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Achievement Levels of Middle School Students in the Standardized Science and Technology Exam and Formative Assessment Probes: A Comparative Study

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Abstract

The present study has two aims. Firstly, it aims to determine eighth grade students' conceptual understanding of floating and sinking through formative assessment probes. Secondly, it aims to determine whether or not there is a significant difference between students' performance in formative assessment probes and their achievement in the Standardized Science and Technology Exam (TEOG 1) exam. The sample of this research is 61 eighth grade students from a central middle school in Eskişehir. Data collection tools are four two-stage formative assessment probes and the scores of the student taken from the first TEOG 1 exam. The answers of the students to the two-stage probes were scored by use of a rubric. Findings indicated that most of the students either: a) both chose incorrect answer and did not write correct scientific explanation (%41); b) chose correct answer but did not write correct scientific explanation (%33); and c) chose correct answer but wrote partially correct explanation (%43). This result indicates the poorness of students' explanation and interpretation skills in formative assessment probes. In addition, the findings of the dependent sample t-test results also indicate that there is a significant difference between the scores of the students taken from the standardized science test (TEOG 1) and the formative assessment probes on the concepts of floating and sinking. This finding shows that the students are more successful on standardized science test than the formative assessment probes in general. These research findings, suggest that students should be exposed to teaching practices based on "formative assessment" that promotes the development of students' skills of explaining, interpreting, and reasoning rather than multiple-choice tests in science lessons.

Key words: Formative assessment, science teaching, TEOG 1

Introduction

When we hear the word 'assessment' in our education system, we first think of written and oral exams, marks obtained in the exams, ranking, stress, or failure. For most of the time, assessment is even used to mean written and oral exams and homework. Using the word assessment as if it was synonymous with summative assessment types simplifies the complex structure, stages and the aim of assessment (Atkin & Coffey, 2005). This is because the marks and points obtained actually constitute only the smallest part of the assessment. However, assessment is a fairly comprehensive concept ranking at the top of Bloom's taxonomy and a skill that requires an advanced performance. The basis of the assessment is to understand what a student has learnt, what he/she does not know well or to determine what kind of misconceptions he/she has in mind and to find qualitative and quantitative solutions.

Researches show that the assessment practices that are not integrated into teaching do not contribute to conceptual understanding of students (Black & William, 1998; Kavanagh & Sneider, 2007; Yin, Tomita, & Shavelson, 2013). The conventional evaluation and assessment methods such as "true-false", "matching", "fill in the gaps", and "multiple choice" questions that are applied at the end of a unit or semester lead to superficial learning and memorizing as they include fragmentary, discrete, and detailed information that students will forget in a short time (Butler, 1987; Butler & Neuman, 1995). Since these kinds of assessment methods which measure the level of learning by heart and low-degree gains focus on giving marks rather than teaching, the learning function of assessment becomes of secondary importance (Black, 1993; Black & William, 1998; Crooks, 1988). Conceptual learning requires such knowledge and skills as explanation, giving examples, interpretation, applying what has been learnt into new cases, and problem-solving rather than learning by heart. It is a known fact that "conceptual learning" is mostly not realized in science lessons where the information is given most of

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the time without taking the prior knowledge that the students already have into consideration. To Angelo and Cross (1993), learning can be achieved without any teaching at all, too. However, teaching without ensuring conceptual understanding is a very ironic situation in educational practices.

Types of Assessment

When the related literature is examined, it is seen that there are 3 common types of assessment which are 1) diagnostic assessment (determining prior knowledge), 2) summative assessment, and 3) formative assessment (Keeley, Eberle & Farrin, 2005; Keeley, 2008).

Diagnostic Assessment

Diagnostic assessment is carried out in order to determine whether the prior knowledge that students have about a subject or field is correct and to determine the misconception that students might have about that subject or field (Keeley, Eberle & Farrin, 2005; Keeley, 2008; Tan, 2010). Such assessments are applied at the beginning of the educational process. The aim of this type of assessment is to recognize the student and to place him/her in the program or job that fits him/her. The placement tests that are applied at schools and private education centers as well as the university placement exams that only aim to classify students based on their achievement levels can be given as examples to diagnostic assessment. The data obtained in these exams do not contribute to the learning of students unless they are used to determine scope and methodology of the course in line with the needs of students. Nevertheless, the aim of the diagnostic assessment should be to determine the level of readiness of students by finding out their imperfect knowledge and what they know wrong before teaching.

Summative Assessment

Called shortly as the assessment of learning, this type of assessment is used mostly to determine academic achievement score and achievement order (Keeley, Eberle, & Farrin, 2005; Keeley, 2008). Being a study to make a judgement about the learning levels among students, this type of assessment measures and certifies whether the students have reached the intended gains in lessons with a certain mark. For example, the mid-term and final exams in universities, the written and oral exams applied in primary and middle schools, high school entrance exams, and international exams such as PISA and TIMMS can be given as examples to summative assessment (Tan, 2010). In this regard, summative assessment is separated from the learning process, and is rather about determining what students have achieved and what they have not.

Formative Assessment

Being a comparatively less known new approach in comparison to diagnostic and summative assessments in the literature, formative assessment has come to forefront over the last 10-15 years in Europe and America especially with the book of Black and William (1998) titled Working Inside the Black Box. It is defined as the assessment carried out to learn (Black & William, 2004) and to teach without any purpose of giving marks (Keeley, Eberle & Farrin, 2005). What is meant by assessment carried out to learn and to teach is to find out what students already know about the subject to be taught and to determine how the lesson is going to be given in the light of their prior knowledge (Black & William, 1998; Furtak, 2012; Yin, Shavelson, Ayala, Ruiz-Primo, Brandon, & Furtak, 2008; Yin, Miki, Tomita & Shavelson, 2013). In his book titled Educational Psychology (1968), Ausubel mentioned this in a very impressive way: In the preface to his book *Educational Psychology: A Cognitive View*, he says that "If [he] had to reduce all of educational psychology to just one principle, [he] would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (Ausubel, 1968, p. vi)" It is promising that this foresight put forward by Ausubel 40-50 years ago has taken place in the literature of today through reference books (Keeley, 2005; 2007; 2008) and studies (Bulunuz & Bulunuz, 2013; Bulunuz Bulunuz, & Peker, 2014; Keeley, 2011; 2012;Torrance & Pryor, 2001).

After determining the prior knowledge of students at the beginning of the course, the incorrect or inadequate concepts that students have in mind are corrected or improved in the light of this prior knowledge. Since this assessment is made during teaching, an effective feedback is provided to both the student and the teacher regarding the teaching and learning process. According to Black and William (1998), Black, Harrison, Lee, Marshall and William (2004), the lesson that is given in the class can result in conceptual learning when the teaching method is re-adjusted in the light of the feedback received from students. If the information collected in diagnostic assessment regarding what students know /do not know or what they do not know well is not used during the teaching of a lesson, there is no formative assessment. Formative assessment is integrated with learning, continuous, and process-oriented.

Formative assessment method has been known in the international literature since the late 1990s and there are several studies where the effectiveness of this method is investigated (Ali & Iqbal, 2013; Black & William, 1998; Keeley, 2008; 2011; 2012; Kopittke, Behnard Wehr, & Menzies, 2012; Torrance & Pryor, 2001; Trauth-Nare and Buck, 2011; Yin, Tomita, & Shavelson, 2013). The results obtained from these studies generally show that the activities carried out through this method increase the cognitive level of students; students display a positive attitudes towards the lesson; and their critical thinking skills are developed. For example, Black and William (1998) have found out in their meta-analysis study where they reviewed nearly 250 studies that formative assessment method increases students' attendance to the lesson, conceptual understanding, and learning motivations. In the action research where the opinions of student groups were asked regarding the method, the participants stated that the implementer- researcher feature of this method contributed to the development of their pedagogical knowledge and skills and thus they had an idea about a more efficient usage of formative assessment processes in the classroom (Trauth-Nare & Buck, 2011). Nevertheless, the studies conducted on the formative assessment method are very limited in Turkey (Aydeniz & Pabuçcu, 2011; Bulunuz & Bulunuz, 2013: 2014; Metin & Özmen, 2010; Yalaki, 2010).

Formative Assessment Probes

One of the forms of formative assessment that has been used successfully in science education is the formative assessment probe (Keeley, 2011). The equivalent of the word "probe" in Turkish means to investigate, to drill, and to research. According to the Dictionary of TDK (Turkish Language Association) (2014), it means "*the act of checking, looking for, and counting in order to understand whether something or someone is present at some certain place and time*". Similarly, these formative assessment probes are the questions used both to find out the prior knowledge of students about the subject before the lesson and to determine the method to teach the lesson without any purpose of giving marks. According to Keeley (2011), only collecting information about students' ideas does not make a probe formative. If the information is used to improve teaching and learning, then the probe can be formative in nature.

In general, formative assessment probes are composed of two parts. In the first part, there is a problem or a question that is written inside a specific context and there are multiple choice answers under the question, unlike the conventional teaching practices. All the distracters that are wrong in this part are the answers that were obtained from the results of the studies carried out in this field. Students are asked to mark the answer that they think is correct. The second part that comes below is the open-ended section where the student is asked to explain "why the choice that he/she marked is correct" or give a detailed scientific explanation to the question.

Research on Floating and Sinking

The concepts of "floating and sinking" are two very common concepts that have been studied both in different countries and also in Turkey. All around the world, there are numerous studies (Hadjiachilleos, Valanides, & Angeli, 2013; Luo, 2006; Potvin, Masson, Lafortune, & Cyr, 2015; Srisawasdi, & Panjaburee, 2015; Wong, & Lau, 2014; Yin et al., 2013) recently focused specifically on middle school students' conceptual understanding on the concepts of floating and sinking. The findings of these studies listed above indicate that middle school students have limited or incorrect understanding about floating and sinking. The results of the research conducted in other counties are quite similar to the research was conducted in Turkey.

When the studies carried out with middle school students about the concepts of floating, sinking, buoyancy force, and pressure are considered, it is seen that students have alternative concepts and misconceptions in their minds that are not related to science. For example, Şahin and Çepni (2011) developed a 2-stage test in order to determine the differentiations in conceptual structures in the minds of the 8^{th} grade students. They found a very significant difference in favor of the experimental group in which teaching was conducted. In another research on the same subject, Seçer (2008) determined the alternative concepts in the "force and motion" unit among the 6^{th} grade students and observed the students in terms of conceptual development. According to the results of Seçer (2008), the students had wrong concepts in their minds that were similar to many alternative concepts available in the literature, which was noticed from the answers they gave in the pretest. In terms of the conceptual development of the students during the teaching stage, the researcher also found out that the students gave scientific answers about some concepts, but failed to make an absolute progress regarding some others.

In the studies carried out with teacher candidates on the same subject, it is seen that they have different concepts about floating, sinking, buoyancy force, and pressure. Demir, Uzoğlu and Büyükkasap (2012) found out in the research that they conducted with science teacher candidates that they had several misconceptions concerning force and motion concepts. With the aim of determining these misconceptions within the scope of this research, some open-ended questions and questions similar to concept cartoons were used, and it was seen at the end of the research that teacher candidates had many misconceptions that were not related to scientific facts about force and motion subjects.

In another study carried out on university students from different majors, Kalın and Arıkıl (2010) aimed to identify the misconceptions that university students had regarding "solutions" and to determine how the "dissolution" in particle size is defined by students. At the end of the study, it was found out that students did not have much difficulty in mathematically calculating the density of a pure substance and the solution given, but they had misconceptions regarding the concept of density. With the research, the reasons behind the misconceptions that students had in mind were determined to be teachers and failure of students in associating their prior knowledge with the new knowledge they acquire in a reasonable way. In another study conducted by Ültay and Kasap (2014) on the second year students studying in the major of Primary School Teaching, the effect of "*floating and sinking objects and buoyancy force in liquids*" subject that was prepared based on the conceptual change approach on the conceptual understanding of students was investigated. It was found out that students had misconceptions concerning floating and sinking objects and the buoyancy force in liquids, and the conceptual change approach that was applied became efficient in teaching them these concepts correctly.

This study has two purposes. The first purpose is to determine the 8th grade students' levels of conceptual understanding of the concepts of floating and sinking through the formative assessment probes. The second purpose is to determine whether there is a significant difference between the performances of students in the formative assessment probes and their achievement in the TEOG 1 exam. In this study, an attempt was made to answer the below-mentioned research questions:

1. What are the 8th grade students' levels of conceptually understanding the formative assessment probes prepared on the subject of floating and sinking?
2. Is there a difference between the performances that students display in the formative assessment probes and their achievement levels in the TEOG 1 (transition from primary to secondary education) 1 exam?

Method

The Design of the Study

This research has been conducted in the survey model (Karasar, 1998; Kaptan, 1998; & Robson, 1997). According to Karasar (1998, p. 77) the survey model is a research approach aiming to describe a past or present situation. In this study, by using the survey model formative assessment probes were used to collect information about middle school students's current initial understandings about the concepts of floating and sinking. In addition, the students' open ended explananations for thev second part of the formative assessment probes on their choices and their TEOG 1 scores were also used to describe these students' conceptual levels about these physical science concepts.

Participants

This study was designed and carried out jointly by a science teacher, a researcher, and two field experts. It was conducted on 61 8th grade students, 29 of them being girl and 32 of them being boy, in Mehmet Gedik Middle school in Odunpazarı District of Eskişehir in the 2014-2015 academic year. The school is a public school in the city center with a medium socio-economic status that has a science and a computer laboratory and that can provide necessary facilities to its student. The fact that the third writer of this study (researcher-teacher) was working as a science teacher in this school became influential on the choice of this school.

Data Collection Tools

TEOG 1 exam is a set of exams conducted every semester for 6 basic courses at the 8th grade by teachers. It has been in practice since the beginning of the 2013- 2014 academic year. TEOG 1 exam consists of 20 multiple choice questions. Each one of these questions is composed of a question statement, one correct answer, and three other distracters. In the TEOG 1 exam conducted in the 2014- 2015 academic year, questions on mitosis, meiosis, heredity, DNA and genetic code, adaptation, and evolution were asked from the "living beings and the life" unit while there were questions about the buoyancy force of liquids and gases, density, and floating and sinking of an object on/in the water from the "force and motion" unit. In the research, the achievement marks that students obtained from 20 science questions were used. The frequency and percent values of the achievement marks that the students participating in the present study obtained from this exam are indicated in the table below. Four 2-stage questions were used for data collection tool based on the formative assessment method. At the end of the first TEOG 1 exam, 61 8th grade students attending a middle school in Eskişehir were asked to answer four 2-stage formative assessment probes in writing.

Table 1. Frequency and percent values of the students' TEOG 1 achievement scores **(N=61)**

TEOG 1 Scores	**F**	**%**
85-100	28	46
70-84	11	18
55-69	11	18
45-54	7	11
0-44	4	7

In the study, 4 formative assessment probes developed concerning the concepts of force and motion by Keeley and Harrington (2010) were used as a data collection tool based on the formative assessment approach. Before choosing the assessment probes, the gains that were set with regards to the force and motion subject in the curriculum were examined and it was aimed to ensure that the probes were compatible with the gains. The assessment questions selected in line with this aim were adapted to Turkish. In the light of the feedback received from field experts in this process, the necessary changes were made, and the assessment probes were finalized. The formative assessment probes are composed of 2 parts. The first part includes different choices regarding the question. As for the second part, students are asked to explain the rule or logic that they use while choosing one particular answer. In the first assessment probe, the relationship between the amount of matter and density is investigated in objects of different sizes but made of the same matter while in the second probe it is asked what position an object floating on the water will have when a hole is made on it. In the third question, the relationship between the amount of matter and the floating and sinking situation is asked while in the fourth question the relationship between the density of an object and its position in a liquid is investigated. The formative assessment probes used in the research can be found in the Appendix A.

Data Analysis

In the related literature, the analyses of the two stage questions are generally made by classifying the answers of students into categories (Çalık, Kolomuç & Karagölge, 2010; Karataş et al., 2003). The probe questions used in this study were evaluated using a rubric developed for the analysis of two-stage questions by Karataş (2003) (See Appendix B). The assessments were made independently by the first author and the third author (i.e. researcher-teacher) of this paper. Whether there was a consistency between the marks given by the two researchers was determined via SPSS based on the inter-rater reliability coefficient. This coefficient was found to be .95 which showed that the assessments of the two researchers were highly consistent with each other. Accordingly, the data were entered in SPSS by matching the data obtained from the questions with the science scores that students got in the TEOG 1 exam. Later, the average scores that students got from the formative assessment probes were compared, by use of t-test with their average achievement scores in the science test within TEOG 1.

Results

The answers that students gave to the formative assessment probes were analyzed in line with the criteria indicated above. The findings below were obtained:

Part One of the Study

The First Formative Assessment Probe: **Comparing Cubes**

In the first assessment probe, the "*relationship between the amount of matter and the density in the objects that are of different sizes but made up of the same matter*." was asked. The findings obtained from the analysis of the answers to this question are indicated in Table 2.

Table 2. The findings obtained from the analysis of the first formative assessment probe

	(N= 61)		
Categories	**Sample Answer**	**f**	**%**
C.A – C.E	- Among the objects that are made of the same matter, the bigger one weighs more. - Since their volumes are the same, they have the same shape. As the volume of the objects that are made of the same matter increases, their mass increases as well. - As they are made of the same matter, the amount of floating, sinking, and melting at a certain temperature are all the same. As only one of them is bigger, it weighs more.	10	16
C.A. – P.C.E	- Since the big cube is bigger than the small cube, it weighs more. The small cube weighs less. - The mass and volume of the big cube is more than those of the small cube. - As the size of one cube is different from the other, its volume and mass are different as well.	11	18
C.A. – I.E	- Big cube is heavier than the small cube. *- The mass, atom, melting point, and volume of anything big is more than those of a small one.*	15	25
I.A. I.E	*-Since it is big, its melting rate is slower. A higher temperature is needed to heat it quickly.* *- As they are made of the same matter, their masses are closer to each other.*	25	41

* The italic sentences are the answers that include alternative concepts.

As it is seen in the Table 2, the majority of the students gave answers that fit in the category of (I.A. - I.E) for the question where the concepts of force and motion were asked. 16% of the students gave answers that fit in the category (C.A -C.E) while 18% in (C.A– P.C.E) When we take a look at the category (C.A–I.E), it is seen that 25% of the students gave answers that fit in this category. Also, it was found out that the students had the following alternative conceptions: *The atom, melting temperature and density of any big object will be more than those of a small one*; *the melting temperature of a big object will be lower*; *and the masses of two objects will be similar as they are made of the same matter.*

The Second Formative Assessment Probe: Solids and Holes

In the second assessment probe, whether "the position of an object changes inside the water when a hole is made on it" was asked. The findings obtained through the assessment of the answers to this question in line with the criteria identified are presented in Table 3.

When the Table 3 is analyzed, it is seen that most of the answers are in the category of (I.A. - I.E) While 41% of the students gave answers that fit in this category, 29% of them marked for the category of (C.A. – P.C.E) and 10% of them for (C.A – I.A). Considering the answers that were given to this question, it is clear that the following alternative conceptions exist in the minds of students: "*If there were holes on ships, they would sink. Thus, all matters that have a hole on them sink. They first sink, then float just like the holes on a sponge. Since it floats before the holes, only a small part of it continues floating when a hole is made on it. Its mass remains the same after it has a hole*."

Table 3. The findings obtained from the analysis of the second formative assessment probe

	(N= 61)		
Categories	**Sample Answer**	**f**	**%**
C.A-C.E	- The floating and sinking of an object are about density. Since density is calculated as follows: 'd= mass/volume', both the volume and the mass reduce in the 2nd figure. - As the volumes of both objects are to be the same, they float in the same way. - The volume does not change when a hole is made on the object. If the volume is the same, it floats in the same way.	12	20
C.A-P.C.E	-The volume does not change when a hole is made on the object. -The hole does not make any difference so they continue to float in the same way. -The object continues to float in the same way even if a hole is made on it.	18	29
C.A – I.A	-In the second figure, only holes are made on the object, which means the structure of the matter is not changed, so floating continues in the same way. -It does not make any difference. The object with the hole remains the same. *It has the same mass.*	6	10
I.A – I.E	*-This is because; there are no holes in ships. If there were, they would sink.* *-Thanks to the holes in rocks looking like a sponge, it first sinks and then floats.* *-Only a very small part of it floats. This is because; it was floating when it was a proper square. If we made a hole on it, only a small part of it would float.*	25	41

* The italic sentences are the answers that include alternative concepts.

The Third Formative Assessment Probe: Floating Logs

In the third assessment probe, the "*relationship between the amount of matter and the floating and sinking situation*" was asked. The findings obtained from the analysis of this question are presented in Table 4.

Table 4. The findings obtained from the analysis of the third formative assessment probe

	ESKİŞEHİR (N= 61)		
Categories	**Sample Answer**	**f**	**%**
C.A–C.E.	-I think it does not make any difference if it is big or small. If their densities are the same and they are made of the same matter, they float in the same way. -This is because; the sinking volume of the object is about the density of the object and liquid. No matter how big the object is, its volume will remain the same. -The volume and the mass of the big log have increased but it floats in the same way as its density is the same.	19	31
C.A-P.C.E	-This is because; their densities are the same -This is because; they are made of the same wood. -As the densities of the identical matters are the same, the mass or volume is not important.	19	31
C.A-I.E	- Floating and sinking are not about the size or width. - As they are made up of the same matter, the size is not important. - The choice B is more reasonable compared to A and C.	20	33
I.A- I.E	-As it is 2-fold bigger, it weighs more. *-More than half of the big log floats on the water because its volume is more.* *- If we put a log that is two times bigger than the 1st log, less than half of it floats.*	3	5

* The italic sentences are the answers that include alternative concepts.

In Table 4, it is seen that 31% of the students gave answers that fit in the category of (C.A– P.C.E), 33% of them marked for (C.A–I.E) and 5% of them for (I.A-I.E) In this probe, the following alternative conceptions were detected: *More than half of the big log floats on the water as its volume is higher. If a half of a log floats while the other half sinks, a log that is 2-fold bigger floats with less than half of it sinking in the water.*

The Fourth Formative Assessment Probe: Floating High and Low

The findings obtained from the analysis of the 4th Formative Assessment Probe that questions the "*relationship between density of an object and its position inside a liquid*" are presented in Table 5 below.

Table 5. The findings obtained from the analysis of the fourth formative assessment probe

	(N= 61)		
Categories	**Sample Answer**	**f**	**%**
C.A – C.E.	-For an object to float on the water, its density has to be high. Accordingly, a matter of a higher density may be used or an extra weight may be added to the ball which will increase the density of the ball. -For the ball to sink more under the water, a matter of a higher density but the same size may be used. When the density of the ball increases, it sinks more. Also, an extra weight might be added to the ball as it will sink more easily as its mass increases. -Adding an extra weight to the ball makes a counter-effect and makes the ball sink more. Using a ball of the same size but of a higher density makes the ball sink more because as the density increases the volume that sinks increases as well.	11	18
C.E – P.C.E	-If a matter that is of higher density than the water is used, the ball sinks. If an extra weight is added to the ball, the water will not hold the ball over the surface and it will sink more. -We get this result when a pressure is made on the top of the ball because either the density or the mass must be higher for the ball to sink deep. -Because the matters of a higher density sink deeper. If the material is denser, we will have the lower buoyancy. As the weight increases, the ball goes down in the water because it is inversely proportional with the buoyancy force.	26	43
C.A – I.E	-*As the mass increases, the buoyancy force decreases.* As the density increases, the buoyancy force decreases. When we add some salt inside the water, the ball goes up toward the surface. So it does not sink. -*If the density is high, the volume that sinks decreases.* -If the density of the liquid or the volume of the object changes, the rate of floating and sinking changes as well.	14	23
I.A – I.E	-If it is made of a matter with higher density, it becomes the same because the ball on the right has a higher density. - It is possible if *a bigger ball made of the same matter* or a ball made of a matter with a higher density is used. -*A liquid with much more density should be used here* because the object sinks as the density increases.	10	16

* The italic sentences are the answers that include alternative concepts.

As it is seen on Table 5, 16% of the students gave answers that fit in the category of (I.A-I.E) while 18% of the students marked for (C.A–C.E) and 43% for (C.A-P.C.E) As for the (C.A-I.E) category, it has 23% of the answers. Also, it was found out that students had the following alternative concepts: *As the mass of the matter increases, the buoyancy force of the liquid increases as well. The big ball that is of a bigger size but made up of the same matter sinks much more. For the object to sink deeper, a liquid with a higher density is needed. If the density of the object increases, the volume that is sinking reduces.*

The findings obtained through scoring criteria given in Appendix B are presented in Table 6. When the total scores that students got from the assessment probes are examined in Table 6, it is seen that for the 3rd question, most of the students gave the answers that fit in the category of C.A. - C.E. As for the D.C. – K.D.G category, most of the answers came from the 4th question while the D.C – Y.G category got most of the answers from the 3rd question. When we take a look at the I.A. - I.E. category, it is seen that the least number of answers came from the 3rd and 4th questions while in the rest of them the answers are of the same frequency for this category.

Table 6. The performance scores of the students in formative assessment probes (N=61)

	1. Probe		2. Probe		3. Probe		4. Probe		Total Score
	f	Score	f	Score	f	Score	f	Score	
C.A-C.E	10	**30**	12	**36**	19	**57**	11	**33**	**156**
C.A-P.C.E	11	**22**	18	**36**	19	**38**	26	**52**	**148**
C.A-I.E	15	**15**	6	**6**	20	**20**	14	**14**	**55**
I.A-I.E.	25	**0**	25	**0**	3	**0**	10	**0**	**0**

Part Two of the Study

Is there a difference between the achievement levels that the students reached in TEOG 1 exam and their performances in the formative assessment probes?

Whether there is a difference between the achievement scores that the students got in science and technology in TEOG 1 exam and their performances in the formative assessment probes was analyzed using the matched-pairs t-test. The result of the analysis is presented on Table 7.

Table 7. Average scores from TEOG 1 and the formative assessment probes and their standard deviations

	N	M	SD	t
TEOG 1 Scores	61	75.00	19.57	11,28*
Formative Assessment Probes Scores	61	52.02	23.54	

* p<.001

The results of the matched-pairs t-test revealed that there is a significant difference between the average scores that the students got in science and technology in TEOG 1 exam and their performances in the formative assessment probes: t (61) = 11.28, p =.001.

Conclusion and Discussion

In the first part of the research, the level of conceptual understanding of the 8th grade students about the concepts of floating and sinking was determined through the formative assessment probes. As for the second part, it was found out whether there was a significant difference between the achievement scores of the students in science questions in TEOG 1 and their formative assessment scores. The results obtained in the study are explained below:

Part One of the Study

In order to answer the first research question (i.e. "What are the 8th grade students' levels of conceptually understanding the formative assessment probes prepared on the subject of floating and sinking?"), the answers that the students gave to the 4 formative assessment probes were analyzed. The results are indicated below:

The 1st Formative Assessment Probe: Comparing the Cubes

When the data obtained from the first assessment probe is examined, it is found out that nearly half of the students (41%) neither marked the correct answer for this probe and nor could write the right scientific explanation in the second part. In other words, almost half of the students could not compare correctly the objects of the same size but different volumes in terms of their physical characteristics such as mass, density, floating and sinking, etc. A quarter of the students (25%) marked the correct answer that says 'only the mass of the cubes made of the same matter but being of the different volume will be different' but couldn't write a correct or scientific explanation in the open-ended part of this question.

Based on these data, it can be said that students cannot use their knowledge on the question, nor can they make deductions, and they have difficulty in comparing objects made up of the same matter but being of different sizes in terms of melting point, density, floating and sinking, atom size, mass, and volume and in making an explanation even if they find the correct answer. The reason behind this failure might be the fact that students have been subject to conventional summative evaluation and assessment methods such as "true-false", "matching", "fill in the gaps", and "multiple choice" questions that are applied continuously at the end of units or semesters. These conventional evaluation and assessment methods generally lead to superficial learning and learning by heart as they contain fragmentary and discrete knowledge that is forgotten in a short period of time. In this regard, it is clear that students cannot analyze more than one case at the same time nor can they make deductions and explanations. The results obtained from this assessment probe are in parallel with the results of Şahin and Çepni (2011). Similarly, they also found out that students have a low level of conceptual understanding and have alternative concepts regarding the subjects of density and floating and sinking within the force and motion unit.

The 2nd Formative Assessment Probe: With and Without Hole

In this probe, the question 'whether an object that is floating on the water continues to do so if holes are made on it?' was asked to students. When the answers are examined, it is seen that nearly half of the students (41%) gave answers that fit the category of (I.A. - I.E). Only 20% of the students guessed correctly that making holes on an object will not change its floating on the water, but they did not make the explanations well. Even though they explained the relationship between the density and the floating and sinking situation correctly, they had difficulty in explaining how making a hole in an object can affect its floating and sinking. This shows us that students fail to use their basic conceptual knowledge in different cases.

The examples that students gave by making a wrong analogy in their explanations such as "If there were holes in ships, they would sink. So any object with a hole on it must sink in the water." and "There are holes on sponge as well, so the object first sinks and then floats on the water." also confirm that. These findings reveal that students cannot put what they learn in the lesson into practice in their daily lives, and they learn the information written on course books by heart and thus have difficulty in building a cause-effect relationship in different questions. The results reached through this question are in parallel with the results of Ültay and Kasap (2014) who determined the conceptual understanding levels of students regarding floating and sinking objects.

The 3rd Formative Assessment Probe: Floating Logs

To the question that asked the position of a log that is floating on the water first but then is made two-fold bigger one, most of the students (95%) gave the correct answer. When compared to the other probes, the highest level of achievement was achieved in this one. This may be because; this question did not involve more than one situation that had to be compared. When the students think about only one situation, they can find the answers more easily. However, when they have to consider more than one situation in the questions, it can be said that they have difficulty in interpreting. Similar to Kalın and Arıkıl (2010), it was seen in the present study that students do not have difficulty while making a density calculation but find it difficult to make an interpretation concerning the density concept in different situations and have many misconceptions about the subject.

The 4th Formative Assessment Probe: Floating and Sinking

Most of the students gave the following answers to the question of 'how the volume of the sinking part of a ball the half of which is floating on the water can be increased?': "By using an object of the same size but with more density" and "By adding a weight to the ball". In this probe, most of the students gave the correct answer, but they could not make the right justification properly. Similarly, in another study Seçer (2008) conducted with the 6th grade students, it was found out that students gave scientific answers regarding some concepts about force and motion but failed to make an absolute progress regarding some others. This shows us that they marked the correct answer thanks to the knowledge that they gained by heart but could not write why they chose that answer or indicate the correct scientific explanation of the concept.

Part Two of the Study

In the second part of the research, it was investigated whether there is a significant difference between the performances of the 8th grade students in formative assessment questions and their achievement scores in science questions in TEOG 1 exam regarding the concepts of floating and sinking. The significant difference between these scores in favor of TEOG 1 exam shows that students are more successful in the standardized middle school science test (TEOG 1) compared to the formative assessment probes. The most important reason why the students generally obtained low scores in formative assessment probes is that they were asked to explain in detail the justification behind the answers that they marked as correct in the second part of the exam.

Since the 8th grade students were used to having multiple choice exams, they did not have any difficulty in finding the right answer in the multiple choice part of the assessment questions. For example, more than 50% of the students gave the correct answer to all assessment questions. However, the analysis results indicate that the students who found the correct answer had difficulty in explaining why they chose that answer in the second part of the assessment questions (23%). This result demonstrates that the explanation and interpretation skills of students are underdeveloped. This is because; even though approximately 15% of the students found the correct answer in the first part, they gave a wrong justification in the second part; and while 14% of the students marked the correct answer in the first part, the explanation they wrote in the second part was partially correct. This finding shows that generally one third, which is a very high rate, of the students have difficulty in making an explanation in the assessment probes. This result might have several reasons. The first reason is that the word 'assessment' has almost all the time come to mean multiple choice tests in the Turkish education system. Since the TEOG 1 exam is composed of multiple choice test questions, both the written exams that teachers hold at schools and the questions in course books are composed of multiple choice tests and there is no question based on reasoning. Letting students be subject to test questions from primary school to middle school does not improve their reasoning and explanation skills, which is not a surprising result. The fact that students cannot make an explanation about the correct answer of a question indicates that they have not understood the subject (Murchan, Shiel,Vula, Bajgora, & Balidemajson, 2013). Among the reasons why students fail when they encounter the question types different from multiple choice tests may be as follows: teachers do not go beyond the conventional methods while evaluating the performance of students; they do not diversify the examples while teaching the subject and do not associate the lessons with the daily life; and they just convey the information in books to the students.

On the other hand, students do not feel a need to make an explanation about why a particular choice is correct even if they find the correct answer because the current assessment system measures mostly the information. Instead of thinking 'How can I use this information in my daily life? or 'How can I make use of the information I have in different situations?', students always worry about solving more and more test questions. This is because they are assessed through the TEOG 1 exam, are subject to an achievement order, and are placed in a high school according their scores. For this reason, students are concerned about the question "How can I keep more information in mind?" rather than "How can I fulfill conceptual learning?" or "What should I do for permanent learning?" All of these can be considered among the reasons why students fail to make an explanation or indicate their ideas in writing about their answers in an exam. One of the most important differences between the formative assessment method and the summative method is that the former helps to re-arrange the lesson plan based on the feedbacks that teachers receive from students through the formative assessment. Conceptual learning can be realized only when that occurs. Since our students have been raised in an assessment system that is based on getting marks at the end of each semester, they cannot receive an effective and objective feedback about their performance in the lesson from their teachers, which causes them to fail to learn the subjects properly and on a scientific basis (Black & William, 1998; Black, et al., 2004).

Recommendations

1. Though formative assessment has efficiently been used abroad for many years, there are very few studies conducted in this area in Turkey. This subject should be brought to the agenda during the in-service training seminars and be introduced to teachers and principals comprehensively. During these seminars, the following points should be explained to the participants with examples from the national and international literature: what is formative assessment?; what makes it different from the conventional assessment methods?; what is its contribution to permanent learning and conceptual change?; what methods and techniques may be used to apply the formative assessment method?; and so on.

2. In order to implement the formative assessment methods on their students and to increase their performances, teachers should be encouraged to do an action research by applying new formative assessment methods and to present the results of their studies at congresses or to share them with stakeholders by publishing the results.

3. The teachers who have been accustomed to making a summative assessment should go beyond the ordinary and concentrate on the questions that improve the reasoning and interpretation skills and the abilities of students to explain their ideas verbally or in writing and on the activities that will improve these skills in the classroom.

4. Teachers should ask about the prior knowledge of students regarding the subject that they are going to teach, schedule their lesson plan in the light of this information, and rearrange the course of the lesson within the scope of the feedbacks they receive while teaching the subject and thus give efficient and objective feedbacks to their students in return.

5. The subject of floating and sinking is one of the subjects that is less known or about which there are a lot of misconceptions in the minds of students, as is the case in many subjects within the science curriculum for middle schools. In order to teach this subject in a more effective way, the problems that are included in the probe questions should be selected from the daily life.

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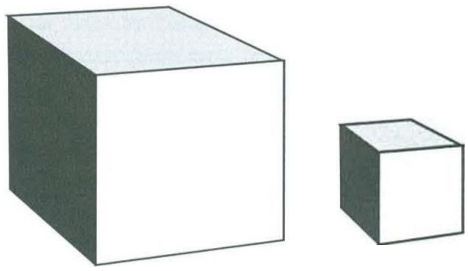
Appendices

Appendix A

First Formative Assessment Probe

COMPARING CUBES

Sofia has two solid cubes made of the same mate- rial. One cube is very large, and the other cube is very small. Put an X next to all the statements you think are true about the two cubes.



A. The larger cube has more mass than the smaller cube.

B. The larger cube has less mass than the smaller cube.

C. The larger cube melts at a higher temperature than the smaller cube.

D. The larger cube melts at a lower temperature than the smaller cube.

E. The density of the larger cube is greater than the smaller cube.

F. The density of the larger cube is less than the smaller cube.

G. The larger cube is more likely to float in water than the smaller cube.

H. The larger cube is more likely to sink in water than the smaller cube.

I. The larger cube is made up of larger atoms than the smaller cube.

J. The larger cube is made up of smaller atoms than the smaller cube.

Explain your thinking. Describe the "rule" or reasoning you used to compare the cubes.

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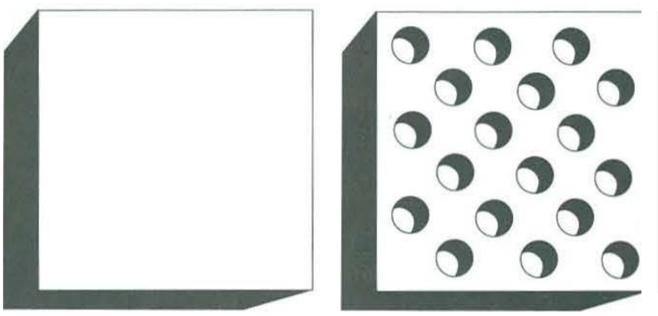
Second Formative Assessment Probe

SOLIDS AND HOLES

Lance had a thin, solid piece of material. He placed the material in water and it Boated. He took the material our and punch ed holes all the way through it. What do



you think Lance will observe when he puts te materi- al with holes back in the water? Circle your prediction.

A It will sink.

B It will barely float.

C It will float the same as it did before the holes were punched in it.

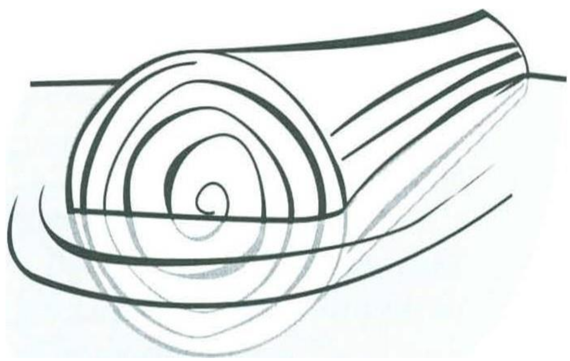
D It will neither sink nor float. It will bob up and down in the water.

Explain your thinking. Describe the "rule" or reasoning you used to make your prediction.

Third Formative Assessment Probe

FLOATING LOGS

A log was cut from a tree and put in water. The log floated on its side so that half the log was above the water surface. Another log was cut from the same tree. This log was twice as long and twice as wide. How does the larg- er log float com pared with the smaller log? Circle the best answer:



A More than half of the larger log floats above the water surface.

B Half of the larger log floats above the water surface.

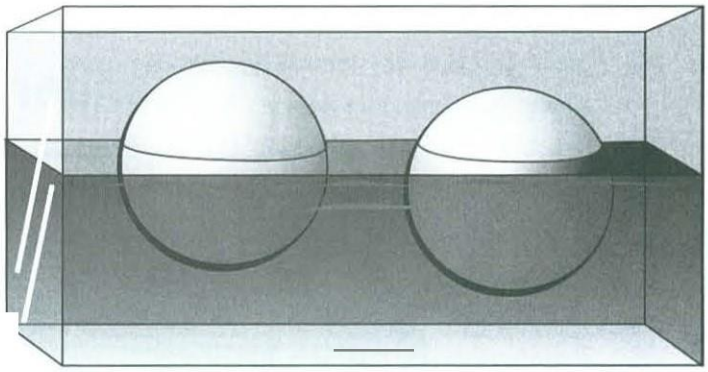
C Less than half of the larger log floats above the water surface.

Explain your chinking. Describe the "rule" or the reasoning you used for your answer.

Fourth Formative Assessment Probe

FLOATING HIGH AND LOW

Sam put a solid ball in a tank of water. As shown by the ball on the left, it floated halfway above and halfway below the water level. What can Sam do to make a ball float like the ball on the right? Put an X next to all the things Sam can do to have solid ball float *so* that most of it is below the water level.



A. Use a larger ball made out of the same material.
B. Use a smaller ball made out of the same material.
C. Use a ball of the same size made out of a denser material.
D. Use a ball of the same size made out of less dense material.
E. Add more water to the tank so it is deeper.
F. Add salt to the water.
G. Attach a weight to the ball.

Explain your thinking. Describe the "rule" or reasoning you used to determine how to change how an object floats in water.

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Appendix B

GRADING MANUAL

The Rubric Used for Evaluating the Answers Given to the Two-Tiered Formative Assessment Probes 1.

Comprehension Levels	Explanation	Evaluation Criteria	Scores
Correct Elaboration	Integrated with scientific perspective and clear with elaboration	Correct Answer- Correct Elaboration **(C.A-C.E.)**	**3**
Partially Correct Elaboration	Partially correct or limited elaboration	Correct Answer- Partially Correct Elaboration **(C.A-P.C.E.)**	**2**
Incorrect Elaboration	Incorrect answer or clearly evident misconception	Incorrect Answer- Correct Elaboration **(I.A-C.E)**	**2**
No Answer	No response or clearly evident misconception	Correct Answer-Incorrect Elaboration **(C.A-I.E.)**	**1**
		Incorrect Answer- Incorrect Elaboration **(I.A-I.E.)**	**0**