Teaching floating and sinking concepts with different methods and techniques based on the 5E instructional model

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Abstract

The purpose of this study was to test the influences of prepared instructional material based on the 5E instructional model combined with CCT, CC, animations, worksheets and POE on conceptual changes about floating and sinking concepts. The experimental group was taught with teaching material based on the 5E instructional model enriched with different teaching methods and techniques including: POE, worksheets, conceptual change text, concept cartoons and animation activities. And the control group was taught with teaching materials based on the 5E instructional model conducted by the Ministry of Education. The pretest, posttest and delayed posttest were applied to the experimental and control groups. Obtained data was analyzed qualitatively and quantitatively. It was seen that students in the experimental group provided more correct reasoning than did the control group in posttest and delayed posttest. Most of the students in the control group have not changed their alternative concepts in the posttest, although the experimental group students moved their alternative concepts in the posttest.

Keywords: Conceptual change, 5E instructional model, POE, worksheet, conceptual change text, concept cartoon, animation.

Introduction

Students' alternative conceptions in science and technology are often resistant to change, at least through traditional instruction (Fisher, 1985; Raghavan, Sartoris & Glaser, 1998; Tytler, 1998; Önen, 2005; Hardy, Jonen, Möller & Stern, 2006; Saka, 2006). Some teaching methods and techniques like conceptual change texts (CCT), concept cartoons (CC), prediction-observation-explanation (POE), interviews about instances and events, interviews about concepts, drawings, fortune lines, relational diagrams, computer assisted materials, word association and analogies are used to provide meaningful learning and conceptual change (White & Gunstone, 1992; Stephenson & Warwick, 2002; Atasoy, 2004; Besson & Viennot, 2004; Çepni, Taş & Köse, 2006; Keleş & Çepni, 2006; Hovardas & Korfiatis, 2006; Çepni et al., 2007). In recent years, researchers have started to use different techniques together to overcome the well known alternative conceptions (Grotzer, 2003; Kawasaki, Rupert Herrenkohl & Yeary, 2004; Zhang, Chen, Sun & Reid, 2004; Besson & Viennot, 2004; She, 2005; Havu-Nuutinen, 2005; Uzuntiryaki & Geban, 2005; Yenilmez & Tekkaya, 2006; Yürük, 2007; Cardak, Dikmenli & Saritas, 2008; Cardak & Dikmenli, 2008; İpek & Çalık, 2008; Kurnaz & Çalık, 2008; Taştan, Dikmenli, & Çardak, 2008; Türk & Çalık, 2008; Ürey & Çalık, 2008; Özmen, Demircioğlu & Demircioğlu, 2009). In the related literature, researchers mainly use CCT and support it with other teaching methods and techniques to overcome the alternative conceptions on the grounds that using some other supportive activities with CCT is more effective than traditional CCT (Çetingül & Geban, 2005; Özmen et al., 2009). These approaches have already served as the basis of many studies in establishing their conceptual framework. For example, Yenilmez and Tekkaya (2006) investigated the effectiveness of combining CCT and discussion web strategies on students' understanding of photosynthesis and respiration in plants; and Uzuntiryaki and Geban (2005) investigated the effect of CCT together with concept mapping instruction and traditional instruction on 8th grade students' understanding of solution concepts. Yürük (2007), tried to compare the effectiveness of an instruction supplemented with CCT over traditional instruction on students' understanding of galvanic and electrolytic cell concepts. İpek and Çalık (2008), used different conceptual methods (work sheet, analogy, CCT) within the four-step constructivist teaching model to eliminate students misconceptions about electric circuits, how "electric charge flows in series and parallel circuits" and "how the brightness of bulbs and the resistance changes in series and parallel circuits." Ürey and Çalık (2008) displayed a sample teaching of the cell and its organelles by combining different conceptual change methods within the 5E instructional model. Türk and Çalık (2008) presented a sample teaching activity about endothermic-exothermic reactions for teacher usage by using different conceptual change methods embedded within the 5E instructional model. Kurnaz and Çalık (2008) used different conceptual change methods embedded within the 5E instructional model to teach heat and temperature and express the difference between them. Taştan et al. (2008) investigated the effects of concept maps, together with CCT, given to 11th grade students on the subject of molecules carrying genetic information. Özmen et al. (2009) aims to determine the effects of CCT accompanied with computer animations on 11th grade students' understanding and alternative conceptions related to chemical bonding.

Studies about floating and sinking

One of the topics, of which many studies were conducted to provide conceptual change, is floating and sinking. In studies about floating and sinking, students' alternative conceptions were discused and different activities were organized to remove these conceptions. Yin, Tomita and Shavelson (2008) determined students' alternative conceptions about buoyancy and density subjects with diagnostic items at the beginning of the unit. Then, they prepared worksheets by taking the alternative conceptions into consideration and applied them to students. When students still had problems, they prepared POE activities to overcome students' misconceptions. Gürdal and Macaroğlu (1997) tried to make out how students perceive the concepts of floating and sinking, and benefited from experimental activities in teaching these concepts. Reid, Zhang and Chen (2003) looked into the performance effect of simulation based on scientific discovery learning with experimental and interpretative support on determining intuitional understanding, adaptation to situation and combining knowledge of students. Zhang et al. (2004) made a three-phased (interpretative support, experimental support, reflective support) experimental study to support simulation-based scientific discovery learning. They examined the effect of simulation-based scientific discovery learning on meaningful and scientific learning, and reflective thinking about the subject of floating and sinking. Kawasaki et al. (2004) used a experimental method to examine theories that students built up and modelled about the floating and sinking unit in 3rd and 4th grades. Kang, Scharmann, Noh and Koh (2005) prepared animations on computers to show that size and weight would not be criteria for floating and sinking of an object. At the beginning of the research, students were given a text requiring explanations to get acquainted with their prior knowledge. Then, another text, including a dilemma situation, was applied to students. Eventually, animations were applied to students to evaluate the two situations. At the end of the study the researchers wanted students to write their beliefs about the subjects floating and sinking. Havu-Nuutinen (2005) examined effect of social argument and instructional process on conceptual change about floating and sinking concepts and benefitted from worksheets to examine conceptual change. Hardy et al. (2006) compared two different programs with the support of various instructional equipment in constructivist learning environments about the topics of floating and sinking. They examined the effects of instructional support within constructivist learning environments for elementary school students' understanding of floating and sinking. McGregor and Gunter (2006) prepared an in-service course for elementary school science teachers about floating and sinking concepts. They benefited from experimental activities prepared from foods and a Titanic simulation related to these foods.

When studies on CCT supported by other teaching methods and techniques to overcome the altenative conceptions are examined, it can be seen that there were not any studies on floating, and sinking concepts using different teaching methods and techniques. Analogies are mostly used with CCT (İpek & Çalık, 2008; Türk & Çalık, 2008; Ürey & Çalık, 2008; Kurnaz & Çalık, 2008). Concept maps (Uzuntiryaki & Geban, 2005; Taştan et al., 2008), discussion web strategies (Yenilmez & Tekkaya, 2006), computer animations (Sahin, Calik & Cepni, 2009; Özmen et al., 2009) and worksheets (İpek & Çalık, 2008; Türk & Çalık, 2008; Ürey & Çalık, 2008; Kurnaz & Çalık, 2008; Yin et al., 2008) are also prefered teaching methods and techniques used together with CCT. According to the related literature, using only one conceptual change method in teaching may bore students in the lessons. Using different teaching methods and techniques together with the 5E instructional model can be effective to provide conceptual change (Jacobson & Kozma, 2000 in cited Özmen et al., 2009; İpek & Çalık, 2008; Türk & Çalık, 2008; Ürey & Çalık, 2008; Kurnaz & Çalık, 2008; Yin et al., 2008; Özmen et al., 2009). When studies concerning floating and sinking concepts were examined, it is seen that worksheets (Havu-Nuutinen, 2005; Yin et al., 2008), simulations (Reid et al., 2003; Zhang et al., 2004; McGregor & Gunter, 2006), animations (Kang et al., 2005), experimental activities (Gürdal & Macaroğlu, 1997) and constructivist learning environments (Hardy et al., 2006), POE (Yin et al., 2008) are used separately. We prepared teaching material about floating and sinking based on the 5E instructional model with some supporting teaching methods and techniques like CCT, CC, worksheets, animation and POE. CCT used in this study was different from the ones found in the literature because at the beginning of CCT, scientific ideas were adopted into daily life situations, activities were presented as short texts with concept cartoons, and the text is supported with hands on activities and animations. Table I shows a literature summary of students' alternative conceptions concerning floating and sinking concepts (Rowell & Dawson, 1977; Strauss, Globerson & Mintz, 1983; Parker & Heywood, 2000; Macaroğlu Akgül & Şentürk, 2001; Reid et al., 2003; Zhang et al., 2004; Kang et al., 2005; Ünal & Coştu, 2005; Havu-Nuutinen, 2005; Özsevgeç & Çepni, 2006; Gearhart et al., 2006; Moore & Harrison, 2007; Joung, 2009).

Table I. *Alternative conceptions about floating and sinking concepts*

Alternative conceptions	Researchers
Small and light objects floats, heavy objects sink	Rowell & Dawson, 1977; Strauss et al., 1983; Kang et al., 2005.
Size of buoyancy force depends on volume and shape of the objects or just depends on the mass of the objects	Reid et al., 2003; Zhang et al., 2004.

Objects heavier than water sink	Özsevgeç & Çepni, 2006.
More gravity is applied to heavier objects	
Sinking of objects is related to their weight	Macaroğlu et al., 2001.
Sinking and floating is explained with objects shape, surface area, air containing, density, being weight and raw material	Parker & Heywood, 2000.
Hanging objects are accepted the same as sinking objects	Ünal & Coştu, 2005.
Floating or sinking of objects are just explained with only volume or weigh of the objects or volume of the liquids	
Density of the floating objects is higher than that of sinking and/or hanging objects	
Density of hanging objects is lower than that of liquids	
Buoyancy force effect on hanging object is more than weight of ebullient water.	
Density of hanging object is equal to that of floating object	
Objects with geometric shape floats, others sink	
When we make a hole in an object, it sinks	
Volume of the liquid effects buoyancy force of the sinking volume of objects. If the liquid is less, buoyancy force will have more effect on it (on the object?)	
When objects part keep afloat increased, buoyancy force also increases	
Floating and sinking concepts are explained with physical characteristics like heavy, light, big, small	Havu- Nuutinen, 2005.
Objects float because of the air in their structure	Moore & Harrison, 2007.
Objects float because it is made of floating object	
God floats the objects	
Boat wants to float so it floats	
Floating is just depends on the shape of objects	Gearhart et al., 2006.
When some part of an object is outside the water or river, it floats. And when all parts of an object is inside the water or a river, it sinks	Joung, 2009.

The theoretical framework of the study

In Turkey, the Science and Technology Education Program that is in accordance with constructivist approach was developed in 2004. Students' textbooks, workbooks and teachers' guidebooks were prepared according to the 5E instructional model. The definition of stages in the 5E instructional model, teaching methods and techniques used to support 5E instructional model are presented below.

5E instructional model

This model consists of five phases. Relevant literature describes the implementation of each phase of the 5E instructional model in teaching science concepts (Çepni, Akdeniz & Keser, 2000; Krantz, 2004; Wilder & Shuttleworth, 2005; Çalık, 2006; Özsevgeç, 2006; Saka, 2006; Özsevgeç, 2007; Orgill, & Thomas, 2007; Vincent, Cassel & Milligan, 2008; Er Nas, 2008) as:

1. *Engagement:* It includes drawing students' interest to the concept, revealing students' prior knowledge about the concept, making students aware of their own knowledge and querying their own knowledge about the concept. At this stage, students are not expected to express the correct concept. This stage is a warm up phase in which students become ready to learn.

2. *Exploration:* This is the most active phase for the students. Students try out their own knowledge, doing observations and gaining experiences about the concept. They freely work in groups. They try to explore scientific knowledge. Teachers' direct students to study in video, computer and library environments, and students are encouraged to solve problems**.**

3. *Explanation:* This is the most active phase for the teacher and includes students sharing and debating their own experiences with each other. Students are encouraged to compare their prior knowledge with observations and explain the relationship between the two. At this stage, teachers could benefit from such methods as computer software, flash animations, CCT, discussion, expression and video.

4. *Elaboration:* Students are encouraged to adapt the new knowledge they have acquired to different situations and to associate it into their daily life. Work sheets, model preparation and activities, including drawing and problem situations, complete the learning needs related to daily life to increase thinking skills. Questions are used to enhance the relationship between the concept and daily life. Moreover, at this stage students find answers to questions that are asked in order to motivate them at the "enter stage."

5. *Evaluation:* Students query new knowledge of concepts they have learned during the previous four stages and make an extraction. And, eventually, they assess their own improvement.

Teaching Methods and Techniques used to support 5E instructional model

Prediction- observation- explanation

The prediction-observation-explanation (POE) method is used in laboratory experiments to focus on students' concept learning and to facilitate presentation and order of the issue. Laboratory activities carried out by POE give students a chance to apply what they have already learned and allow generalizations of their own scientific knowledge to science subjects outside of the curriculum. The POE technique is used to deepen the understanding of the concept (White & Gunstone, 1992). Students are asked the originations of the events to motivate them to consider, and an opportunity is given to them to make observations. As a result of the predictions and observations made, students are asked to give explanations about the concept. In this context, the main underlying cause of students' thinking about the concept can be revealed (White & Gunstone, 1992; Köseoğlu, Tümay & Kavak, 2002).

Worksheet

Worksheets can be used for different purposes such as development of scientific process skills with laboratory activities (Havu-Nuutinen, 2005; Moore & Harrison, 2007; Yin et al., 2008; İpek & Çalık, 2008; Türk & Çalık, 2008; Kurnaz & Çalık, 2008; Şahin et al., 2009; Karslı & Şahin, 2009). Before the preparation of worksheets, their structure should be explicit. Situations such as pictures, images, cartoons, and current and interesting questions can be used to make worksheets interesting and eye-catching.

Conceptual Change Texts

A CCT is a text used to put the challenges between scientifically correct concepts and alternative concepts clearly and is used to support classroom activities and facilitate students learning (Chambers & Andre, 1997; Uzuntiryaki & Geban, 2005; Çaycı, 2007). What is intended with CCT is to correct students' prior knowledge or organize students' new knowledge. It is prepared to provide students to think that their existing knowledge is insufficient for explaining a new situation (Sevim, 2007). CCT started with a situation about common alternative conceptions. Students are asked to predict what will happen at the situation. Questions are used to activate students' alternative conceptions. Then general alternative conceptions are stated and the wrong parts of these alternative conceptions are explained. Students question their alternative conceptions and figure out lacking points in their knowledge. Dissatisfaction of students about their existing knowledge is expected. New and scientifically correct knowledge of the concept about the topic is presented with examples. Finally, teachers discuss the situations with the students to help them understand the scientific explanations (Chambers & Andre, 1997; Uzuntiryaki & Geban, 2005; Pınarbaşı, Canpolat, Bayrakçeken & Geban, 2006; Çaycı, 2007; Sevim, 2007).

Concept Cartoon

The concept cartoon (CC) is a teaching method used frequently in courses. Alternative concepts in science are as short texts with cartoon characters (Keogh, Naylor & Downing, 2003). CC are prepared as a poster and defined as an instructional material to support instruction (Kabapınar, 2005). Although a CC seems very simple, it has a complex structure. Scientific ideas are adapted into daily life situations with the help of CC. Trying to present every scientific situation that appears in daily life with a story is very difficult and takes more time. But this way, students have opportunities to compare their scientific knowledge with daily life situations (Keogh & Naylor, 1999a). Every cartoon should present different ideas for every situation (Keogh & Naylor, 1999a; Stephenson & Warwick, 2002; Clark, 2005). Text should have very small space in concept cartoons. Spaces should be left in speaking bubbles of concept cartoons to give opportunity to students to evaluate themselves (Keogh & Naylor, 1999a). CC could be prepared as homework for students (Keogh & Naylor, 1999a). It could also be prepared as worksheet (Kabapınar, 2005). Complex and abstract science concepts could be expressed simply by cartoons (Stephenson & Warwick, 2002; URL-1, 2005). Discussion about CC should be made on probable situations instead of theories (Keogh & Naylor, 1999b; Clark, 2005; Kabapınar, 2005), and should include general alternative conceptions and scientifically right ideas (Kabapınar, 2005; Clark, 2005). It is recommended that giving names to the cartoons and providing students to say their ideas with using cartoons names, so that students can explain their ideas more comfortably.

Animations

Animation is described as the motion of many pictures and figures in a scenario. It offers various opportunities to the educational environment. It facilitates understanding, and helps complex natural events be understood more clearly (Taş, 2006). It also gives an opportunity to students to see natural events that could not be taken into a classroom environment (Ayas, Yılmaz & Tekin, 2001). It gives an opportunity to do dangerous experiments in a computer environment confidently in a short amount time, to repeat the experiments (Sinclair, Renshaw & Taylor, 2004; Yılmaz & Saka, 2005), and give an opportunity to students to observe experiments virtually in the schools that do not have equipment required for the experiments (Yılmaz & Saka, 2005). It encourages students to be motivated and active during course time and increases students' interest towards science and technology (Yiğit & Akdeniz, 2003; Sinclair et al., 2004).

Purpose

The purpose of this study is to determine the influences of the prepared instructional material based on the 5E instructional model combined with CCT, CC, animations, worksheets and POE on conceptual changes about floating and sinking concepts.

Methodology

Method

In this study, the quasi-experimental research design consisting of an experimental group (EG) and a control group (CG) is used (Cohen & Manion, 1994; Çepni, 2007). Each group is given both a pretest and a posttest. In the study, a delayed posttest was also implemented to both CG and EG students in addition to the pretest and posttest. The same science teacher taught both groups. The EG is taught with teaching materials based on the 5E instructional model, prepared for the elementary school's 8th grade floating and sinking subject in the "Force and Motion" unit. These teaching materials are enriched with different teaching methods and techniques (POE, Worksheets, CCT, CC and Animations). The CG is taught with the existing textbook materials developed by the Ministry of Education based on the 5E instructional model of the constructivist theory. After the pilot study (240 min), implementation of the main research took 6 course hours (240 min).

The sample

48 students, 25 EG and 23 CG from the 8th grade students (14–15 years), formed the sample. Six groups, which were socially and economically similar to each other, were formed within the EG and CG. Students were selected according to their achievement scores from The Level Determination Exam (LDE). Experimental group (EG) students are coded as E1, E2, E3,….., E25. Control Group (CG) students are coded as C1, C2, C3,……, C23.

Data collection tool

Students' alternative conceptions, for both the EG and CG, were determined by using three two-tiered questions from the two-tiered Determining Differentiation in Conceptual Structure Test (DDCST) prepared by Şahin (2010). Its Cronbach's Alpha reliability coefficient is 0.81. These questions were applied to the sample as pretest, posttest and delayed posttest. The first-tier of each item consists of a content question having four choices; the second part of each item contains reasons for the answer given in the first-tier response. As a data-collecting tool, 3 two-tier questions were used in this study. The first question is asked to determine whether the study sample has the common alternative conceptions about floating and sinking from the literature. The second question is asked to examine students' ideas about the position of objects in the liquid related to the case of floating and sinking. The third question is asked to compare the density of subject with the density of the fluid for determining their conceptual structure related to buoyancy force with fluid density.

Data analyses

Researchers used different categories for evaluating students' levels of understanding (Abraham, Gryzybowski, Renner & Marek, 1992; Haidar & Abraham, 1991; Marek, 1986). Abraham et al. (1992), gave the final form to the understanding level categories often used in various studies such as "no understanding," "specific misconception," "partial understanding together with a specific misconception," "partial understanding" and "full understanding" categories and gave were given points 0, 1, 2, 3 and 4. These categories are based on and used in the subsequent studies (Çalık, Ayas & Coll, 2010; Özsevgeç, 2007).

In this study scoring categories created by Şahin (2010) are used to analyse the levels of differentiaon in conceptual structures. According to the scoring categories created by Şahin (2010), first stage of the two-tiered questions were analysed under three categories as a correct choice (CC), incorrect choice (IC) and empty (E). CC pointed as 5, IC pointed as 1 and E is pointed as 0. In order to distinguish the IC category from the E category, a 0 point is not given to the IC category. If students receive the IC category it doesn't mean that they do not know anything. In order to identify a significant difference between students choosing the CC and IC, 5 points are given to the CC category. At the beginning, 10 of the students' qualitative responds were examined and the emerged situations were regarded while analysing the qualitative responses of second phase of the two-tiered test of students. Then, categories like correct reason (CR), partial correct reason (PCR), reason including alternative concepts (RIAC), incorrect reason (IR) and unrelated reason/empty (UR) were established for students understanding level and were aligned and marked according to their importance. Categories used to analyse the second phase of two-tiered questions; their points and content were presented in Table II.

Table II. *The used categories for analyzing of two-tier questions, the points and index of the categories*

Understanding Level/ Abbreviation	Points	Index
Correct Reason / (CR)	10	Answers including all aspects of the validity reason
Partially Correct Reason / (PCR)	8	Answers don't include all aspects of the validity reason, just includes some aspect.
Reason Including Alternative Concept / (RIAC)	3	Answers including partially correct knowledge and misconceptions in the explanation.
Incorrect Reason / (IR)	2	Answers including incorrect knowledge.
Unrelated Reason / Empty (UR)	0	Answers including unrelated reason, Answers not showing the relationship with the question To avoid or write just the questions as answers.

Eleven categories scores, which were used in data analysis, were gathered by adding the points of the first and second stages of two-tiered questions. Expressing the reason for marking the first stage true or partly true is more important than just marking the correct choice; so CC, PCR, RIAC categories are in front of the IC category. As all the questions in the questionnaire were categorised in CC-CR category, the highest total points that students can take is (15x3) 45.

Statistical analyses were done after the data collected from the two-tiered questions were classified and marked. The non-parametric Wilcoxon Signed rank test for related samples and the Mann-Whitney U test for independent samples were used for data analyses. As two-tiered questions are a kind of classified scale, and the data doesn't show normal dispersion, the non-parametric analysing technique was used in this study (Özdamar, 2004).

Table III. *Categories, abbreviations and points used to classify students' answers*

Categories	Abbreviation	Points
Correct Choice - Correct Reason	CC- CR	15
Correct Choice - Partially Correct Reason	CC-PCR	13
Incorrect Choice - Correct Reason	IC-CR	11
Incorrect Choice - Partially Correct Reason	IC- PCR	9
Correct Choice - Reason Including Alternative Concept	CC- RIAC	8
Correct Choice - Incorrect Reason	CC- IR	7
Correct Choice - Unrelated Reason / Empty	CC- UR	5
Incorrect Choice -Reason Including Alternative Concept	IC-RIAC	4
Incorrect Choice - Incorrect Reason	IC-IR	3
Incorrect Choice - Unrelated Reason / Empty	IC-UR	1
Empty - Unrelated Reason / Empty	E-UR	0

Pilot study

A pilot study is conducted covering 30 8th grade elementary school students (six groups) and their science teachers. Applicability of the developed teacher guided material and instructional material was examined during the pilot study.

Researchers provided only technical support to the science teacher in the implementation process of the teaching materials.

Implementation of the study

Implementation process of the prepared material is given below in Figure 1.

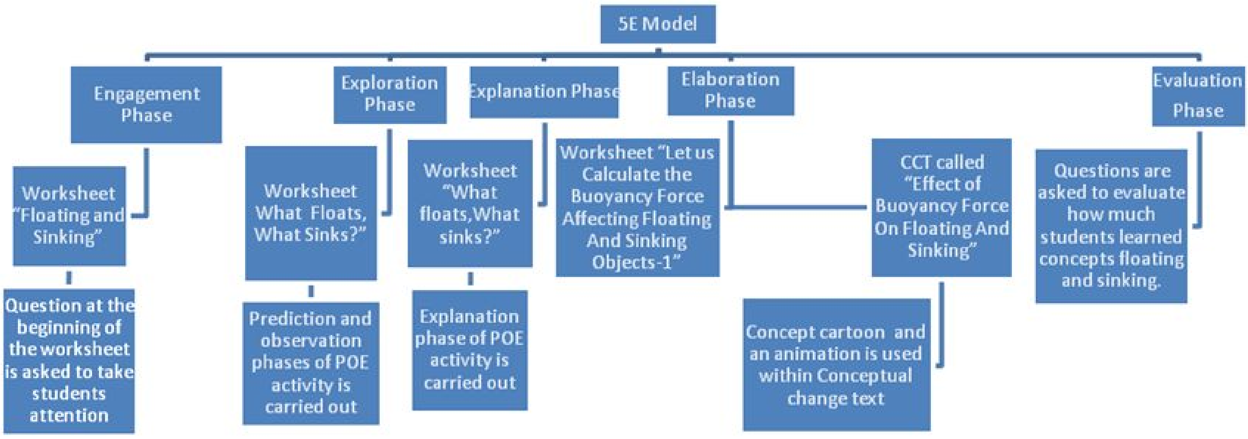

Figure 1.*Theoretical framework of the developed teaching material*

In this study, worksheets were prepared to implement activities in a certain order and were enriched with the teaching methods and techniques (CCT, CC, animations, worksheets and POE) for effective implementation of each phase of the 5E instructional model. Five worksheets were prepared. One worksheet is presented in Appendix 1. Teacher guided material containing a detailed explanation about the usage of the material applied in the study is given in Appendix 2. Animation screen views are given as an example in Appendix 3. The same science teacher did the applications to the both the EG and CG. The applications were completed in the same period and amount of time for both groups. The developing material according to the 5E instructional model enriched with different teaching methods and techniques was applied to the EG. The workbook and course book were prepared according to the 5E instructional model recognized by the Ministry of Education were applied to the CG.

Results

Data was collected from three open-ended questions and presented under the title "Quantitative Data" and "Qualitative Data." The flow chart of the data is given below (Figure 2).

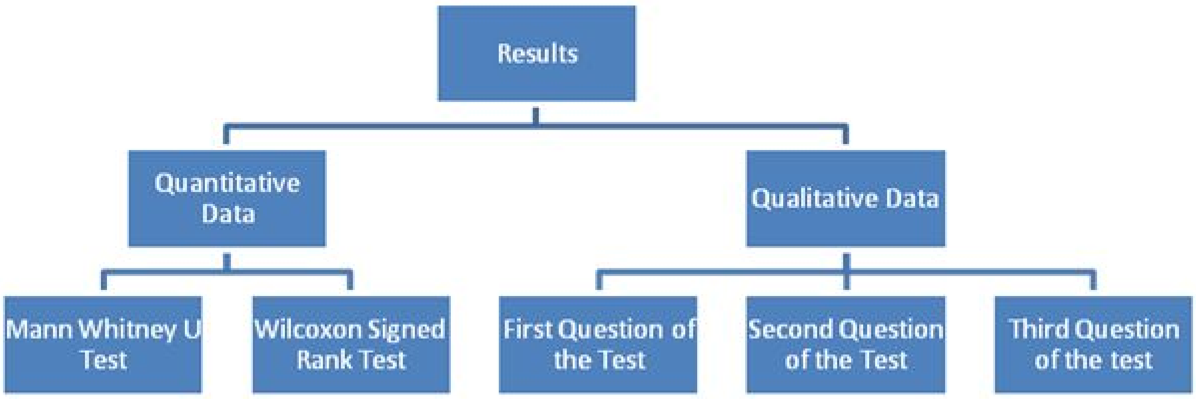

Figure 2. *Flowing chart of the data*

Quantitative data

The Mann Whitney U pretest results (Table IV) and Mann Whitney U posttest results were introduced (Table V).

Table IV. *Mann Whitney U pretest results*

Group	N	Mean Rank	Sum of Rank	U	p
Experiment	25	24.96	624.00	276.000	**0.812**
Control	23	24.00	552.00		

As can be seen from Table IV (U=276.000, $p > 0.05$), there is no significant difference between the EG and CG according to the pretest. The averages ordered of the EG and CG are closer to each other [E (24.96); C (24.00)].

Table V. *Mann Whitney U posttest results*

Group	N	Mean Rank	Sum of Ranks	U	p
Experiment	25	30.86	771.50	128.500	**0.001**

Control	23	17.59	404.50		

As can be seen from Table V (U=128.500, $p < 0.05$), there is a significant difference between the EG and the CG according to posttest. The EG and the CG average order has a significant difference in favor of EG [E (30.86), C (17.59)].

Table VI. *Mann Whitney U delayed post-test results*

Group	**N**	**Mean Rank**	**Sum of Ranks**	**U**	**p**
Experiment	25	33.06	826.00	73.500	**0.000**
Control	23	15.20	349.00		

As can be seen from Table VI (U=73.500, $p < 0.05$), there is a significant difference between the EG and CG according to delayed posttest. The EG and CG average order has a significant difference in favor of EG [E (33.06), C (15.20)].

In this section, Wilcoxon Signed Ranked Test results covering the CG (Table VII) and EG (Table IX) were presented.

Table VII. *Comparison of the CG Wilcoxon Signed Rank posttest and pretest*

Posttest- Pretest	**N**	**Mean rank**	**Sum of Ranks**	**z**	**p**
Negative Rank	10	9.80	98.00	-.262	.793
Positive Rank	10	11.20	112.00		
Ties	3				

* **Based on negative order**

As seen from Table VII (z= -.262, p> 0.05), there is no significant difference in favor of pre and posttest for the CG. When Table VII is examined, 10 students' pretest scores are higher than their posttest scores in the CG. Ten students' posttest scores are higher than their pretest scores. It is also seen that 3 student's pretest and posttest scores remained the same.

Table VIII. *Comparison of the CG with Wilcoxon Signed Rank delayed posttest and posttest*

Delayed posttest-Posttest	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	15	11.77	176.50	-1.625	.104
Positive Ranks	7	10.93	76.50		
Ties	1				

As it is seen in Table VIII (z= -1.625, p> .05), there is no a significant difference in favor of delayed posttest and posttest for the CG. When Table VIII is examined it is seen that 15 students' posttest scores are higher than their delayed posttest scores in the CG. Seven students' delayed posttest scores are higher than their posttest scores. It is also seen that 1 student's delayed posttest and posttest scores are same.

Table IX. *Comparison of the EG with Wilcoxon Signed Rank posttest and pretest*

Posttest - Pretest	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	3	5.17	15.50	-3.844	.000
Positive Ranks	21	13.55	284.50		
Ties	1				

*** Based on negative order**

As it is seen in Table IX (z= -3.844, p< .000), there is a significant difference in favor of the posttest for the EG. When Table IX is examined it is seen that 3 students' pretest scores are higher than their posttest scores in the EG. Twenty-one students' posttest scores are higher than their pretest scores. It is also seen that 1 student's pretest and posttest scores are same.

Table X. *Comparison of the EG with Wilcoxon Signed Rank posttest anad delayed posttest*

Delayed Posttest - Posttest	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	9	12.22	110.00	-.537	.592
Positive Ranks	13	11.00	143.00		
Ties	3				

*** Based on negative order**

As it is seen in Table X (z= -.537, p> .000), there is no a significant difference in favor of the delayed posttest and posttest for the EG. When Table X is examined it is seen that 13 students' delayed posttest scores are higher than their posttest scores in the EG. Nine students' posttest scores are higher than their delayed posttest scores. It is also seen that 3 students' delayed posttest and posttest scores are same.

Qualitative data

In this section, students' answers in pretest, posttest and delayed posttest are compared and given as figures.

Question 1:

I. A marble with 50 gr mass
II. A tray with 1000 gr mass
III. A square shaped bell jar with 100 gr mass

If we put the substances above into water, which one of the following is absolutely true about floating and sinking situations in water?
a) The tray with 1000gr mass sinks.
b) The square shaped bell jar with 100 gr mass floats.
c) The marble with 50 gr mass floats.
d) Nothing can be said about floating and sinking situation of substances in water.
* * It represents the correct answer of the question

Because: ……………………………………………………………

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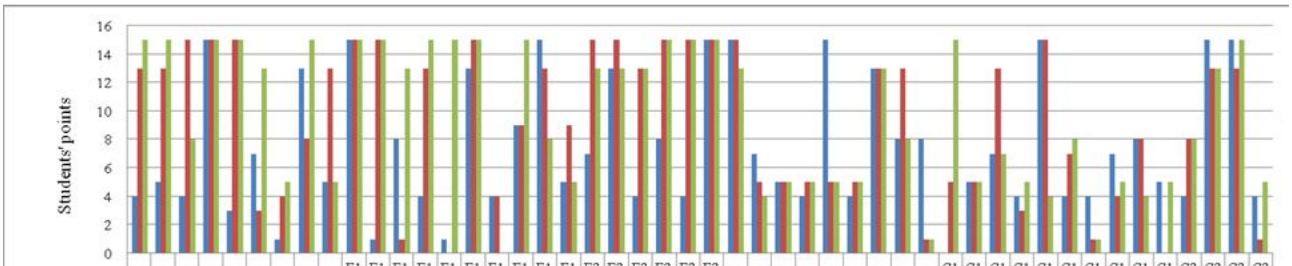

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25
Pre-test	4	5	4	15	3	7	1	13	5	15	1	8	4	1	13	4	9	15	5	7	13	4	8	4	15
Post-test	13	13	15	15	15	3	4	8	13	15	15	1	13	0	15	4	9	13	9	15	15	13	15	15	15
Delayed-test	15	15	8	15	15	13	5	15	5	15	15	13	15	15	15	0	15	8	5	13	13	13	15	15	15

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
Pre-test	15	7	5	4	15	4	13	8	8	0	5	7	4	15	4	4	7	8	5	4	15	15	4
Post-test	15	5	5	5	5	5	13	13	1	5	5	13	3	15	7	1	4	8	0	8	13	13	1
Delayed-test	13	4	5	5	5	5	13	8	1	15	5	7	5	4	8	1	5	4	5	8	13	15	5

Graph 1. *Students' pretest, posttest and delayed posttest results for question 1*

When Graph 1 is examined it is seen that 24% of the EG and 30% of the CG students are in IC-RIAC category. In the pretest, 16% of the EG and 21% of the CG students are in the CC-CR category. 75% of the EG students who have alternative concepts in the pretest remove them in posttest and moved to CC-CR category. None of the students in CG having alternative concept in pretest could move to CC-CR category in posttest. Only one of the students in the CG moved from the CC-RIAC to the CC-PCR category. When delayed posttest scores are examined, 56% of the EG and 8% of the CG students are in the CC-CR category. Figure 1 shows that the students from the EG, numbered E1, E13, E23 and E24, have alternative conceptions in pretest; then they removed their alternative concepts and moved to the CC-CR category in the delayed-posttest. In the pretest, E13 said, "There is air inside of a bell jar; this air applies buoyancy force to the bell jar." In the delayed posttest, E13 removed the alternative conception and marked the choice "nothing can be said about floating and sinking situation of substances in water" and said, "Substances density should be given." E3 has an alternative conception in the pretest that the "mass of [a] tray is more than mass of water so it sinks." Then E3 moved to the CC-CR category in the posttest but turned back to the alternative conception at the delayed posttest. E3 said, "It is not possible to say something since the mass of water is not given." None of the CG students that had alternative cocncepts in the pretest moved to the CC-CR category at delayed posttest. Students C8, C15, C18 and C20 had alternative conceptions in the pretest and they remained during the delayed posttest. C4, C6, C13 and C23 students had alternative conceptions in pretest, and then in delayed posttest they choose the correct choice, but could not explain any reasons for their choices. C14 is in

CC-CR category in pretest and explains his reason as the "Density of these objects could not be known. To know the density of these objects also their volumes should be given." But in delayed posttest C14 moved to IC-RIAC category and explained the reason by saying, "As the mass of tray is more, it sinks."

Question 2: When a student puts an egg into water it sinks. What should the student do for the egg to float in the water?

a) Add water into the container
b) Solve a very big amount of salt in water*
c) Add olive oil into the water
d) Vaporize some of the water
Because: ……………………………………………………………………..

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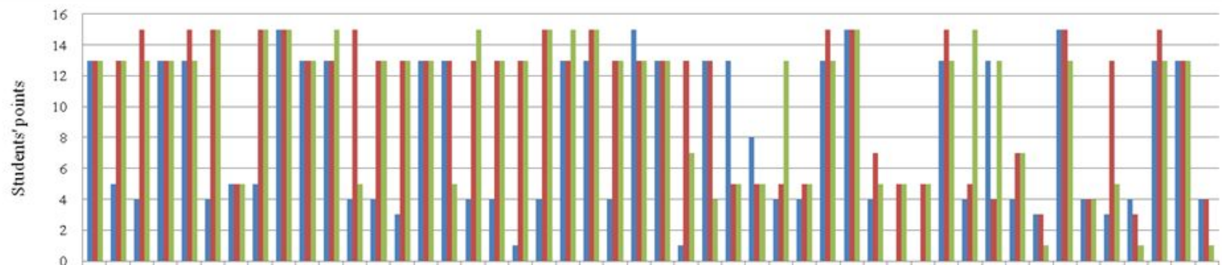


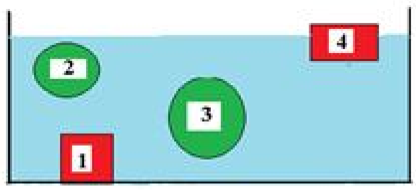
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25
Pre-test	13	5	4	13	13	4	5	5	15	13	13	4	4	3	13	13	4	4	1	4	13	13	4	15	13
Post- test	13	13	15	13	15	15	5	15	15	13	13	15	13	13	13	13	13	13	13	15	13	15	13	13	13
Delayed-test	13	13	13	13	13	15	5	15	15	13	15	5	13	13	13	5	15	13	13	15	15	15	13	13	13

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
Pre-test	1	13	13	8	4	4	13	15	4	0	0	13	4	13	4	3	15	4	3	4	13	13	4
Post- test	13	13	5	5	5	5	15	15	7	5	5	15	5	4	7	3	15	4	13	3	15	13	4
Delayed-test	7	4	5	5	13	5	13	15	5	5	5	13	15	13	7	1	13	4	5	1	13	13	1

Graph 2. *Students' pretest, posttest and delayed posttest results for question 2*

When Graph 2 is examined it is seen that eight students from the EG and eight students from the CG are in the IC-RIAC category. Although in the EG 4 students passed from the IC-RIAC category to the CC-CR category in posttest, but none of the students in this category are in the CG. EG students have misconceptions in the pretest also pass to the CC-PCR category in posttest. When the EG and CG students delayed posttest results are examined, it is seen that eight students are in the CC-CR; fourteen students are in the CC-PCR category from the EG, two students are in the CC-CR category and 7 students are in the CC-PCR category from the CG. When we examined Figure 2, we saw that students from the EG numbered E3, E6, E13, E17, E18, E20 and E23 have alternative conceptions in pretest then they removed their alternative concepts and moved to the CC-CR category in delayed posttest. In the pretest, E3 said "The mass of a sinked egg is more than the mass of water. When water is added the mass of the egg becomes less than the mass of water so it floats." She removed her alternative concept in delayed posttest and said, "When we add salt, the density of the water increases so buoyancy force also increases." C5, C6, C9, C13, C15, C18, C20 and C23 students from CG have alternative conceptions in pretest, only C13 codded student has an alternative concept in pretest finally moved to the CC-CR category in the delayed posttest. The C2 coded student is in the CC-PCR category in both the pretest and posttest, but moved to IC-RIAC category in the delayed posttest. She explained her reason as "When oil is going to the top of water it can hold it." C18 coded student has an alternative concept of "when we put water it floats" in the pretest and could not remove his alternative concept in delayed posttest, too.

Question 3: In the figure, objects numbered 1, 2, 3 and 4 are in a balance in the water. Accordingly which statements given below are correct?



I. Just the object numbered 4 is floating in water.
II. Objects numbered 1, 2 and 3 are sinking in water.
III. Objects numbered 2, 3 and 4 are floating in water.

a) Only I   b) I and II   c) Only III *   d) I, II and III

Because: …………………………………………………………………..

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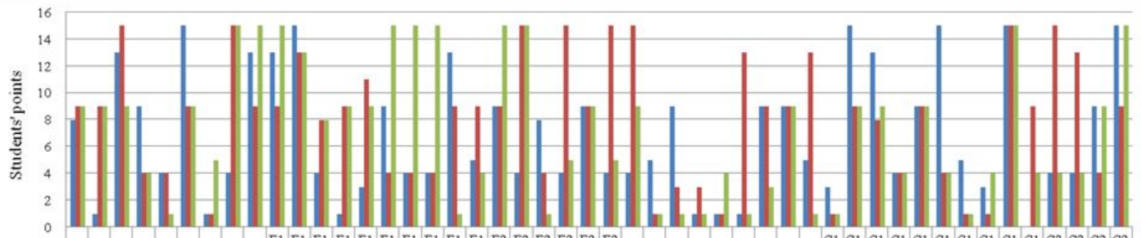

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25
Pre-test	8	1	13	9	4	15	1	4	13	13	15	4	1	3	9	4	4	13	5	9	4	8	4	9	4
Post- test	9	9	15	4	4	9	1	15	9	9	13	8	9	11	4	4	4	9	9	9	15	4	15	9	15
Delayed-test	9	9	9	4	1	9	5	15	15	15	13	8	9	9	15	15	15	1	4	15	15	1	5	9	5

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
Pre-test	4	5	9	1	1	1	9	9	5	3	15	13	4	9	15	5	3	15	0	4	4	9	15
Post- test	15	1	3	3	1	13	9	9	13	1	9	8	4	9	4	1	1	15	9	15	13	4	9
Delayed-test	9	1	1	1	4	1	3	9	1	1	9	9	4	9	4	1	4	15	4	4	4	9	15

Graph 3. *Students' pretest, posttest and delayed posttest results for question 3*

When Graph 3 is examined it has seen that eight EG students in pretest are in the IC-RIAC category and four CG students are in the IC-RIAC category in pretest. In posttest, only three students from the IC-RIAC category had a conceptual change and passed through to the CC-CR category. Eight students from the EG and 2 students from the CG pass through to the CC-CR category in delayed posttest. When we examined Figure 3, we saw that students from the EG numbered E8, E16, E17 and E21 have alternative conceptions in the pretest, and then they removed their alternative concepts and moved to the CC-CR category in the delayed posttest. E12, E16, E17, E21, E22 and E25 assess being under water as sinking in the pretest. E16 and E17 continued this idea in posttest, but in delayed posttest they removed their alternative conception and moved to the CC-CR category. E12 and E22 continued to have their alternative conceptions through the pretest and delayed posttest. E12 explained his idea as "2, 3 and 4 float in water, and water applies buoyancy force on them." She thought that buoyancy force does not effect sinking objects. None of the CG students that had alternative conceptions in pretest moved to the CC-CR category in delayed posttest. Although student C15 was in the CC-CR category and did not have any alternative conceptions in pretest, the student moved to the IC-RIAC category in delayed posttest. She explained her reason as, "Object number 4 is floating above the water. Objects numbered 1, 2 and 3 are inside of the water so they sink." Students coded C13, C20 and C21 had an alternative conception in the pretest and in the delayed posttest, too.

Discussion and conclusion

The purpose of this study was to investigate the influences of the prepared instructional material based on the 5E instructional model combined with CCT, CC, animations, worksheets and POE on changing alternative concepts of students about floating and sinking concepts.

Quantitative analyses were done in order to find whether there is a significant difference between the EG and the CG pretest, posttest and delayed posttest results. As seen from Table IV, there is no significant difference between the EG and the CG according to pretest results. Average order of the EG and the CG were closer to each other [U= 276.000, p>0, 05]. This shows that the EG and CG has similar backgrounds on floating and sinking concepts. After the implementation of the material, when the posttest results were examined, significant difference was found in favor of the EG [U= 128.500, p<0.05]. This means that the material based on the

5E instructional model enriched with different teaching methods and techniques like POE, worksheets, CCT, CC and animation activities has a more positive effect on concept learning of floating and sinking concepts than the existing material based on the 5E instructional model implemented by the Ministry of Education. Also, when the delayed posttest results were examined, a significant difference was seen in favor of the EG [U= 73.500, $p<0.05$]. Using different teaching methods and techniques together in an instruction is more effective than traditional learning in removing students' alternative conceptions (Reid et al., 2003; Havu-Nuutinen, 2005; Hardy et al., 2006; İpek & Çalık, 2008; Yin et al., 2008; Özmen et al., 2009). It could be concluded that using instructional material enriched by different teaching methods and techniques has a positive influence on the permanence of learning.

When the results of Wilcoxon signed rank test for the CG are examined, it is seen that there is no significant difference in favor of the pretest, posttest and delayed posttest results for the CG. When Table VII is examined, it has seen that 10 students' pretest scores are higher than their posttest scores, and 10 students' posttest scores are higher than their pretest scores in the CG. However, when results of the EG are examined it is seen that there is a significant difference in favor of posttest results for the EG. When Table IX is examined, 3 students' pretest scores are higher than their posttest scores in the EG. Twenty-one students' posttest scores are higher than their pretest scores. Since the posttest results of the EG are better than the CG, we could conclude that educational materials have an important effect on the EG students' conceptual development about floating and sinking more than the existing material in the textbooks. In other words, it can be said that results of Wilcoxon signed ranked test is consistent with the result of Mann Whitney U test. Also, when the delayed posttest results for the EG and the CG students were compared, students in the EG perform more permanent learning than students in the CG.

Figure 1, 2 and 3 show that students in the EG removed their alternative conceptions and most of them moved to the CC-CR category in the delayed posttest. But not many of the CG students moved to the CC-CR category in delayed posttest. This also shows the effect of instructional material embedded with different teaching techniques through the existing one (Çalık, 2006; Özmen et al., 2009).

Figure 1, 2 and 3 show that most of the students in the CG have not moved their alternative concepts in the posttest, although the EG students moved their alternative concepts in the posttest.

From these findings, we can conclude that instructional materials enriched with different techniques could be effective in removing alternative conceptions and providing conceptual change more than the existing material. Although we used the 5E instructional model enriched with different teaching methods and techniques for the EG, we were not fully successful in removing all of the alternative concepts for all students (Çepni et al., 2006). For example, students in both the EG and CG could not remove their alternative conceptions like "objects inside of water are sunk, because floating means to be above of water," and "heavy objects always sink." There are well known reasons for not removing alternative conceptions fully. Concepts could be too abstract for the level of students (Başer & Çataloğlu, 2005), the nature of the concept is resistant to change (Fisher, 1985; Çalık, 2006) and the concept has a hierarchical structure.

Although every teaching methods and technique is useful in teaching and learning science, each one has some defects (Carlton, 1999; Keleş & Çepni, 2006). Using a single teaching methods and technique could not always provide conceptual change if students alternative conceptions were resistant to change (Keleş & Çepni, 2006). We used the 5E instructional model enriched with different teaching methods and techniques to overcome these weaknesses. We were successful to some extent in removing alternative conceptions in the EG in comparison with the CG. We can conclude that using different teaching methods and techniques together has a positive influence in removing some alternative conceptions.

Students sometimes have problems in constructing abstract and hierarchical concepts in their minds because it is difficult to know sub-concepts, which will build a base on the related concept, and to build relationships between the concepts and to understand the nature of an abstract concept (Rowell & Dawson, 1977; Sere, 1982; Snir, 1991; Macaroğlu Akgül & Şentürk, 2001; She, 2002; Grotzer, 2003; Kawasaki et al., 2004; She, 2005; Özsevgeç & Çepni, 2006). To learn floating and sinking concepts, at first students should construct the concept of density in their minds. Before understanding the density concept, students have to construct the particular structure of the subject (Strauss et al., 1983; Grotzer, 2003).

Also, it is known that perfect learning sometimes does not occur although a perfect teaching has been executed (Bodner, 1990), as every student perceives in a different way. Although the material was very effective for some of the students to remove their alternative conceptions, it was ineffective in removing some of them (Thorley, 1990; Duit & Treagust, 2003). These conceptions are called hardcore in the related literature. Aypay, Erdoğan and Sözer (2007) suggest that the teacher-centered instruction model should be tried to remove the hardcore alternative conceptions because maybe the difficulty of removing the alternative conception comes from the nature of the concept and Turkish students were familiar with teacher-centered instruction.

Therefore, to have efficient results in conceptual change studies, it is becoming important to use different teaching and learning activities and presenting alternative teaching materials.

Suggestions

1. Because of the time and equipment problems, teachers are not able to do all of the activities. With animations all activities can be easily done. We noticed that some more animations could be made to support the learning of the topics floating, sinking and buoyancy force.

2. Although teaching in both groups is done according to the 5E instructional model, there is a significant difference in favor of the EG. This shows that instructional material based on the 5E instructional model combined with different teaching methods and techniques is more effective than the current instructional material, which is also based on the 5E instructional model. So, more instructional activities about science concepts, including different teaching methods and techniques, should be prepared. These materials should be applied and their effects on removing alternative conceptions should be determined.

3. We used different teaching methods and techniques together in this study. But we do not know exactly which technique mostly removed students' alternative conceptions and in what stage of the 5E instructional model. It means we have not collected enough data in the implementation process of the materials. We just collected data and came to a conclusion from the pretest and posttest data.

4. We know that every student learns in a different way or has different attitudes towards different techniques. When we use many techniques in one lesson, the diversity of students' attention and motivation towards lessons could be increased. In this way individual difference is also taken into consideration.

5. In order to learn floating, sinking and buoyancy force concepts meaningfully; volume, density and mass concepts should be learned initially. Thus, volume, density and mass concepts should be taught and understood before the floating, sinking and buoyancy concepts are presented. Relationships between mass, volume and density should be taught with more animations and experiments explaining the changing of volumes of similar and different subjects.

6. The teacher-centered approach should not be rejected completely. If alternative concepts could not be removed by using all the up-to-date teaching methods and techniques, then the teacher-centered approach should be put into practice.

7. Activities that work should be prepared so that teachers have chance to select the appropriate level for his/her students and more support (equipment, activity books, guide books, interdisciplinary support by other colleagues) should be given to teachers to apply them so most teachers attention will be drawn into meaningful science teaching.

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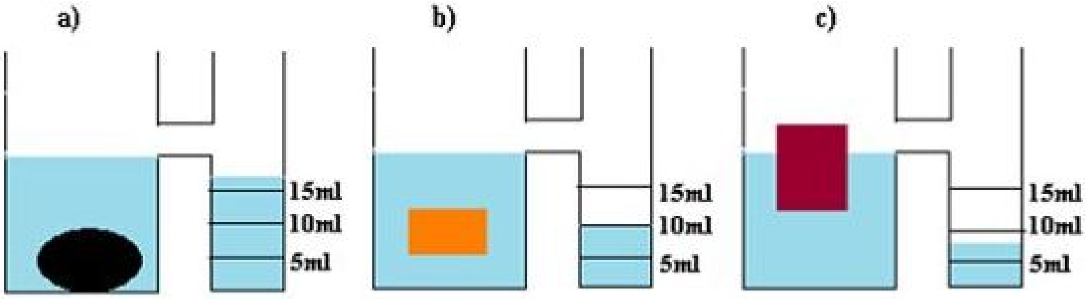
Appendix

Appendix 1

LET'S CALCULATE BUOYANCY FORCE EFFECTED FLOATING AND SINKING OBJECTS- I



➤ In above a, b and c choices, different objects are standing in water. Which of the subjects do you think water applies more buoyancy force? Write down your estimates

....

Do the following acivity to control your estimate.

Activity 7: Relationship between buoyancy force and weight of brimming liquid

Equipments: 2 N weight, water, dynamometer, graduated cylinder (250 ml).

How to do?

1. Put 150 ml water into a graduated cylinder.
2. Measure objects weight in air with a dynamometer.
3. Entire all the object into water filled graduated cylinder and measure its weight in water with dynamometer. Write your measuring value into Table 8 (do not touch the object to the side and bottom of the graduated cylinder)
4. Calculate buoyancy force that water applied to object.
5. Determine the amount of liquid rising in graduated cylinder when the object is in water and write to Table 8.

Table 8. Relationship between buoyancy force and amount of drimming water

Objects weight in air (N)	Objects weight in water (N)	Buoyancy force (N)	Amount of water rising in graduated cylinder (ml)

6. Explain the relationship between the buoyancy force on objects and weight of rising water in graduated cylinder with benefiting the data obtained from experiment.
....
....

Appendix 2

1. The worksheet called "Let's Calculate the Buoyancy Force Effecting Floating and Sinking Objects–I" is given to students. The purpose of these activities is to establish the relationship between buoyancy force and the amount of liquid brimming over the object.

2. Let students complete "Activity 7."

3. At the end of Activity 7 students are expected to make a generalization like "buoyancy force affected on an object is equal to the weight of water that it causes to overflow." Note: As the Formula W=m.g was not given to students, you should calculate the weight of water rising in graduated cylinder in Newton's terms. For example, the weight of 20 ml is equal to 0.2 Newton.

4. Students are also expected to respond to the question at the beginning of the worksheet. The answer to the question must be "more buoyancy force will effect on object" found in choice A because the object in this bucket cause to overflow more water. Objects cause an overflow equal to their volume. As the buoyancy force effecting an object is related to the volume of the objects sinking in water, more buoyancy force is effecting choice A.

5. Give students the worksheet called "Let's Calculate the Buoyancy Force Effecting Floating and Sinking Objects–II." The aim of this worksheet is to establish the relationship between buoyancy force and equilibrium condition of the object. Students are expected to make a conclusion like "objects should be hanging or floating with leaving some part of itself at the surface of water in equilibrium condition."

6. Note: Students think hanging is a different situation then floating. An emphasis should be put on hanging is also a floating situation.

7. Students should do Activity 8 to understand this situation clearly.

Appendix 3

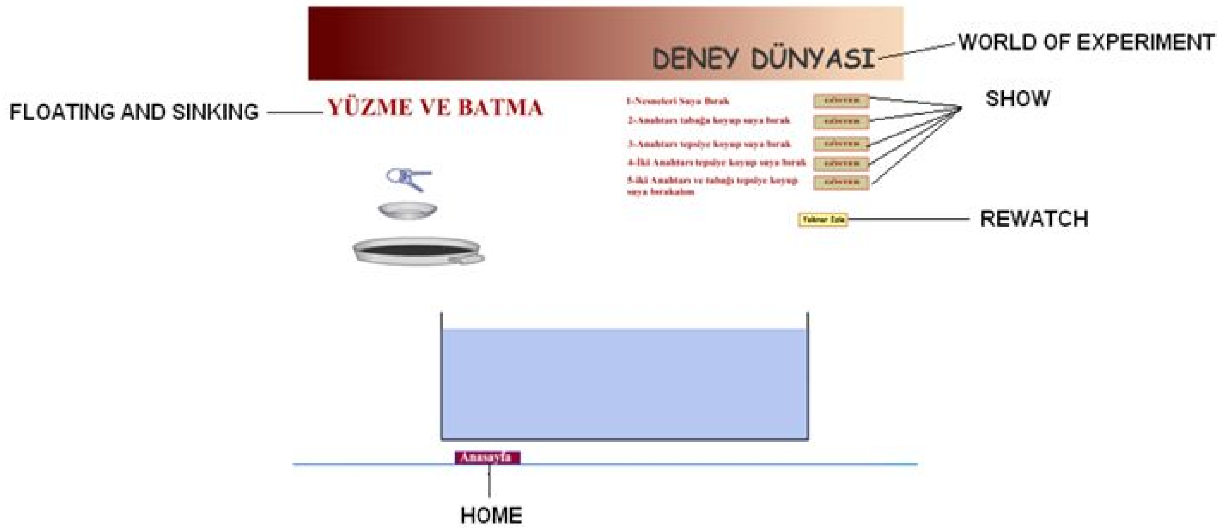


Figure 3. Animation screen called “Floating and sinking”

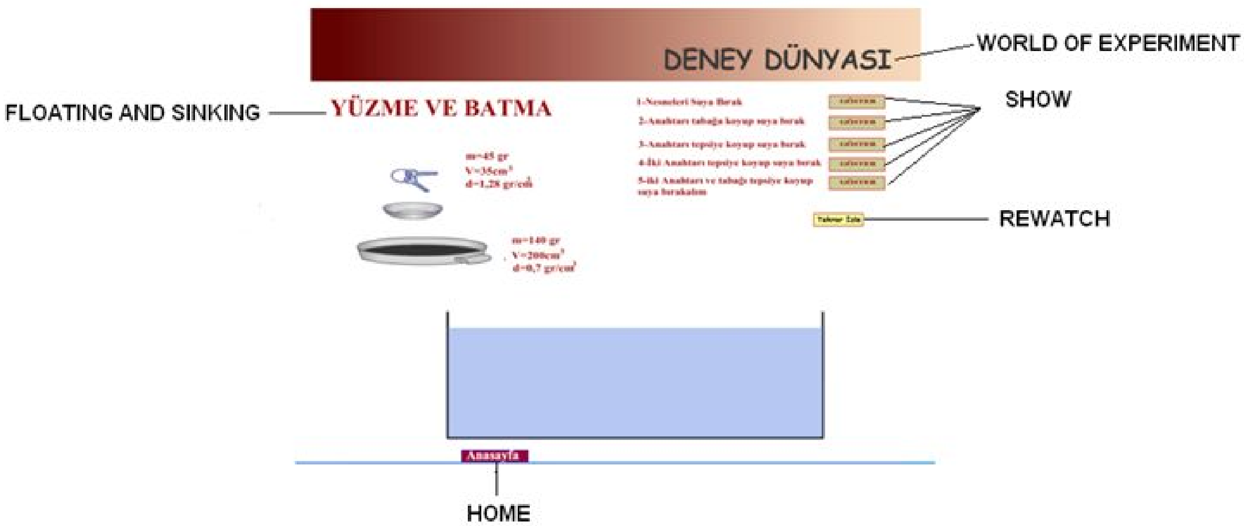


Figure 4. Animation screen called “Floating and sinking” (when you see objects mass, volume and density)

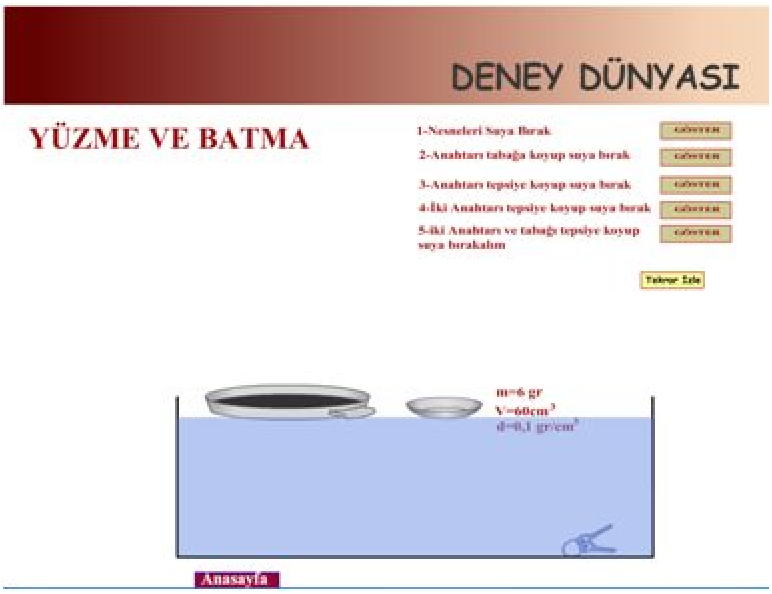


Figure 5. Animation screen about situations of key, plate and tray