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Effect of Different Teaching Methods and Techniques Embedded in the 5E Instructional Model on Students' Learning about Buoyancy Force

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Abstract

The purpose of this study is to investigate the effectiveness of developed instructional material based on the 5E instructional model which is enriched with various teaching methods and techniques for students' learning of the buoyancy force concept. The teaching strategy based on the 5E instructional model is derived from a constructivist view of learning. The sample group consisting of forty-eight students (Control Group=23; Experiment Group=25) is selected from two different eighth grade classes in Giresun, Turkey. Four two-tier questions are used to collect data, and data are analyzed both qualitatively and quantitatively. The findings suggest that using different teaching methods and techniques embedded in the 5E instructional model enables students to remedy some misconceptions about the buoyancy force, but does not completely eliminate them.

Keywords: Elementary education, the 5E instructional model, teaching methods and techniques, the buoyancy force.

Introduction

Learning is a complex concept. There is not any law of learning. Many philosophers tried to explain some questions about learning, such as how learning occurs. As a parallel to these questions, Jean Piaget, Jerome Bruner and David Ausubel put forward some learning theories: cognitive development, meaningful learning and learning through discovery (Ayas et al., 2007). However, to explain learning philosophers put forward different learning approaches and theories. One of the approaches is the conceptual change approach. The conceptual change approach is based on the studies of Piaget and Zeitgeist, and it has been developed by Posner, Strike, Hewson, and Gertzog (1982) (cited by: Chambers & Andre, 1997). The conceptual change model came out in 1980 to enlighten the role of students' previous knowledge of their own learning (Thorley, 1990). Conceptual change requires the arrangement of learning activities necessary for students to construct their own learning (Biemans & Simons, 1995). The conceptual change approach has been studied in literature with the aim of getting conceptual change in to students' learning. In these studies, some materials based on conceptual change strategy include conceptual change text (Alparslan, Tekkaya & Geban, 2003; Chambers & Andre, 1997; Çakır, Uzuntiryaki & Geban, 2002; Çalık, 2006; Geban & Bayır, 2000; Köse, 2004; Tekkaya, 2003), refutational text (Palmer, 2003), computer supported teaching (Biemans & Simons, 1995; Talib, Matthews & Secombe, 2005; Tao & Gunstone, 1999; Windschitl, 2001), demonstration experiment (Gedik, Geban & Ertepınar, 2002), analogy (Çalık, 2006) are mostly used. Researchers point out that although

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students' misconceptions cannot be remedied completely with the conceptual change approach; this approach is useful in reducing the effects of misconceptions and preventing new ones from arising (Çalık, 2006; Duit & Treagust, 2003; Gedik et al., 2002; Windschitl, 2001). Also, researchers see a benefit from the 5E instructional model, which is one of the constructivist learning approach models, to get conceptual change. Studies clearly show that the 5E instructional model is highly appropriate for getting conceptual change in the teaching of science concepts (Kurnaz & Çalık, 2008; Sahin, Calik & Cepni, 2009; Türk & Çalık, 2008; Ürey & Çalık, 2008).

Since students' misconceptions are not completely remedied by means of only one conceptual change method, the researchers assume that using different conceptual change methods embedded in the 5E instructional model together will not only be more effective in enhancing students' conceptual understanding, but also it may eliminate most of students' misconceptions (Çalik, Okur & Taylor, 2010; Sahin et al., 2009). In these studies about the 5E instructional model, it is suggested that teacher and student guide materials should be developed and different teaching methods and techniques embedded in the 5E instructional model should be used (Brown, 2006; Orgill & Thomas, 2007; Sahin et al., 2009; Wilder & Shuttleworth, 2005). In parallel with this case, researchers have examined the effect of these materials on students' achievement and conceptual change (Cardak, Dikmenli & Saritas, 2008; Fazelian, Naveh Ebrahim & Soraghi, 2010; Stephen & Huziak-Clari, 2007; Şahin, 2010; Tural, Akdeniz & Alev, 2010; Ural Keleş, 2009; Vincent, Cassel & Milligan, 2008). When these studies are considered, it is seen that there is no conceptual change study based on the 5E instructional model related with the buoyancy force concept at the elementary 8^{th} grade.

One of the abstract science concepts students have trouble understanding is the buoyancy force. The buoyancy force is a hierarchical concept that requires relating mass-volume-density concepts with each other (She, 2002, 2005; Ünal & Coştu, 2005). While teaching the buoyancy force concept, it must be known that buoyancy force is related with the submerged volume of the object in liquid or gas. The buoyancy force is related to unbalanced and balanced forces. Additionally, students are supposed to relate the buoyancy force concept with the weight of displaced liquid (Joung, 2009; Moore & Harrison, 2007; She, 2002, 2005). As seen in instructional sets, buoyancy force requires a mental struggle. It can be said that it is a great contribution to develop instructional materials including instructional sets mentioned above in order to teach the buoyancy force concept. Taking individual differences into account is important to eliminate students' misconceptions and provide meaningful learning (Lamanauskas, Bilbokaite & Gedrovics, 2010; She, 2005) due to the fact that each student has a unique learning style (Çalik et al., 2010; Lamanauskas et al., 2010; Raghavan, Sartoris & Glaser, 1998; She, 2005; Tytler, 1998b; Uğur, Akkoyunlu & Kurbanoğlu, 2009). Even if teaching is effective, students could learn as much as they perceive (Bodner, 1990). In this respect, it can be said that teaching materials accounting for as many individual differences as possible are very important for science education.

In conclusion, this study has much to contribute to science education literature. This paper reports on an investigation of the effectiveness of the intervention using different teaching methods and techniques within the 5E instructional model for teaching the buoyancy force concept.

Theoretical Basis of the Study

The 5E instructional model

The 5E instructional model is one of the models of the constructivist learning approach. The 5E instructional model consists of five phases. Relevant literature describes the implementation of each phase of the 5E instructional model in teaching science concepts given below (Goldston, Day, Sundberg & Dantzler, 2010; Hanuscin & Lee, 2008; Krantz, & Barrow, 2006; Krantz, 2004; Liu, Peng, Wu & Lin, 2009; Orgill & Thomas, 2007; Özsevgeç, 2006; Vincent et al., 2008; Wilder & Shuttleworth, 2005).

First Phase 'Engage': It includes attracting students' interest to the concept, revealing students' pre-knowledge about the concept and making students aware of their own knowledge and querying them 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.

Second Phase 'Explore': Students test their own knowledge by doing observations and gaining experiences about the concept. They work in groups. They try to explore scientific knowledge. Teacher directs students to study with video, computer, and in library environments and students are encouraged to solve problems**.**

Third Phase 'Explain': This phase is the teachers' most active phase and it includes students sharing and debating their experiences with each other. Students are encouraged to compare their prior knowledge with observations and explain the relationship between them. At this stage, teachers could benefit from using methods such as computer software, flash animations, Conceptual Change Text (CCT), argumentation, expression, and video.

Fourth Phase 'Elaborate': Students are encouraged to adapt new knowledge they have acquired in previous phases to different situations and to associate it with their daily life. Work sheets, model preparation, activities including drawing, problem situations and questions related to daily life are used to enhance the relationship between the concept and daily life. Moreover, at this stage students find answers to the questions which are asked to motivate them at the "enter" stage.

Fifth Phase 'Evaluate': Students query new knowledge of the concept they have learned in the previous four stages and make an extraction. And, eventually, they assess their own improvement.

Teaching Methods and Techniques Embedded in the 5E Instructional Model

Predict-Observe-Explain

The Predict-Observe-Explain (POE) method is used in laboratory experiments to focus on students' conceptual learning, facilitate presentation and arrange the sequence of the topic. The POE technique is used to probe the understanding of the concept (White & Gunstone, 1992). Students are asked about the origins of the events in order to motivate them to focus on the topic. Students are then given an opportunity to make some observations. As a result of the predictions and observations, students give explanations about the concept (Sheppart, 2006; White & Gunstone, 1992).

Worksheet

A worksheet is an instructional material which is suitable with any learning approaches such as constructivist learning approach, conceptual change approach etc. When literature is examined, it is seen that different worksheets have been developed about various science concepts (Çalık, 2006; Havu-Nuutinen, 2005; İpek & Çalık, 2008; Karslı & Şahin, 2009; Kurnaz & Çalık, 2008; Moore & Harrison, 2007; Sahin et al., 2009; Şahin, 2010; Türk & Çalık, 2008; Tytler, 1998a; Ürey & Çalık, 2008; Ünal, 2005; Yin, Tomita & Shavelson, 2008). Worksheets can be used for different purposes, such as development of scientific process skills with laboratory activities (Karslı & Şahin, 2009). Before the preparation of worksheets, their structure should be determined explicitly. Pictures, images, cartoons, and interesting daily life questions can be used to make worksheets interesting and eye-catching.

Worksheets have been preferred in educational research for presenting the activities based on the 5E instructional model in a good sequence. Also, even if students are highly affected by computer animations, they may lose their motivation over time. Therefore, worksheets are used to make computer animations more effective and to provide the continuity of students' interest (Bayrak & Doğan, 2009).

Conceptual Change Text

The Conceptual Change Text (CCT) is an instructional material which is suitable with conceptual change approach. The CCT is preferred to provide conceptual change in various studies. The CCT is effective in overcoming students' alternative conceptions because it activates the students' misconceptions, presents common misconceptions, and tries make the learner comprehend explanations that are scientifically accepted. Reasons for misconceptions are explained plausibly in the CCT (Çalık, 2006; Köse, 2007; Özmen, 2008; Özmen, Demircioğlu & Demircioğlu, 2009). The activities in which CCT is often used are based on the 5E instructional model (Çepni, Şahin & İpek, 2010; Şahin, 2010; Ural Keleş, 2009). When the studies of the CCT are examined, the research topics of the CCT are "osmosis and diffusion" (Köse, 2007), "solutions" (Çalık, 2006; Pınarbaşı, Canpolat, Bayrakçeken & Geban, 2006), "chemical bonding" (Özmen, 2008; Özmen et al., 2009), "electricity" (Chambers & Andre, 1997; İpek & Çalık, 2008), "electrochemical cells" (Yürük, 2007), "cell" (Ürey & Çalık, 2008), "endothermic- exothermic reactions" (Türk & Çalık, 2008), "heat and temperature" (Kurnaz & Çalık, 2008), "work, power, energy" (Cerit Berber & Sarı, 2009), "Let's classify livings" (Ural Keleş, 2009), "gas pressure" (Şahin & Çepni, 2011) and "liquid pressure" (Şahin, İpek & Çepni, 2010). But there is no research topic relating the CCT with the buoyancy force concept. Also, in the literature it has been determined that the CCT is effective when the CCT is used together with computer animations (Özmen, 2008; Özmen et al., 2009; Şahin & Çepni, 2011; Şahin et al., 2010). In this study, the computer-supported the CCT was used.

Concept Cartoons

Concept cartoons use alternative concepts in science by introducing them as short texts with cartoon characters (Keogh, Naylor & Downing, 2003). Concept cartoons can be prepared as posters and defined as instructional materials to support instruction (Kabapınar, 2005). Each cartoon should present different ideas for each situation (Clark, 2005; Keogh & Naylor, 1999; Stephenson & Warwick, 2002). Concept cartoons should include general misconceptions and also scientifically right ideas (Clark, 2005; Kabapınar, 2005). It is recommended that giving names to the cartoon characters and providing students a chance to say their ideas using cartoon names makes students more comfortable (Kabapınar, 2005).

Computer Animation

Computer supported instruction does not only consider students' alternative conceptions, but also helps students see the microscopic world via computer animations (Çepni, Taş & Köse, 2006; Levine & Donitsa-Schmidt, 1998; Liao, 2007; Momalougos, Kollias & Vosniadou, 2007; Owusu, Monney, Appiah & Wilmot, 2010; Özmen et al., 2009; Tao & Gunstone, 1999; Trey & Khan, 2008; Zhang, Chen, Sun & Reid, 2004).). It gives many opportunities to enrich the education environment. It facilitates the understanding of complex natural events more clearly. It provides students the possibility to see natural events which are not possible to bring into the classroom environment. It also makes it possible to do experiments that take a long time in the laboratory in a short time and to repeat the experiments one or two times (Sinclair Kesley, Renshaw & Taylor, 2004). Giving immediate feedback to each student in crowded classrooms is also possible. Moreover, students get a chance to repeat the subject with computer software, CD etc. It not only motivates students towards science and technology courses (Sinclair et al., 2004), but also provides the opportunity to observe invisible events (Şahin & Çepni, 2009; Şahin et al., 2010; Trey & Khan, 2008). In contrast to these benefits, when computer animations are used consistently without any supportive teaching materials, students' motivation may be diminished because students tend to communicate with the teacher (Trey & Khan, 2008). Hence, in this study, computer animations were supported by the CCT, concept cartoons and worksheets.

Methodology

A quasi-experimental method was used in this study because the participants of the study were already distributed to classrooms by the school management. Because school authorities did not allow the researchers to constitute new classrooms for experimental purposes, they randomly assigned the present groups as experiment and control groups (Cohen & Manion, 1994). In quasi-experimental research design, each group was given both a pre-test and a post-test, measuring the dependent variable before and after exposure to the independent variable. In this study, a delayed-test was also implemented to both Control Group (CG) and Experiment Group (EG) students after about three months of administering the post-test.

The Sample

The sample of this study consisted of 48 (experiment group, N=25; control group, N=23) elementary 8^{th} grade students. One volunteer science teacher participated in the study. The same science teacher taught in both groups. The teacher had 24 years of experience in teaching science and he participated in an in-service education seminar of science curriculum based on the 5E instructional model in 2004. He was told how to use the teaching materials about the buoyancy force concept one hour before the application by the researcher. Because he took part in the development process, he is already familiar with the materials.

Teaching Process

National Ministry of Education (NME) proposed 14 hours for teaching the "Force and Motion" unit including buoyancy force concept in the curriculum of elementary science and technology of 8^{th} grade. Nine lesson hours (360 minutes) are suggested to teach only the buoyancy force concept, which includes floating-sinking, gas and fluid buoyancy force concepts. For this reason, these applications were completed in 9 lesson hours for both the EG and the CG. Also, lessons based on the 5E instructional model were implemented for both the EG and the CG because NME agreed with the 5E instructional model for the curriculum of elementary science and technology. Teaching materials based on the 5E instructional model were developed by using different teaching methods and techniques during the unit. The EG students were divided into six groups. In the implementation process, the material supported with the CCT, concept cartoons, computer animations and worksheets, which was developed for this study by the researchers, was administered to the EG group, while the other instructional materials such as a student course book, work book and teacher guide book based on the 5E instructional model were studied in the CG. In the CG, during the lessons, the teacher tried to make a student-centered instruction based on the 5E instructional model using, discussions and oral explanations. The textbook was used as the principal source and it included different activities related to the buoyancy force. Instructional environment of the EG is presented in Figure 1.

Figure 1. Instructional Environment of the Experiment Group

Instruments

EG and CG students' conceptual changes were identified via four two-tier questions which were taken from "Determining Differentiation in Conceptual Structure Test (DDCST)" prepared by Şahin (2010) including 16 questions. The test's reliability coefficient (Cronbach's Alpha) was computed as 0,81. Because the data obtained from the test did not show normal distribution and the questions used in the test were included in the classified scale, the test's validity was determined by a hypothesis test. Expert opinions were taken for the construct validity. The first-tier of each item consists of a content question having four choices; the second tier explores students' reasons for their choices made in the first tier. The two-tier questions are presented in Appendix A. The first question was asked in order to probe the understanding of the students about the relationship between the effect of fluid buoyancy force and gas buoyancy force on standing and moving objects or floating and sinking objects. The second question was searching for the relationship among fluid buoyancy force, submerged volume of the object and the amount of displaced fluid concepts. The third question was asked to investigate the students' understanding of the relationship among fluid buoyancy force, the density of fluid, and sinking and floating concepts. The fourth question was asked to probe the students' understandings about the relationship among gas buoyancy force, volume of object and gas pressure concepts.

Data Analysis

Different categories were used to evaluate understanding levels of students by researchers. These categories were composed of data collected from open-ended questions (Abraham, Gryzybowski, Renner & Marek, 1992; Haidar & Abraham, 1991; Marek, 1986). The final form of the understanding level categories which are often used in studies were determined as no understanding, specific misconception, partial understanding with specific misconception, partial understanding and full understanding, which were also used by Abraham et al. (1992), and these categories were coded as 0, 1, 2, 3 and 4 scores respectively. In data analysis, categories developed by Şahin (2010) were used. According to the categories of Şahin (2010), the first phase of the two-tier questions was evaluated in three subcategories: Correct Choice (CC), Incorrect Choice (IC) and Empty (E). CC was 5 score, IC was 1 score and E was 0 score. Due to the necessity of distinguishing categories IC and E, so 0 was not scored for category IC because students in category IC cannot be counted as people who not know anything. Additionally, CC was a 5 score, so there was a clear distinction between students in categories CC and IC. Before the analysis of students' qualitative answers in the second phase of two-tier questions, almost 10 students' qualitative answers were immediately examined and possible situations were considered. Then, Correct Reason (CR), Partial

Correct Reason (PCR), Reason Including Alternative Concepts (RIAC), Incorrect Reason (IR) and Unrelated Reason/Empty (UR) categories were formed according to the students' qualitative answers. The categories used to analyze the second part of questions are presented in Table 1 with indexes and scores.

Table 1. The categories used to analyze two-tier questions with the scores and indexes

Understanding Level/ Abbreviation	Scores	Index
Correct Reason / (CR)	10	Answers include all aspects of valid reason
Partially Correct Reason / (PCR)	8	Answers include some aspects of valid reason
Reason Including Alternative Concept / (RIAC)	3	Answers include partial correct information with misconceptions
Incorrect Reason / (IR)	2	Answers include incorrect information.
Unrelated Reason / Empty (UR)	0	Answers include unrelated reason. Answers are irrelevant to the question. Answers are just same as the questions.

According to the importance order, categories were ranked and category CR was put in the first order, while category PCR was in the second, category RIAC was the third and category IR was the forth. The reason of putting category RIAC above category IR was that there were explanations including some partial correct information rather than misconceptions as in category IR. In the category IR, given information was incorrect whereas category UR contained several different situations such as repetition of the question, unrelated explanations and irrelevant answers to the question. Even though the explanation was incorrect in the category IR, some explanations were tried by students, so category IR was placed above category UR. Eleven categories made of a combination of both phases' codes of two-tier questions were used for grading the first and second phase of two-tier questions. When 11 categories were arranged carefully, each structure had hierarchically different scores. The categories used in the analysis of the two-tier questions, abbreviations of the categories, and scores are shown in Table 2.

Table 2. The categories, abbreviation and scores used to classify students' answers

Categories	Abbreviation	Scores
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

The scores of 11 categories were obtained by summing the scores given in the first and second phase of two-tier questions. The importance order of these total scores was parallel to the importance order of the categories. Categories CC-IR, IC-CR and IC-PCR were above category CC-UR, because writing correctly or partially correct in the second phase of two-tier questions was more important than only marking a choice. To provide with reliable data, the researcher analyzed the pre-test data of the EG and CG at two different times, one month between grading. Reliability is to achieve similar or compatible results at different times and from different sample. The consistency of the researcher's grading papers at two different times was calculated as 93% and 87% for the EG and CG, respectively.

If all the questions were answered in the category CC-CR, students would take maximum (15x4) =60 (total) scores. After data collection, papers were classified; scores were given and then statistical computations were done.

In the statistical analysis of the data, non parametric Wilcoxon Signed Ranks for related samples and Mann Whitney U test for unrelated samples were used. The reason for using non-parametric tests in this study was that two-tier questions were included in the classified scale and the data did not show normal distribution. In this case, it was appropriate to use non-parametric analysis techniques (Özdamar, 2004). Also, the EG and CG students' answers in the pre, post-and delayed-tests were tabulated together with percentages.

Using teaching methods and techniques embedded in the 5E instructional model

The Science and Technology course was taught with main course books based on the 5E instructional model, which is enriched by worksheets, the POE technique, animations and the CCT in the EG. Teaching of the buoyancy force concept was completed in 9 course hours in both groups. Eight worksheets, seven animations, one concept cartoon, animation and argument supported the CCT were used in the EG.

Worksheets were not only used to keep the lesson going systematically, but also used to give an opportunity to students to overview the whole lesson. An example of a worksheet is given in Appendix B. The experiments appearing in the worksheets were based on the POE technique. According to the POE technique, students were supposed to write their predictions about a given issue in the worksheet in the prediction step. Then students were supposed to record data obtained in the experiment in the observation step in the worksheet. They recorded the results of the experiment, and finally students made an inference by comparing their predictions and observations.

Using the literature review of students' misconceptions, the researchers prepared a CCT. In the CCT, different ideas were introduced with four cartoon characters in a concept cartoon question. This was followed by the prediction phase in which students the expressions of the concept cartoons and made some predictions about which expressions were correct. Additionally, an animation and an experimental activity were presented to refute misconceptions. And finally, students were informed about the scientifically correct explanations which were supported by examples, experimental activity and an animation. In the literature, many examples and figures were used in the texts in order to help students understand the scientific concepts and to realize the limitations of their ideas. To help students, figures and animations were used. An example of a conceptual change text used in the study is presented in Appendix C. In this study, a concept cartoon including four characters called Ahmet, Burcu, Melek and Hasan was used to activate students' pre knowledge in the introduction phase of CCT. The characters in the cartoon discussed buoyancy force, floating and sinking concepts. Only Hasan displayed scientifically correct information. The rest of the characters showed misconceptions.

In order to increase the effectiveness of the 5E instructional model, seven animations based on teaching activities were used in the study. The animations were developed by the researchers using Flash MX 2008, photo shop and paint programs. In the animations, the story of king's crown between Archimedes and Syracuse about buoyancy force and the working principle of Panama Canal were displayed. In addition, in teaching gas buoyancy force, it was also examined that how increasing or decreasing gas density would affect gas buoyancy force exerted on the object. Concrete mediums were given to reveal the relationship between gas buoyancy force and the volume of the object. Some animation print-screen views are given in Appendix D.

Results

Statistical Results about Effect of Different Teaching Methods and Techniques Embedded in the 5E Instructional Model on Students' Learning

Data collected from the two-tier questions were computed statistically. The results of the statistical computing are presented below.

Table 3. The comparison of Mann-Whitney U test results of pre-test for the EG and the CG

Group	N	Mean Rank	Sum of Ranks	U	p
The EG	25	26.58	664.50	235.500	0.282
The CG	23	22.24	511.50		
Total	48				

As seen in Table 3, There is no significant difference between pre-test results of the EG and the CG ($U=235.500$, $p> .05$). It is seen that the mean rank of the EG and the CG are close to each other.

Table 4. The comparison of Mann-Whitney U test results of post-test for the EG and the CG

Group	N	Mean Rank	Sum of Ranks	U	p
The EG	25	33.42	835.50	64.500	.000
The CG	23	14.80	340.50		
Total	48				

As seen in Table 4, There is a statistically significant difference between post-test results of the EG and CG ($U=64.500$, $p< .05$). When the mean ranks of the EG and the CG are considered, it is seen that a significant difference of the mean ranks in favor of the EG.

Table 5. The comparison of Mann-Whitney U test results of delayed post-test for the EG and the CG

Group	N	Mean Rank	Sum of Ranks	U	p
The EG	25	29.50	737.50	162.500	.010
The CG	23	19.07	438.50		
Total	48				

As seen in Table 5, there is significant difference between delayed post-test results of the EG and CG in favor of the EG ($U=162.500$, $p< .05$).

Table 6. The comparison of the Wilcoxon Signed Ranks test results of pre-and post-tests for the CG

Post test- pre test	N	Mean Rank	Sum of Rank	z	p
Negative Rank	7	10.36	72.50	-.908*	.364
Positive Rank	12	9.79	117.50		
Ties	4				
Total	23				

*Based on negative ranks

There is no significant difference between pre and post-test results ($z= -.908$, $p> .05$). In Table 5, it is clearly seen that 7 students' pre-test scores are higher than post-test scores while 12 students' post-test scores are higher than pre-test scores. Also, it is seen that 4 students' pre and post-tests scores are equal.

Table 7. The comparison of the Wilcoxon Signed Ranks test results of pre-and post-tests for the EG

Post test- pre test	N	Mean Rank	Sum of Ranks	z	p
Negative Rank	5	4.80	24.00	-3.728*	.000
Positive Rank	20	15.05	301.00		
Ties	0				
Total	25				

*Based on negative ranks

There is significant difference between pre-and post-test results of the EG ($z=-3.728$, $p< .05$) in favor of the post-test of the EG. As seen in Table 7, 20 students' pre-test scores are smaller than post-test scores.

Qualitative Results about Effect of Different Teaching Methods and Techniques Embedded in the 5E Instructional Model on Students' Learning

The findings collected from two-tier questions related with the buoyancy force of fluids and gases are presented below respectively.

When the data in Table 8 is examined, it is seen that 8% of the EG in the pre-test, 84% of the EG in the post-test and 60% of the EG in the delayed post-test are placed in the CC-CR category. 13% in the pre-test, 47% in the post-test and 30% of the CG in the delayed post-test are placed in the CC-CR category. In the pre-test 32% of the EG and 38% of the CG are placed in the IC-RIAC category. When the post-test data is examined, it is seen that in the IC-RIAC category, although there is no student in the EG, 21% of the CG is put in this category.

Table 8. The findings collected from the first question in the pre-test, post-test and delayed post-test

Categories	Students' answers	Pre-test		Post-test		Delayed Post-test	
		EG (%)	CG (%)	EG (%)	CG (%)	EG (%)	CG (%)
CC-CR	"Buoyancy force affects all of them in their environment. But because they have different densities, they were not lifted in the air or water."	8	13	84	47	60	30
CC-PCR	"All bodies may be affected by buoyancy force. All substances have a density, so there is buoyancy force effect."	16	-	-	4	-	4
IC-CR	"Buoyancy force affecting swimmer is heavier than the weight of the swimmer. Buoyancy force affecting marble is less than the weight of the marble. Also, this case is similar to all bodies in the atmosphere." "There is water buoyancy force. Also, buoyancy force affects balloon. The marble and the plastic ball were not moved by buoyancy force affecting them because they are affected by gravity."	-	4	-	4	8	-
IC-PCR	"Buoyancy force of the water affects swimmer and marble. There is buoyancy force in the every score of water."	24	16	4	13	4	4
CC-RIAC	"If these things were affected by buoyancy force, these substances could not float and they had sunk." "Liquid pressure affects swimmer. There is the effect of gas pressure on hot-air balloon and ball. All of them are affected by buoyancy force" "Buoyancy force of the water affects swimmer, buoyancy force of air affects flying balloon. The marble and ball are affected by buoyancy force of the ground."	4	4	4	4	4	4
CC-UR	"There is buoyancy force around all of them." The majority of the students did not write their ideas.	4	-	4	9	4	35
IC-IR	"Because, the density of the swimmer is less than water, the buoyancy force of water affects swimmer." "Because hot-air balloon and ball are stable on the ground, they are not affected by buoyancy force."	4	8	-	-	4	-
IC-RIAC	"If the buoyancy force of sea were not affected by the swimmer, the swimmer would not be floating and the swimmer would have sunk."	32	38	-	21	12	17
E-UR	"Lifting arms, the swimmer swims. If we let the hot-air balloon free, it flies itself."	8	13	4	9	4	4

Table 9. The findings collected from the second question in the pre-test, post-test and delayed post-test

Categories	Students' answers	Pre-test		Post-test		Delayed Post-test	
		EG (%)	CG (%)	EG (%)	CG (%)	EG (%)	CG (%)
CC-CR	"Sinking volumes in water are equal. The displaced water is equal to the submerged volume of the object."	24	13	32	4	52	22
CC-PCR	"The volumes of two objects are under the water. Small volume of I numbered object is above water level. The volume of IV numbered object which is above water is bigger than the volume of I numbered object. The objects shown in II and III numbered choices are completely in water."	12	17	16	9	8	9
CC-RIAC	"Because these objects are heavier than water, these objects overflowed water" "The objects shown in II and III numbered choices are about to sink. The amount of overflowing water of the submerged objects is equal."	24	13	24	9	12	26
CC-UR	"I saw as if II and III numbered choices were equal"	16	13	8	22	12	22
CC-IR	"The amounts of overflowing liquid are equal in II and III numbered choice." "The mass of both objects are equal."	-	30	4	9	-	-
IC-IR	"I and IV numbered objects apply much more pressure in the experiment."	-	4	4	22	4	-
IC-RIAC	"Because the objects are floating as the weight of the objects and it is the same. The amount of the overflowing liquid depends on the weight of the object. So my answer is I and IV"	20	-	4	9	8	13
IC-UR	"The volumes of the objects are close to each other." "Because two objects overflowed equal amount of liquid."	4	4	8	9	4	4
E-UR		-	4	-	9	-	-

When the data in Table 9 is considered, it is obviously seen that 24% of the EG in the pre-test, 32% of the EG in the post-test and 52% of the EG in the delayed post-test is placed in the category CC-CR. 13% of the CG in the pre-test, 4% of the CG in the post-test and 22% of the CG in the delayed post-test is classified in the category CC-CR. While 20% of the EG is put in the category IC-RIAC in the pre-test, there are no students of the CG in this category. However, 4% of the EG and 9% of the CG in the post-test are put in the same category (IC-RIAC). In addition to this, it is seen that 8% of the EG and 13% of the CG in the delayed post-test is placed in the category IC-RIAC.

Table 10. The findings collected from the third question in the pre-test, post-test and delayed post-test

Categories	Students' answers	Pre-test		Post-test		Delayed Post-test	
		EG (%)	CG (%)	EG (%)	CG (%)	EG (%)	CG (%)
CC-CR	"If we add salt to water, the density of water increases and the buoyancy force of water also increase."	8	9	32	22	32	8
CC-PCR	"Salt increases the density of water. Also, if the density of water increases, the object moves upward"	40	30	64	17	56	30
CC-RIAC	"The salt can lift with weight"	-	4	-	-	-	-
CC-UR	"Among others this choice came to me the most logical one. For example sea water"	12	-	4	30	12	30
CC-IR	"Salt decreases the density of egg and so the density of egg is smaller than the density of the liquid"	-	-	-	9	-	9
IC-IR	"If we add olive oil to water, water stays above oil"	-	9	-	9	-	-
IC-RIAC	"The mass of the submerged egg is bigger than the mass of water. When water is added, the mass of the egg is smaller than the mass of the water. So the egg floats." "When water was added to the container, the density of water increases and the egg rises to the top of water." "The water should be evaporated. If less water is in the container, the possibility of remaining the object in the air increases." "Olive oil can lift egg to the top of water. Because olive oil will rise to the top of water." "When my mother boils eggs, eggs float."	36	35	-	13	-	9
IC-UR	-	4	4	-	-	-	13
E-UR	-	-	9	-	-	-	-

When the data in Table 10 is taken into consideration, it is seen that 8% of the EG in the pre-test, 32% of the EG in the post-test and 32% of the EG in the delayed post-test is ranked in the CC-CR category. While 9% of the CG in the pre-test, 22% of the CG in the post-test and 8% of the CG in the delayed post-test is ranked in the CC-CR category, 36% of the EG and 35% of the CG in the pre-test are placed in the IC-RIAC category. Even though there are no students of the EG in pre and post-tests in the same category, 13% of the CG in the post-test and 9% of the CG in the delayed post-test are classed in this category. Also, 12% of the EG in the pre-test is classed in the CC-UR category while there is no students in the CC-UR category. But 30% of the CG in the post-and delayed post-tests are classed in the CC-UR category.

Table 11. The findings collected from the fourth question in the pre-test, post-test and delayed post-test

Categories	Students' answers	Pre-test		Post-test		Delayed Post-test	
		EG (%)	CG (%)	EG (%)	CG (%)	EG (%)	CG (%)
CC-CR	"As going upward in the atmosphere, air pressure decreases. The balloon expands and buoyancy force also increases. Thus, tension increases"	-	-	-	-	8	-
CC-PCR	"As going upward in the atmosphere, air pressure decreases, the balloon expands. So, tension increases with the expansion of the balloon."	12	4	48	4	36	26
IC-PCR	"I think that going upward in the atmosphere, the effect of gravity decreases." "As going upward in the atmosphere, air pressure decreases and tension increases."	12	17	4	13	-	4
CC-RIAC	"As going upward in the atmosphere, air pressure increases and volume of the balloon expands."	4	13	16	9	24	17
CC-UR	-	32	13	16	9	4	44
CC-IR	"As going upward in the atmosphere, air pressure decreases, the balloon expands and weight of the balloon increases."	-	-	8	-	4	4
IC-IR	"If tension increases, then Newton decreases."	20	13	-	17	-	4
IC-RIAC	"As going upward in the atmosphere, pressure increases and volume decreases."	16	4	-	4	8	-
IC-UR	"The minimum force is one Newton."	4	22	4	44	12	-
E-UR	"I do not know"	-	13	4	-	4	-

When the data in Table 11 is considered, it is seen that only 8% of the EG in the delayed post-test is put in the CC-CR category. Actually, when the answers of the EG and CG in the CC-PCR category are examined, it is clearly seen that percentages of the EG are more than the CG. When the percentage rates of the EG and CG in the CC-UR category are taken into account, especially in the delayed post-test, the CG students' percentage is considerably higher than EG students. Moreover, the percentage rates of the CG students is remarkably higher than the EG in the IC-UR category.

Results and Discussion

When the EG's and the CG's pre-test scores are compared, it is seen that there is no significant difference between the EG's and the CG's backgrounds ($U=235.500$, $p> .05$; see Table 3) before the intervention. This case indicates that the EG and CG students have similar prior knowledge. It is known that students may come to the instruction environments with right or wrong knowledge that may have been arisen from their environments (Dekkers & Thijs, 1998; Novak, 1988; Seiger-Ehrenberg, 1981). It is seen that statistically significant difference is in favor of the EG students' post-test results when EG students' pre-and post-test results are taken into account (see Table 7). In Table 6, it is also shown that this significant difference is not seen between the pre-and post-test of the CG students. Table 4 shows that the mean ranks of the EG and CG students' post-test results score out a significant difference in favor of the EG ($U=64.500$, $p< .05$). Under these circumstances, it can be remarked that the instructional material applied in the EG is highly effective in increasing the students' success.

In addition, when the EG and CG students' delayed post-test results are compared (U=162.500, p< .05) by Table 5, it can be seen that the mean ranks score out a significant difference in favor of the EG. This situation can be explained through the effectiveness of the material applied in the EG rather than the material in the CG to ensure learning retention.

When students' qualitative answers are examined in detail, although in both groups it is found that the percentage of students answered in the CC-CR category increased after instruction, especially in the EG. It can be understood from the percentage rates of both EG and CG students that EG and CG students have some misconceptions. However, the EG students' misconceptions were eliminated considerably more effectively than in the CG students (see Table 8, 9, 10, 11). Using different teaching methods and techniques within the 5E instructional model has a positive effect on providing students' conceptual change. One of the misconceptions some students had is "*buoyancy force affects the objects floating in the fluid, buoyancy force does not affect the objects sinking in the fluid*." In parallel with this finding, Ünal and Coştu (2005) determined this misconception: "*if volume of the object remained above water increases, buoyancy force increases*." When the studies in the literature are considered, it is commonly seen that the misconception related to the buoyancy force is caused by not being able to associate submerged volume of the object and the buoyancy force affecting the object. This misconception is that "*the magnitude of the buoyancy force depends on the volume and shape of the object or only on the mass of the object"* (Besson, 2004; Reid, Zhang & Chen, 2003; Ünal & Coştu, 2005; Zhang et al., 2004). The reason for the misconception determined in this study may arise from students thinking that flotation must exist in order to understand the presence of the buoyancy force.

The second misconception is "*in water and air environments, gravity exerts buoyancy force on objects staying on the ground."* In this study, the can we sink the balloon in the water? activity was developed to remedy or prevent this misconception. In this activity, students felt the direction of the buoyancy force as upward. This case can be interpreted that no matter how much education is achieved, a learner constructs her/his own perception (Bodner, 1990). Because this misconception does not appear in the literature, identifying it makes a good contribution to the literature. Moreover, determining this misconception is so important because it is now possible to take provision against the occurrence of the misconception in future students' minds. The reason for the appearance of this misconception can be that students may confuse the direction of the buoyancy force with the direction of gravity. Another reason can be the confusion of impact-impulse forces with the buoyancy force on the object.

The third misconception is "*gas buoyancy force affects moving objects*." Whereas the EG did not seem to have this misconception, this misconception was appeared in the CG of pre-test, post-test and delayed post-test. While some students in the CG demonstrated this misconception in the pre-test, they were successful in eliminating it in the post-test, i.e. the instruction was good at remedying the misconception some CG students had showed before. On the other hand, some CG students who did not have this misconception and explained scientifically correct knowledge constructed this misconception in their minds in the post-test. In addition to this, "The project of Hasan" activity with scientific clarification and animation was applied in the EG and it was effective at removing or replacing this misconception with scientific knowledge.

The fourth misconception is "*buoyancy force affects objects on which fluid and gas pressure are applied*." The reason for the formation of this misconception may be that students may be confusing pressure and buoyancy force concepts in the way that they use pressure concept while intending buoyancy force or vice versa, as found in Psillos and Kariotoglou's study (1999) in which students mixed pressure and force concepts. Buoyancy force is also originated from the difference in gas and air pressure (Raghavan et al., 1998; Sere, 1998). But according to the findings, students are not aware of this case. Students could explain the case by using pressure concepts while meaning force or vice versa, as shown in the literature (Basca & Grotzer, 2001; Kariotoglou & Psillos, 1993; Önen, 2005; Psillos & Kariotoglou, 1999; Tytler 1998b). Similarly, Sere (1982) found that students had trouble understanding the balance in gas pressure and opposite forces.

The fifth misconception some students displayed is "*air buoyancy force affects objects flying in the air; air buoyancy force does not affect stable objects which cannot fly in the air*." This misconception is similar to the misconception of *"fluid buoyancy force affects objects floating in the fluid, fluid buoyancy force does not affect objects submerged in the fluid and buoyancy force affects moving objects*." The reason some students have this misconception may be that students think that the objects have to move as a result of gas buoyancy force. Similarly, students may think that gas pressure is associated with motion. They believe that if gas pressure does not exist, there is no motion (Sere, 1982). Although the majority of the EG students showed this misconception in the pre-test, they were able to remedy it in the post and delayed post-tests. In contrast, there were fewer the EG students in the category CC-UR while there were more CG students in the post-and delayed post-tests. It is not known how students had a conceptual framework in the CC-UR. In other words, it can be said that students in the CC-UR group may or not have scientific knowledge related to the topic; also these students may have some misconceptions. This situation can be interpreted as the POE implementation in the activities in the EG is more effective than course books studied in the CG, in terms of reasoning. Because gas particles are not macroscopic, students have difficulty understanding and making gas buoyancy force concrete. The students think that if there is gas pressure, then motion should exist, students want to see something concrete related to gas buoyancy force and the presence of gas.

When the data collected from the fourth question is examined, it is seen that although 8% of the EG students could explain the relationship between atmospheric pressure, volume of the object and air buoyancy force in the delayed post-test, the CG students are not so good at explaining this relationship. Also, in the pre-test, post-test and delayed post-test it is clearly seen that the number of the EG students explaining the question with the PCR is more than the number of the CG students. It is remarkable that the students in this category could not interpret the question in relation to air buoyancy force, they could explain it in such a way that: *as going upward in the atmosphere, gas pressure decreases and volume of the balloon increases*. Additionally, this situation may also have originated from the buoyancy force concept having a hierarchical structure. Understanding concepts' hierarchical structures is believed quite important because it means that fundamental concepts are already known, and it establishes a good relationship between concepts (She, 2002; 2005). In this study, computer animations are used to identify the relationship among buoyancy force, gases density and change in the volume of the balloon by going upward in the atmosphere. Additionally, the relationship between volume of the object and gas buoyancy force is animated with the "The Project of Hasan" animation activity. In spite of the activity and animations, it is seen that the EG students could not establish the relationship between atmospheric pressure, volume of the object, and buoyancy force about air concepts.

Some students have the misconception of *"heavy objects displace more water*" about the relationship of volume of displaced fluid and the buoyancy force. Students believe that heavy objects sink. Also, the other two misconceptions can be defined as *"floating objects overflow more water"* and "*because heavy objects sink, they overflow more water while sinking and if their weights are equal, objects float. So they overflow equal amount of water*." Grotzer (2003), Besson (2004) and Tytler (1998b) explained that some misconceptions may arise because students could not establish the relationship among the concepts. Similarly, She

(2002, 2005) emphasizes that the buoyancy force concept has a hierarchical structure, causing the formation of misconceptions in students' minds. Thus, students must primarily construct some fundamental concepts, such as mass, volume, density, submerged volume in their minds before learning the buoyancy force concept. Another misconception is "*the objects near the bottom of water are about to sink and the objects overflow equal amount of water; objects overflow equal amount of water if these objects are in same water, approximately both objects float in the same level*." In this study, apart from the written expressions of course books, "The crown of King" activity which is supported by animations being developed in order to prove whether or not objects sunk in the same fluid overflow an equal amount of fluid. The relationship between the amount of overflowed fluid and the buoyancy force concepts is also presented in the worksheets, the POE activities and animations. Loaded and unloaded ship animations help students establish the relationship between submerged volume of object and the buoyancy force, whereas the working principle of The Panama Canal is watched by students to provide consistency to the students' understanding of the relation between the submerged volume of the object and the buoyancy force. The conceptual chance approach emphasizes that concepts should be presented fruitfully and plausibly because the construction of concepts in students' mind is important (Hewson & Hewson, 2003).

One misconception some students have is about the relationship between floating, sinking, density and the buoyancy force concepts, for example "*salt can lift the objects by making them heavier.*" It is thought that this misconception may have originated from the confusion of weight and density concepts because several researches had similar findings (Kang, Scharmann, Noh & Koh, 2005; Özsevgeç & Çepni, 2006; Ünal & Coştu, 2005).

Another student misconception is "*if water evaporates, egg remains on water.*" The probable cause of this misconception can be that students think that objects appearing on the top of water are floating, and submerged objects are sinking. A similar misconception is determined in Joung's (2009) study. It is stated that experiences encountered in daily life would cause the formation of this misconception (Besson, 2004; Macaroğlu Akgül & Şentürk, 2001; Moore & Harrison, 2007; Ünal & Coştu, 2005). In this study, one student of the EG explains that *little amount of water should be evaporated, when my mother boils the egg, it floats.* This is an example of the misconception originating from experiences in daily life. In contrast to this situation, it is seen that for some students, the misconception originates from wrong ideas such as "*if amount of water increases, the egg floats.*" The possible causes of this misconception may be that students believe that adding water makes water's mass heavier than the egg, or adding water to the bowl makes the density of water increased. In other words, students could not establish a relationship among density, mass and volume concepts. Also, similar misconceptions are determined in previous researches (Macaroğlu Akgül & Şentürk, 2001; Özsevgeç & Çepni, 2006; Reid et al., 2003; Rowell & Dawson, 1977; Strauss, Globerson & Mintz, 1983; Yin et al., 2008). Consequently, it is clearly seen that using different teaching methods and techniques together within the 5E instructional model is very important. In this way, more individual differences can be addressed. It is very important that Bodner (1990) said that no matter how effective the instruction, it cannot be expected that every student will be successful.

Conclusions and Implications

If the advantages and disadvantages of teaching methods and techniques are taken into consideration, it is extremely important to use different teaching methods and techniques together due to the fact that some methods or techniques can cover the other methods' or techniques' shortcomings and make teaching enriched and more effective (Carlton, 1999; Çalık et al., 2010; Çalik et al., 2010; Çepni et al., 2010; Çetin et al., 2009; Çepni & Keleş, 2006; Özmen, 2011; Özmen et al. 2009; Akpınar & Ergin, 2007; Bayrak & Doğan, 2009;

Randler & Bogner, 2009). For instance, nevertheless CCT including some comparisons between alternative conceptions and scientifically correct knowledge is presented, students' motivation is decreased by a long time usage (Çalik, et al., 2010; Çetin et al., 2009). Researchers overcome this disadvantage by using animations within CCT (Özmen, 2011; Özmen et al., 2009; Şahin et al., 2010; Çalik et al., 2010). On the other hand, it is also known that if animations are used for a long time, students' motivation is affected negatively and they need to talk to their teachers face to face (Trey & Khan, 2008). The studies in the literature suggested using different teaching methods and techniques together, too (Çetin et al., 2009; İpek & Çalık, 2008; Ürey & Çalık, 2008; Yin et al., 2008; Türk & Çalık, 2008; Kurnaz & Çalık, 2008; Şahin et al., 2009). It is also emphasized that using different teaching methods and techniques together is quite effective for permanent learning (Akpınar & Ergin, 2007; Bayrak & Doğan, 2009; Çepni et al., 2010; Randler & Bogner, 2009).

In this study, students' understanding of the underlined concepts of gas buoyancy force, and fluid buoyancy force were improved by using the combination of these methods and techniques. Therefore, it is believed that the results of the study are different from the others and useful for future research. On the other hand, some misconceptions are still encountered after the implementation. This case indicates that it is not easy to alter some students' misconceptions, completely. Because all students learn and understand in different ways, different teaching methods and techniques should be used in science teaching to address their different learning styles and perceptions. Science instruction also needs to include some other contemporary teaching methods in order to make students' learning of science concepts more effective and enhanced. In conclusion, it is suggested that combining different methods and techniques such as computer supported CCT, animation, the POE, worksheet and hands-on activities may be a useful way for teaching buoyancy force, and also teachers may benefit from this or another combination if necessary. Undoubtedly, researchers may also improve this approach by integrating new teaching methods.

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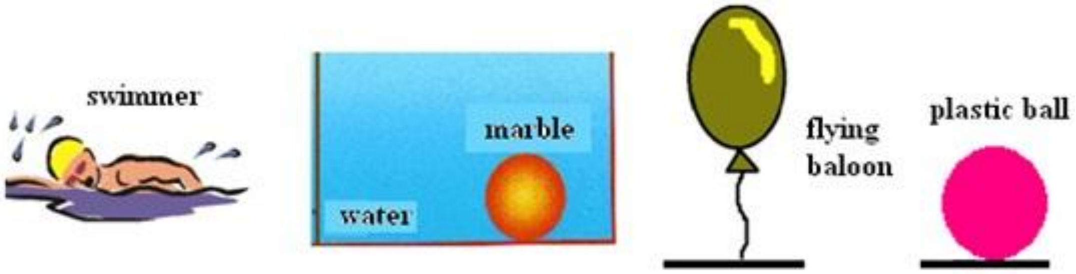
Appendix A.1. First and Second Questions of the Two-Tier Test Questions

Question 1:

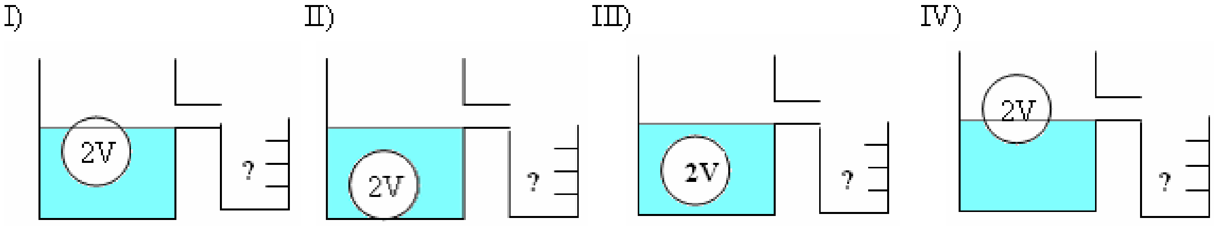


Which one or ones of the above pictures is affected by the buoyancy force? (The flying balloon and plastic ball are in the same environment).

a) Swimmer
b) Swimmer and flying balloon
c) Swimmer and marble
d) Swimmer, marble, flying balloon and plastic ball*

Because:.…………………………………………………………………………………
…………………………………………………………………………………………………

Question 2: In the below pictures, substances with the same volume are placed into the barrels filled with water. Which one of these substances will cause equal amounts of water from the barrels to over flow?



a) II and IV   b) II and III*   c) III and IV   d) I and IV

Because:…………………………………………………………………………………
………………………………………………………………………………………………...

* Represents the correct answer to the question.

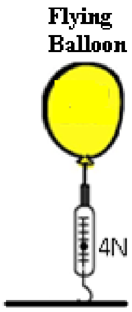
Appendix A.2. Third and Fourth Questions of the Two-Tier Test Questions

Question 3: When a student puts an egg into water, it sinks. What should the student do to make the egg float in the water?

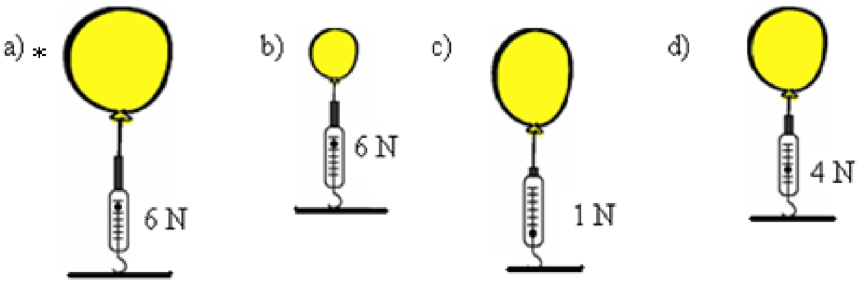
a) He should add water into the container
b) He should dissolve a very large amount of salt in water*
c) He should add olive oil the water
d) He should vaporize some water

Because:………………………………………………………………………………………
……………………………………………………………………………………………………

Question 4:



When Ayşe tied the flying balloon to the ground at home with the dynamometer, the dynamometer distended like in the figure. Ayşe measured the tension as 4 Newtons. If Ayşe tied her flying balloon to the Zigana Mountain, which is higher than her house, which one of the below does she measure in the dynamometer?



Appendix B. Worksheet

Gas Buoyancy force

➢ What can be the answer to Heidi's question? Please write your ideas below.
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………

Please watch the animation your teacher will show in order to check whether or not your thoughts are correct. Please follow the instructions below.

1. If the air in a bell glass is vacated, does any change happen in the needle of the dynamometer? Please write your ideas below.

………………………………………………………………………………………………
………………………………………………………………………………………………

2. When the air in a bell glass is vacated, what happens to the needle of the dynamometer? Please write your observations.

………………………………………………………………………………………………
………………………………………………………………………………………………

3. Please compare your predictions and observations. You may make some inferences related to animation by discussing within the group. Please write your explanations below.

………………………………………………………………………………………………
………………………………………………………………………………………………

4. In contrast with the experiment in the animation you watched, if some amount of air was added to the bell glass, does any change happen to the needle of the dynamometer? Please write your predictions below.

………………………………………………………………………………………………
………………………………………………………………………………………………

When some amount of air is added to the bell glass, what happened to the needle of the dynamometer? Please write your observations.

………………………………………………………………………………………………
………………………………………………………………………………………………

6. Taking the observations from both animations into account, please make inferences related to these experiments.

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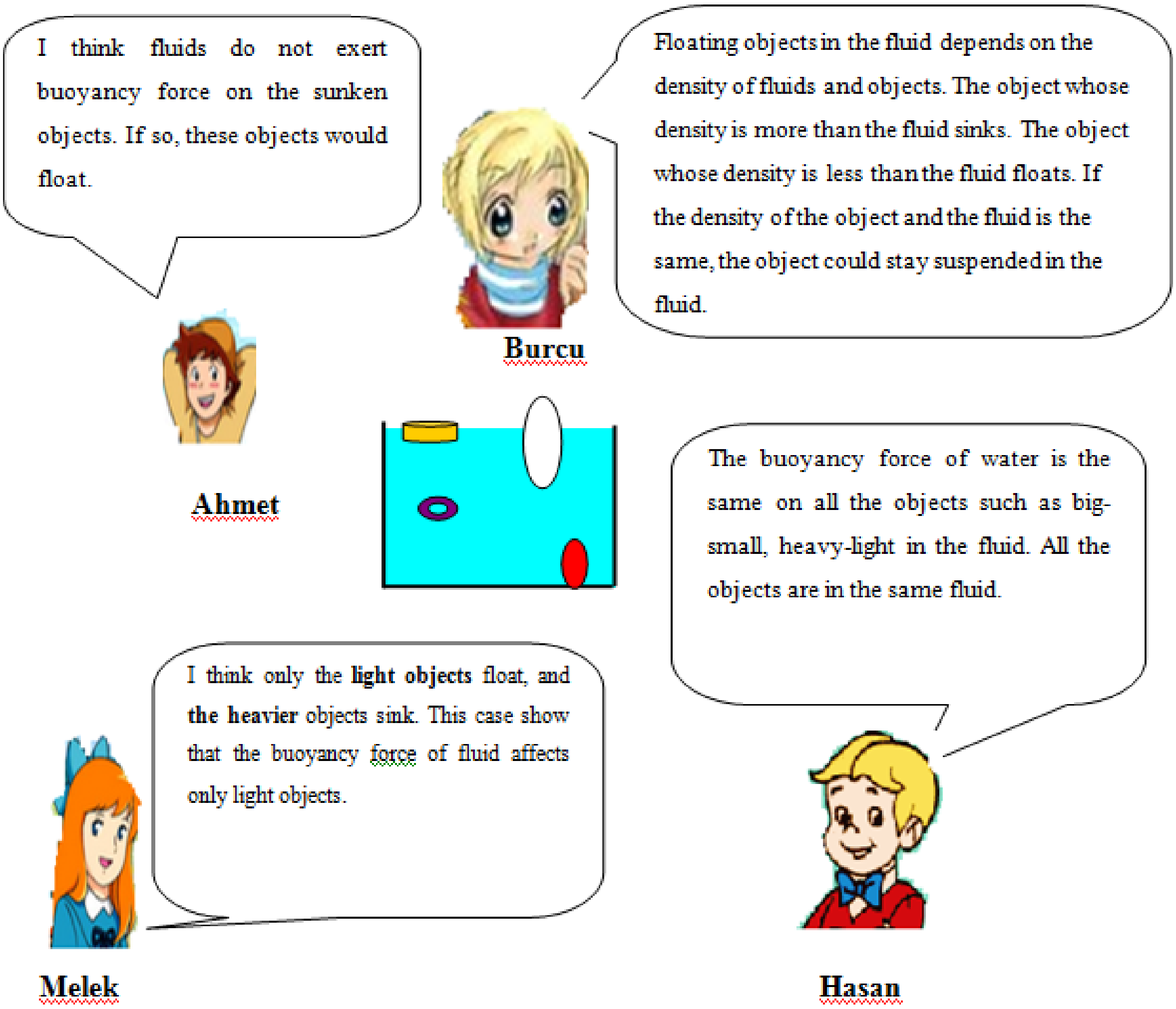
………………………………………………………………………………………………

Appendix C.1. Concept Cartoon and Computer Animation Supported CCT



In the passage above, students discuss the situations of liquids floating and sinking and buoyancy force that liquids apply to the objects. Do you agree with these students' ideas? If you do, whose ideas are closer to yours? Please explain why.

……………………………………………………………………………………

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Appendix C.2. The Text Chapter of the Concept Cartoon and Computer Animation Supported CCT

The Effect of Buoyancy force on Floating and Sinking

Ahmet thinks that buoyancy force will not affect sinking objects. Ahmet's idea is wrong. For example, when we are swimming, we could lift a rock from the bottom to the top of the water easily. But we have difficulty lifting the same rock on the ground because water helps us lift the rock in sea with the buoyancy force. It is understood that **liquids also apply buoyancy force to submerged objects. If the buoyancy force of the liquid is less than the object's weight, the object sinks in the liquid.**

Melek claims that only light objects float, and heavy objects sink. Melek's idea is wrong, because when a small rock thrown into water, it could sink, but a big log put into water could float. From this view, Burcu's opinion about the floating of objects depends on objects' and liquids' density, not their weights. **If the density of the object is lower than the density of liquid, it floats; if it is higher, it sinks**. If the density of an object is equal to the density of liquid, the object hangs in place. Suspended objects are another type of floating objects. We can float a sinking object and can sink a floating one by changing the density of objects. *Watch the "Floating and Sinking" computer animation (situation of key, plate and tray in water).*

Moreover, we can sink a floating object by changing the density of water. **When the density of water is decreased, the buoyancy force applied to the object also decreases**. Also, we can float a sinking object by increasing the density of water. **When the density of water increases, buoyancy force applied to the object also increases**. You can observe this feature in the egg example. Put an egg into water and observe it. Then add some salt into water and observe the egg's new position in the salty water.

Hasan claims that equal buoyancy force is applied to all objects in water. His idea is also wrong. Because **the buoyancy force that liquids apply to objects depends on the volume of the objects remaining in water.**

You read the text in which Ahmet, Burcu, Melek and Hasan discuss their ideas. Answer the questions below by taking the results into consideration.

1. "Light objects floats, heavy objects sink." Do you agree with this idea? Explain your reasoning.

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2. Is the buoyancy force exerted on all objects in the same liquid equal? Explain your reasoning.

....

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3. What are the factors effecting buoyancy force of liquids applied to objects?

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Appendix D.1. Screen Views of Computer Animations

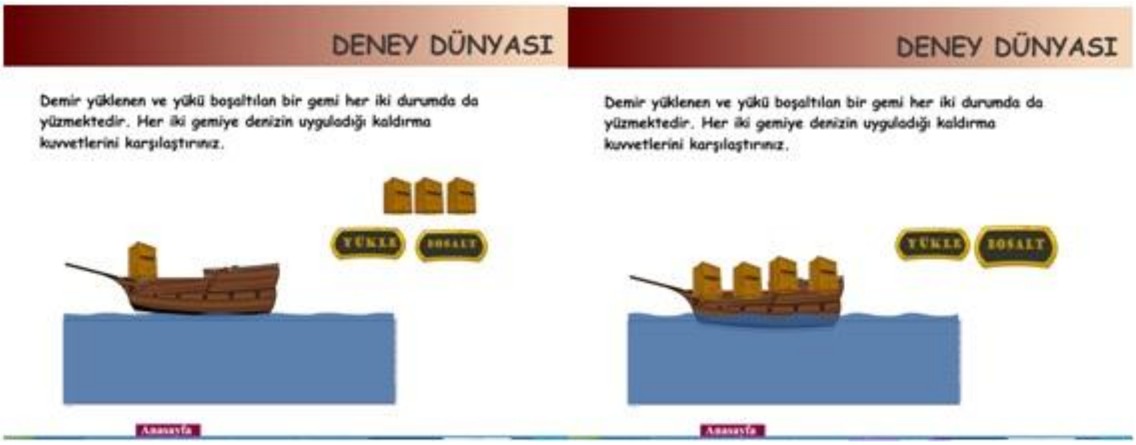

Figure D.1. The animation print-screen views describing the buoyancy force effect on loaded and unloaded ships

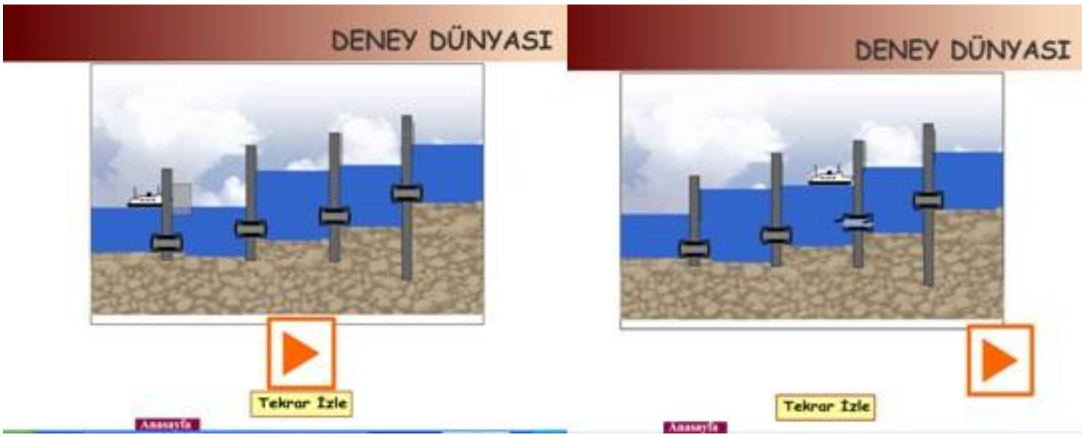

Figure D.2. The animation print-screen views describing The Panama Canal

Figure D.3. The animation print-screen views describing the relationship between volume and gas buoyancy force

Appendix D.2. Animations' Screen Views

Figure D.4. Animation print-screen views describing the relationship between gas density and buoyancy force exerted on the object

Figure D.5. The animation print-screen views describing Archimedes and King Syracuse story