the fact that the actual result differs from the expected result (Anderson, 1986).

In the third question of TCUD, students were asked to list out the density of liquids. While no scientifically correct answers were encountered in the preinstruction, scientifically correct answers increased after the instruction. However, there was a slight decrease in scientifically correct answers in the first and second conceptual durability tests compared to postinstruction. While the misconception that honey is solid was encountered before the instruction, this misconception was not encountered after the instruction and in the 1st CDT. In the 2nd CDT, this misconception was encountered at the same rate as preinstruction. These students had their pre-instruction ideas again 24 weeks after the instruction and continued to express their ideas about this misconception. The frequency of the misconception that the liquid with high density remains on top decreased until the 1st CDT and returned to the pre-teaching level in the 2nd CDT. Students who had this misconception before the instruction continued to express these ideas in the 2nd CDT. Similarly, Trundle, Atwood and Christopher (2007) found that the student could have the misconceptions that they had before the instruction long after the instruction ended. Hewson and Hewson (1984) explained that some students' ideas about misconceptions continue to remain constant after the instruction and they have misconceptions again after a while even if they give scientifically correct answers. The misconception that it depends on the shape of the container was encountered only before the instruction and it was observed that the instruction was effective in the change of the students' ideas about this misconception. In the post guided inquiry-based instruction and conceptual durability tests, students did not have ideas about this misconception. Studies have supported that an inquiry-based learning approach is effective in the change of ideas about students' misconceptions (Korganci, Miron, Dafinei & Antohe, 2014; Prince, Vigeant & Nottis, 2012; Ucar & Trundle, 2011). To sum up, it was found that the guided inquiry-based learning approach is effective in middle school students' correct answers about the concept of density. Zvoch, Holveck and Porter (2019) encountered a similar result in their study. Similarly, Almuntasheri et al. (2016) concluded that the guided inquiry-based learning approach is effective in middle school students' understanding of the concept of density. In another study, Trundle and Bell (2010) found that the guided inquiry-based learning approach is effective in the change of students' misconceptions towards scientific ideas about the phases of the Moon. It was also seen that guided inquiry-based learning approach was effective in maintaining their ideas related to correct answers in durability tests performed 6 and 24 weeks after the instruction. The results showed that the guided inquiry-based learning approach is effective in realising the conceptual change in students related to density concept and ensuring durability in their scientific ideas. However, it was seen in some questions that students had misconceptions they had before the instruction after long periods. It has been suggested in many studies that conceptual change is always not very easy and students can regain their pre-instruction ideas long after the instruction ended even if they give scientific answers (Georgides, 2000; Kucukozer, 2013; Trundle, Atwood & Christopher, 2007).

4.1. Recommendations for the future studies

Within the scope of this study, 8 hours of instruction was implemented. Studies for longer periods may be carried out to investigate the conceptual durability. Therefore, more extensive content may be studied for longer periods. Studies in which the conceptual durability is investigated for longer periods may be conducted. After 24 weeks, it was observed that there was an increase in the correct answers for some questions compared to postinstruction. At this point, students' exams may have been effective in the answers of their durability tests. More detailed data may be collected about the reasons for the increase in the correct answers in durability tests.

References

Almuntasheri, S., Gillies, R. M., & Wright, T. (2016). The effectiveness of a guided inquiry-based teachers' professional development programme on Saudi students' understanding of density. *Science Education International*, *27*(1), 16-39.

Anderson, B. (1986). The experiential gestalt of causation: A common core to pupils' preconceptions in science. *European Journal of Science Education, 8*(2), 155-171. Doi: 10.1080/0140528860080205.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction. *The Science Teacher*, *72*(7), 30-33.

Bostan-Sarıoglan, A., & Kuçukozer, H. (2017). Effect of meaning making approach on students' conceptual understanding: An examination of angular momentum conservation. *International Journal of Education in Mathematics Science and Technology*, *5*(3), 203-220. Doi: 10.18404/ijemst.296035.

Bunterm, T., Lee, K., Ng Lan Kong, J., Srikoon, S., Vangpoomyai, P., Rattanavongsa, J., & Rachahoon, G. (2014). Do different levels of inquiry lead to different learning outcomes? A comparison between guided and structured inquiry. *International Journal of Science Education*, *36*(12), 1937-1959. Doi: 10.1080/09500693.2014.886347.

Campbell, M. (2006). *The effects of the 5E learning cycle model on students' understanding of force and motion concepts*. Unpublished master's thesis, University of Central Florida, Orlando, Florida.

Colburn, A. (2000). An inquiry primer. *Science scope*, *23*(6), 42-44.

Driver, R., & Oldham, V. (1986). A constructivist approach to curriculum development in science. *Studies in Science Education, 13*(1), 105-122. Doi: 10.1080/03057268608559933.

Driver, R. (1989a). Students' conceptions and the learning of science. *International Journal of Science Education*, *11*(5), 481-490. Doi:10.1080/0950069890110501

Driver, R. (1989b). Changing conceptions. (ed: In P. Adey, et al.). *Adolescent development and school science*. New York: The Falmer Press.

Duit, R. (2009). Bibliography – STCSE students' and teachers' conceptions and science education. Kiel, Germany: University of Kiel.

Fang, S, Hsu, Y, Chang, H., Chang, W., Wu, H., & Chen, C. (2016). Investigating the effects of structured and guided inquiry on students' development of conceptual knowledge and inquiry abilities: A case study in Taiwan. *International Journal of Science Education, 38*(12), 1945-1971. Doi:10.1080/09500693.2016.1220688.

Flynn, S., & Hardman, M. (2019). The use of interactive fiction to promote conceptual change in science. *Science & Education*, *28*(1-2), 127-152. Doi:10.1007/s11191-019-00032-6.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. *Review of Educational Research, 82*(3), 300–329. Doi:10.3102/0034654312457206

Hansen, M. L. (2002). Defining inquiry: Exploring the many types of inquiry in the science classroom. *Science Teacher, 69*(2), 34–37.

Hewson, P.W., & Hewson, M.A.B. (1984). The role of conceptual conflict in conceptual change and the design of science instruction. *Instructional Science, 13*(1), 1-13.

Hewson, P.W. (1992). Conceptual change in science teaching and teacher education. *Paper presented at a meeting on "Research and Curriculum Development in science Teaching" under the auspices of the National Centre for Educational Research, Documentation, and Assessment, Ministry for Education and Science*, Madrid, Spain.

Jiang, F., & McComas, W. F. (2015). The effects of inquiry teaching on student science achievement and attitudes: Evidence from propensity score analysis of PISA data. *International Journal of Science Education*, *37*(3), 554-576. Doi: 10.1080/09500693.2014.1000426.

Jones, M. G., & Brader-Araje, L. (2002). The impact of constructivism on education: Language, discourse, and meaning. *American Communication Journal*, *5*(3), 1-10.

Joung, Y. J. (2009). Children's typically-perceived-situations of floating and sinking. *International Journal of Science Education, 31*(1), 101-127. Doi:10.1080/09500690701744603.

Georgides, P. (2000). Beyond conceptual change learning in science education: Focusing on transfer, durability and metacognition. *Educational Research, 42*(2), 119-139. Doi: 10.1080/001318800363773.

Koksal, E. A., & Berberoglu, G. (2014). The effect of guided-inquiry instruction on 6th grade Turkish students' achievement, science process skills, and attitudes toward science. *International Journal of Science Education*, *36*(1), 66-78. Doi: 10.1080/09500693.2012.721942.

Korganci, N., Miron, C., Dafinei, A., & Antohe, S. (2015). The importance of inquiry-based learning on electric circuit models for conceptual understanding. *Procedia-Social and Behavioral Sciences*, *191*, 2463-2468.

Kucukozer, H. (2013). Designing a powerful learning environment to promote durable conceptual change. *Computers & Education*, *68*, 482-494.

Lee, V. S. (2012). What is inquiry-guided learning? *New Directions for Teaching and Learning*, *129*, 5-14. Doi: 10.1002/tl.20002

Lim, B. R. (2001). *Guidelines for designing inquiry-based learning on the web: Online professional development of educators* (pp. 1-272). Indiana University.

Miles, M. B., & Huberman, A.M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook* (2nd ed.). Thousand Oaks, California: SAGE.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction-what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching, 47*(4), 474–496. Doi: 10.1002/tea.20347.

National Research Council [NRC] (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. National Academies Press.

Osborne, R. J., & Freyberg, P. (1985). Learning in science: The implications of children's science. *Auckland*, NZ: Heinemann.

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage publications.

Prince, M., Vigeant, M., & Nottis, K. (2012). Using inquiry-based activities to repair student misconceptions related to Heat, energy and temperature. In *2012 Frontiers in Education Conference Proceedings* (pp. 1-5). IEEE.

Sackes, M., & Trundle, K. C. (2017). Change or durability? The contribution of metaconceptual awareness in preservice early childhood teachers' learning of science concepts. *Research in Science Education, 47*(3), 655-671. Doi: 10.1007/s11165-016-9522-1.

Scherr, R. E. (2003). An implementation of physics by inquiry in a large-enrollment class. *The Physics Teacher*, *41*(2), 113-118. Doi: 10.1119/1.1542051.

Stender, A., Schwichow, M., Zimmerman, C., & Härtig, H. (2018). Making inquiry-based science learning visible: the influence of CVS and cognitive skills on content knowledge learning in guided inquiry. *International Journal of Science Education, 40*(15), 1812-1831. Doi: 10.1080/09500693.2018.1504346.

Trundle, K. C., Atwood, R. K., & Christopher, J. E. (2007). A longitudinal study of conceptual change: Preservice elementary teachers' conceptions of moon phases. *Journal of Research in Science Teaching*, *44*(2), 303-326. Doi: 10.1002/tea.20121.

Trundle, K. C., & Bell, R. (2010). The use of a computer simulation to promote conceptual change: A quasi-experimental study. *Computers and Education*, *54*(4), 1078–1088. Doi: 10.1016/j.compedu.2009.10.012.

Ucar, S., & Trundle, K. C. (2011). Conducting guided inquiry in science classes using authentic, archived, web-based data. *Computers & Education*, *57*(2), 1571-1582. Doi: 10.1016/j.compedu.2011.02.007.

Vosniadou, S., & Ioannides, C. (1998). From conceptual development to science education: A psychological point of view. *International Journal of Science Education*, *20*(10), 1213-1230. Doi: 10.1080/0950069980201004.

Zvoch, K., Holveck, S., & Porter, L. (2019). Teaching for conceptual change in a density unit provided to seventh graders: A comparison of teacher-and student-centered approaches. *Research in Science Education*, 1-27. Doi:10.1007/s11165-019-09907-8.