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The Knowledge Structures about Buoyancy Concept of Secondary School Students: Phenomenological Primitive Flotation

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Abstract

The aim of this study is to determine the eighth grade secondary school students' knowledge structures regarding the concept of buoyancy. The study included eight students. Semi-structured interview technique was used to collect the data. Students were asked seven questions about buoyancy and the questions were presented with visual materials. Different contexts were created through the questions and visuals in the interviews. Interviews were videotaped and then transcribed. With reference to the raw data, basic codes were generated and associated with two main themes. A specialist's opinion was referred for the determination of basic concepts. The agreement between two experts was .91. All the students gave inconsistent answers to the first question set (questions about the relationship between buoyancy and mass). Except for student seven and eight, others students' responses to the second question set were inconsistent (questions about the relationship buoyancy and immersed volume). In conclusion, study findings support that knowledge structures of the students are consistent with "knowledge in pieces theory".

Keywords

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Conceptual change theories
Knowledge structures
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Introduction

How students learn the content of physical sciences is one of the primary issues of science teaching because the content of science is composed of a great deal of concepts about students' daily lives. Thus, at the beginning of their formal education on science; with the effect of the cultural context that they are in and especially with the effect of the language used, students have a naive thought system relating to a great number of concepts and they come to formal learning environment with prior concepts.

The literature of science education is full of a great deal of psychological, cognitive, epistemological, neurobiological studies and critics relating to the concepts structured in the mind (Carey, 1985; 1986; Hatano, & Inagaki, 1994; Keil, 1992; Klein, 2006; Lawson, 1995, 2003a, 2003b, 2003c, Louca, Elby, Hammer, & Kagey, 2004; Smith, diSessa, & Roschelle, 1993; Vosniadou, 1994; Vosniadou, 1996; Vosniadou & Ioannides, 1998). In addition, especially the questions "how does learning take place?" and "what happens to cognition during this process?" have triggered the studies on conceptual changes and knowledge structure theories which are used as effective explanation instruments in science teaching (Greca & Moreira, 2000; Limon & Mason, 2002; Özdemir & Clark, 2007; Vosniadou, Ioannides, Dimitrakopoulou, & Papademetriou, 2001; Vosniadou, 2002; Vosniadou, Baltas, & Vamvakoussi, 2007).

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"Theory-like knowledge structure (synthetic meaning) theory", which is one of the conceptual changes theory, is based on the acceptance that concepts are structures in the form of single, isolated and independent schemes (Vosniadou, 2002). The theoretical foundation that underlies suh an acceptance comes from Piaget's cognitive development theory and the constructivist learning theory inspired by this theory and also Kuhn (1970)'s notion of paradigm shift. However, knowledge in pieces theory (diSessa, 1993) and other studies relating to field education practice (Posner, Strike, Hewson, & Gertzog, 1982; Chi & Roscoe 2002) have revealed that a great number of the concepts of science are in the form of an interrelated system. Even though the conceptual ecology theory developed by Posner et al. (1982) is under the influence of Piaget and Kuhn, it accepts the view that conceptual structure is formed of interrelated elements rather than isolated factors.

In light of the foregoing the conceptual framework of our study is formed by two basic theories of conceptual change namely, "theory like knowledge structure" by Vosniadou (1994) and "knowledge in pieces theory" by diSessa (1993). Therefore, the aim of this study is to determine that which theory of conceptual change is used for the conceptualization of "buoyancy" in science learning process and to identify the students' ways of thinking. It is expected that these results would make great contributions to the program developers, implementers and students as well in developing and implementing activities related to the conceptual learning in science education. Thus, the contents of course books and experimental activity applications can be revised depending on the nature of the concepts to be learned.

Since our study is based on the aforementioned conceptual change theories, it is of importance to review the outlines of these theories.

A Close Look on the Theories

Vosniadou's theory-like knowledge structure and diSessa's knowledge in pieces theories are supported by their studies conducted at different times on the concept of force which is one of the most basic concepts of physics (diSessa, Gillespie, & Esterly, 2004; Ioannides & Vosnioadou, 2002).

Vosniadou (1994)'s theory-like knowledge structure theory accepts the view that cognitive structures of naive students are similar to the cognitive structures of scientists. Such a cognitive structure consists of isolated and independent concepts which have a specific consistency for the cognitive period it belongs to. According to this view, conceptual change starts with consistent and naive cognitive structures which have a specific conceptual framework that the individual forms from his/her genuine experiences outside formal education environment. In the next stage, the individual experiences the processes of science teaching in formal environment and starts interacting with the previous conceptual framework using his/her newly encountered information. Thus, new consistent and synthetic or hybrid conceptual structures are formed for a specific period. These structures have specific conceptual frameworks. This situation ends with the replacement of new and consistent scientific conceptualization with the hybrid conceptual structure as the last stage. The most striking assertion of Voniadou (1994)'s theory is the view that the initial naive concepts belonging to a specific cognitive period and synthetic or hybrid concepts of the next stages show consistency for the related period just like scientific concepts. For example, in her study Vosniadou (1994) defined conceptual models expressed by the terms internal force (initial conceptual model), internal-acquired force (synthetic or hybrid model) and gravitational force (scientific model).

According to another dimension of this theory, students form framework theories about nature or physical universe such as static universe or sense of direction in the universe based on their personal experiences outside the school environment (Ioannides & Vosniadou, 2002; Mayer, 2000; Vosniadou, 1994; Vosniadou, 2002; Vosniadou & Brewer, 1992a). These framework theories form a scope, i.e. a border, in terms of how to perceive a specific phenomenon of the physical universe, such as the phenomenon of force. According to Vosniadou (1994), conceptual change is in fact making this framework theory change. That is, only the changes that are oriented at conceptual structure related to specific phenomenon such as force, movement and energy do not provide the expected change. With reference to the example, as long as the perception of naive static universe in students is not changed during such a process, a casual explanation about immobility will not be necessary while an explanation about mobility will be necessary. Similarly, unless the perception of direction is not based on a scientific ground, the movement of an object in space will explained based on the references of up and down. Thus, even if the structure or the concept of questions related to the concepts of force, movement and energy change, the students will always give naive answers with a specific consistency. In short, theory-like conceptual change theory accepts the notion that there is a firm association between a specific explanation based on a phenomenon and framework theory.

diSessa (1993)'s theory is radically different from Vosniadou (1994)’s theory. For diSessa (1993), students’ cognitive structure (naive cognitive structure) is formed from a great many units of thought in pieces and in the form of a network. According to diSessa (1993), this structure which is in pieces in the naive stage will always continue to include thought units which contribute to the structure in pieces, although less when compared with the initial, even if the level of cognitive efficiency increases. These thought units are mostly structures that have not reached conceptualization level yet.

The most striking point of this theory is the fact that it is formed of a great number of small pieces of knowledge which create a feel of naturality and it has a complex knowledge network in the naive cognition of students. These structures in pieces can be associated with different hierarchical levels and complexity in case of each different problem of the same phenomenon diSessa called context (diSessa, 1993, 2002). Thus, each different context makes a different part of this complex thought system start to move. This situation causes a knowledge structure formed for any phenomenon to act differently in every different context and to show inconsistency. This structure in pieces can be called a conceptual ecosystem by Posner et al. (1982) on condition that it is applied to the theory of knowledge structure in pieces (diSessa, 2002). In fact, what is meant here is that it includes pieces of perceptual information (related to direct evidence at phenomenological and specific empirical level) supported by different fields of experience and an intuitional knowledge structure related to any phenomenon of the physical universe on the level of personal experiences outside the school environment. These structures are known as phenomenological primitives (p-prims) (diSessa,1993, 2002). P-prims are structural elements that can be repeated at naive cognition and provide cognitive coordination (diSessa & Minstrell, 1998). Thus, conceptual change can be defined as the transition from inconsistent knowledge in pieces into knowledge structures which are more consistent when compared with naive cognitive structure. That is, the process of the reorganization of the intuitive fragmented thought structures ends with conceptual change. One of the most important points of knowledge in pieces theory is the assertion that concepts are excessively context sensitive.

In summary, within the theory-like knowledge structure theory, there is a mental model that individuals form about a phenomenon or problem situation, a framework theory that forms the basis of this mental model and a theory perception specific for this problem situation (Vosniadou & Matthews, 1992). This theoretical structure argues that a new problem situation is solved within the borders of the mental model that works under the influence of framework theory. According to this view, a great number of problem situations can be adapted to the existing mental structure (assimilation). However, mental models are dynamic and productive enough to allow for individuals to form hybrid structures. Thus, in this theory conceptual change starts with consistent naive concepts, continues with consistent hybrid concepts and ends with consistent scientific concepts.

In diSessa (1993)’s knowledge in pieces theory, a student’s naive cognitive structure is inconsistent and an expert’s cognitive structure is relatively more consistent. That is, there exists a very big difference between a student and an expert in terms of cognitive consistency. In this theory, conceptual change starts with fragmented and inconsistent intuitional thought structures and ends with a relatively more consistent knowledge structure with the reorganization of knowledge structure in pieces.

Related theories will now be analyzed based on ampirical studies.

Literature

There are a great number of studies related to conceptual change and development in the literature of science teaching; however, these studies avoid making a very big generalization and their results are limited with participants (Southerland, Abrams, Cummins, & Anzelmo 2001). Among these studies, there are research articles which document that the knowledge structures of students relating to the students' different science concepts are coherent with Vosniadou (1994)'s theory-like knowledge structure theory (Chi, 1988; Greca & Moreira, 2000; Harrison, Grayson, & Treagust, 1999; Ioannides & Vosniadou, 1991, 2002; Nersessian, 1989; Vosniadou, 1991; Vosniadou & Brewer, 1992a, 1992b; Vosniadou & Matthews, 1992; Vosniadou & Kempner, 1993; Vosniadou, Baltas, & Vamvakoissi, 2007), while there are also studies which empirically support diSessa (1993)'s knowledge in pieces theory (Abrams, & Southerland, 2001; Becker & Towns, 2012; Clark, 2006; Glynn & Duit, 1995; Libarkin, Kurdziel, & Beilfus, 2003; Greca & Moreira, 2000; Greenbowe & Meltzer, 2003; Jasien & Oberem, 2002; Pintrich, Marx, & Boyle, 1993; Pintrich, 1999; Sherin, 2000, 2001, 2006; Shepardson, Wee, Priddy, & Harbor, 2007; Southerland, Abrams, Cummins, & Anzelmo, 2001; Tytler, 1998; Ueno, 1993). The following part gives examples to studies which may be an evidence for Vosniadou's theoretical explanation:

Vosniadou and Matthews (1992) found out that primary school students adapted the concepts they learned about the structure of the Moon to their existing conceptual structures. Other studies have shown that when students face problem situations that contradict with their mental structures, they either form schemes which contradict with each other or they form synthetic hybrid structures that may be considered as misconception (Chi, 1988; Vosniadou, 1991; Vosniadou & Brewer, 1992a).

In their study on the shape of the Earth and the distribution of entity on the Earth, Vosniadou and Brewer (1992a) found out that students had different and consistent mental models in different cognitive periods. Thus, the students displayed mental models in the beginning stage relating to experiences outside the school environment, synthetic hybrid models which were revealed in different stages of the education process and also some models which were consistent with scientific conceptualization.

Similarly, in their study on the formation of day and night, Vosniadou and Brewer (1992b) reported that students had different and consistent mental models in different cognitive periods. This study also illustrated naive mental models displayed at the beginning and new hybrid models which were revealed with the interaction of formal knowledge and naive models. There are examples relating to the consistency of these models with a specific cognitive process.

Ioannides and Vosniadou (1991, 2002) also indicated that students formed different mental models for the concept of force. Students displayed internal force and acquired force perceptions at the beginning stage while they formed new hybrid models by combining mental structures representing their internal force and acquired force perceptions with gravitational force.

According to Greca and Moreira (2000), students can reason about phenomenons with the help of mental models. However, according to the authors, mental models are continually restructured through new conceptions and new experiences. That is, they are dynamic. This dynamism is a result of the personal and contextual side of conceptualization.

The following part gives examples to studies and research articles which may be an evidence for diSessa's (1993) knowledge in pieces theory:

Demastes, Good and Peebles (1996) asserted that conceptual change theories which try to explain the comprehensive changes of concepts, can not always explain conceptual change fully, as in the conceptual change theories of Vosniadou and Posner et al. in their studies, they emphasized that the conceptualization of students relating to the theory of evolution are cumulative, double or multiple configurations. Such results seem to document that evolutionary thought structures are quite coherent with p-prim and knowledge in pieces theory.

Tytler (1998) also reported that concepts are context sensitive. The consideration shows that semantic configuration or conceptualization changes depending on conditions. Tytler founded that students formed different answers in different activities and naive conceptualization had a complicated, layered and hierarchical structure. Within this context, according to Tytler, students' explanations and ideas on a new phenomenon, for example air pressure, are greatly influenced by their phenomenal experiences relating to matter and air. According to this view, epistemological past and related way of perceiving the physical universe on which explanations about a new phenomenon are based influence the new explanation. The study asserts that students think through interrelated conceptual layers, not within the framework of a consistency provided by a theory. A similar finding was put forward by Turcotte (2012). Turcotte showed that students could use a previous conceptualization about a specific phenomenon for explaining a new phenomenological experience. Students associated their conceptualizations about phenomenon such as buoyancy and flotation with their explanations about free fall, parachute slowing down the free fall and air pressure.

This situation is accordant with diSessa (1993)'s approach that concepts and therefore naive thoughts have a network structure related to each other and that based on the context, different elements of the network can come into action. At the same time, it adds to the examples of extending the usage area of any p-prims (diSessa, 1993). The findings of this study and other studies summarized above support the view that there may be different methods of contextualization and conceptualization in the learning of scientific concepts. In this context, it is important to find out which conceptual change theories the students have based their scientific concepts on.

Southerland et al. (2001) reported that the answers given by students of different classes varied on a level of about between 71% and 63% in an interview. Similarly, the answers given by students of different classes varied even for one question during the interview. It was found that the students did not change their initial casual explanations intentionally during an interview, but their explanations changed in a short time depending on the questions, that is the context. These findings are in parallel with knowledge in pieces theory. The study also asserted that students of different classes developed causal (teleologic) and anthropomorphic explanations unintentionally depending on the context. Southerland et al. (2001)'s findings also showed that students explained different biological mechanisms intuitively through need p-prim. At the same time, characteristics of the explanations of students from different classes (even the explanations of second and twelfth graders) such as inconsistency, context sensitivity and temporariness continued and it was observed that students gave answers that supported the theory of knowledge in pieces.

In a study Louca et al. (2004) conducted with third grade teachers and their students, they asserted that students had thought structures that were transitive and changing momentarily depending on the context in their comments of a specific science content and this situation could be best explained through knowledge in pieces theory. According to the study, theories such as framework theory or theory-like knowledge structure theory and accomodation theory cannot explain why the students' answers change as the context about the subject changes. However, knowledge in pieces theory gives a good explanation to science education workers and teachers about the mechanism of students' changing their answers based on the context.

Clark (2006) has reported that students' explanations on thermal equilibrium and conductivity-insulation concepts about thermodynamics subject of physics are multiple and fragmented, interrelated, changing in terms of context, contradictory and inconsistent. Thus, the findings presented by the author are compatible with knowledge in pieces theory which asserts that students' naive thought structures consist of numerous conceptual elements on various organizational levels. At the same time, the explanations made by students both in the inital study and also during longitudinal situation study show that their thoughts are mostly contradictory and coherent with atomistic p-prims which become active depending on the context.

Sherin (2001) developed a conceptualization being comparable with the p-prim concept, with reference to diSessa (1993). In his study, he stated that university students formed new formulas or changed the existing ones to explain the existing factual problems. At the same time, Sherin (1996, 2001, 2006) asserted that cognitive systems of experienced or semi-experienced students were formed from huge, complicated and atomistic knowledge elements. Sherin calls such thought structures symbolic forms. In Sherin (2001)'s study, students gave inconsistent answers to questions about objects with different weights starting their actions with free fall and same initial speed, and developed symbolic forms are compatible with p-prims. According to the study, the reason for this situation is that the students acquire various knowledge elements while learning physics. Such knowledge elements are different from the structure of formal physics, they affect the application and explanation of formulas and they act like diSessa's p-prims. That is, as a result of their formation, symbolic forms correspond to p-prims which constitute the inital explanations of concepts such as force, speed, association of free fall and gravitation and energy defined by diSessa (1993) (Greenbowe & Meltzer, 2003; Hadfield & Weiman, 2010; Jasien & Oberem, 2002). Similarly, Becker and Towns (2012) have reported that university students make a great number of symbolic form explanations about mathematical equations. The authors explained the formation of symbolic forms in students' cognition with the view that the formal equations that the students come across in their education are far from the natural phenomenon they represent.

While publications about the conceptual analysis of various science concepts according to conceptual change theories (for exp: Force (diSessa, Gillespie, & Esterly, 2004; Ioannides & Vosniadou, 2002), frictional force (Sherin, 2001), biological evolution (Southerland et al., 2001), human circulatory system (Chi, de Leeuw, Chiu, & LaVancher, 1994)) are common throughout the world, studies in this field are very scarce in Turkey (Özdemir, 2007; Özdemir & Clark, 2009). An important study on the analysis of buoyancy based on conceptual change or knowledge structure theories was made by Turcotte (2012) and no other significant study was found in international literature. No study was found in Turkey on the analysis of this concept in terms of conceptual change theories. This situation makes our study important. In addition, in today's world where concept teaching is a rising approach, the analysis of students' knowledge structures according to conceptual change theories will inevitably contribute to schedule development studies and thus formal learning environment.

In this study, the sudents' consistent answers to questions on different activities of the same concept show that the related concept was structured based on theory-like knowledge structure theory, whereas their inconsistent or different answers show that the same concept was structured based on knowledge in pieces theory (Özdemir & Clark, 2007, 2009). Based on this approach, the research question of our study was "which conceptual change theory corresponds to students' knowledge structures on the concept of buoyancy and what are these knowledge structures?"

Method

This study is a qualitative study and it has a phenomenological design. Phenomenological design provides important advantages about researching the phenomenon that we are aware of but do not have detailed and thorough understanding about (Yıldırım & Şimsek, 2008). As stated by Yıldırım and Şimşek (2008), they can appear as "entities, phenomenon, events, experiences, perceptions, tendencies, situations and concepts". We can come across these phenomena in various forms in our daily lives. However, this does not mean that we thoroughly understand and comprehend these phenomena. Phenomenological design provides a suitable research basis for phenomena that are not fully unknown to us, but yet the meanings of which we cannot comprehend. Thus, it becomes possible to bring to light the initial basis of our phenomenological concepts and to deciphere the covert and the hidden (Creswell, 1998). Since our study is about the perceptions of students on the buoyancy of water and the concept of swimming and the covert association between these, phenomenological design, which allows thorough analysis, was preferred.

Participants

The study group consisted of 8th grade secondary school students aged 13 - 15 years. The students were selected from volunteers attending a private educational institution in a province in the Central Black Sea Region of Turkey. Because data are obtained through face to face interviews, communicative students were preferred. In addition, students have similar socio-economic status and moderate success at school. The students had previously received training about the scientific concept (buoyancy) of the subject of the study, within science curriculum. We received support from the teachers who were working in the institution for the determination of this information.

Data Collection Tool, Data Collection and Analysis

Presentations used in the interviews consist of 7 questions. In the presentation, students were asked to interpret the situation in each question. Different visual contexts were created regarding the "concept of buoyancy". One context is the first question set (first theme) consisting of questions about the relation between "buoyancy and mass". The second one is the second question set (second theme) regarding the relationship between "buoyancy and immersed volume". Thus, the students were provided with the opportunity to give answers in different context to the same concept.

Related visuals and practice questions are as follows:

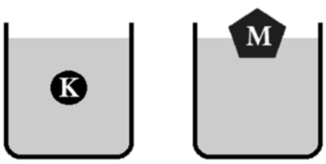
Question 1)

Object K is put in fluids of different density in the figure. How are the buoyancy forces applied to this object in both situations? Why?

Question 2)

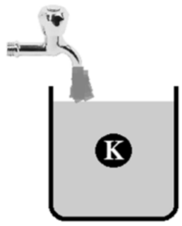
Objects K and L which have an equal mass are put in fluids of different density in the figure. How are the buoyancy forces applied to these objects? Why?

Question 3)



Objects K and M which have an equal mass are put in fluids of different density in the figure. How are the buoyancy forces applied to these objects? Why?

Question 4)



There is a stable object K inside the fluid in the figure. If denser fluid is added in the container what will happen to the buoyancy force that affects object K? Why?

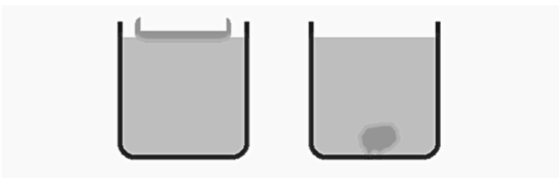
Question 5)

Objects K and N which have an equal immersed volume are put inside the fluid in the figure. How is the buoyancy force applied to these objects? Why?

Question 6)

Objects K and P which have an equal volume are put inside the fluid in the container in a hanging position. How are the buoyancy forces applied to these objects? Why?

Question 7)



The boat in the figure which is made of plasticine can float. When the same boat is squeezed back and thrown in the container, it sinks. How are the buoyancy forces applied to these object in both situations? Why?

Figure 1. Data Collection Tool and Questions Used in Research

During these practices, questions scuh as “what do you mean?” and “can you clarify some more?” were asked to understand the basic thought structures behind the students’ answers. All the interviews were video recorded by the researcher and the recordings were analyzed after transcription.

In the analysis of the data, the researcher was inspired by the coding and analysis methods introduced by Vosniadou and Brewer (1992a, 1994) and Creswell (1998). The table of reference basic concepts which show the scientific conceptual association relating to question sets and which were used in the analysis of raw data is below (Table 1). This analysis basically consists of the following steps: (1) determination of codes related to buoyancy with reference to raw data, (2) association of students’ ideas with two basic themes (buoyancy-mass association and buoyancy- immersed volume association) based on the questions, (3) presentation of the evidence (quotations) that reinforces the findings, (4) determination of the knowledge structure or structures that form a basis for the naive thoughts of students.

The association of students' thoughts with two predetermined themes was also examined by an expert. A consistency level of .91 was found between two experts in making an association between buoyancy-mass and buoyancy- immersed volume themes and the repeated concepts in the raw data.

Table 1. Basic Concepts of Question Sets

	Mass	Object Volume	Immersed Volume	Fluid Density
1. Buoyancy applied to same objects in fluids of different densities	Since the masses of the same objects will be the same, the buoyancies that affect them are the same, too.	Since the masses of the objects are the same, the volume of the object does not have an influence on buoyancy.	Since the masses of the objects are the same, the immersed volume of the object does not have an influence on buoyancy.	Since the masses of the objects are the same, fluid density does not have an influence on buoyancy.
2. Buoyancy applied to different objects with equal mass in fluids of different densities	Since the masses of the same objects will be the same, the buoyancies that affect them are the same, too.	Since the masses of the objects are the same, the volume of the object does not have an influence on buoyancy.	Since the masses of the objects are the same, the immersed volume of the object does not have an influence on buoyancy.	Since the masses of the objects are the same, fluid density does not have an influence on buoyancy.
3. Buoyancy applied to different objects with equal mass in fluids of same densities	Since the masses of the same objects will be the same, the buoyancies that affect them are the same, too.	Since the masses of the objects are the same, the volume of the object does not have an influence on buoyancy.	Since the masses of the objects are the same, the immersed volume of the object does not have an influence on buoyancy.	Since the masses of the objects are the same, fluid density does not have an influence on buoyancy.
4. Buoyancy applied to the object by a densier fluid added in the fluid	With the increase in the density of the mixture, the object with the same mass does not sink and this shows that buoyancy stays the same.	For this situation, the volume of the object does not have an influence on buoyancy.	For this situation, the immersed volume of the object does not have an influence on buoyancy.	Since the object moves up as a result of the increase in the denisty of the fluid, this situation does not have an influence on buoyancy.
5. The buoyancy applied to different objects with equal immersed volumes in the same fluid	Since the masses of the objects are unknown, no comment is made on buoyancy.	For this situation, the volume of the object does not have an influence on buoyancy.	Since the immersed volumes of objects which do not sink in the same fluid are the same, their buoyancies are the same.	For this situation, the density of the fluid does not have an influence on buoyancy.
6. The buoyancy applied to different objects hanging with equal volume in the same fluid	Since the masses of the objects are unknown, no comment is made on buoyancy.	Since the immersed volumes of objects hanging in the same fluid are the same, their buoyancies are the same.	Since the immersed volumes of objects hanging in the same fluid are the same, their buoyancies are the same.	For this situation, the density of the fluid does not have an influence on buoyancy.
7. Sinking of the toy boat made from play-dough	For this situation, mass does not have an influence on buoyancy.	For this situation, the volume of the object does not have an influence on buoyancy.	The dough sinked to the bottom since its immersed volume decreased and thus buoyancy decreased.	For this situation, the density of the fluid does not have an influence on buoyancy.

Bulgular

In accordance with the results of the analysis, a total of 9 codes (density of liquid [D. L.], mass/weight [M./W.], density of object [D. O.], volume of object [V. O.], shape of object [S O.], immersed volume [I. V.], sinking [S.], surface area [S. A.], identical object [I. O.]) were identified from raw data obtained from eight students' responses to seven questions (Table2). Accordingly, all of the eight grade secondary school students showed inconsistencies in their responses to the first question set (1st – 4th questions) regarding the relationship between" buoyancy and mass" (Table 2).

Table 2. The Ideas of Students About Buoyancy Concept in the Two Question Sets

	The Relationship of Buoyancy Concept - Mass Concept (First Question Set) 1th-4th Questions				The Relationship of Buoyancy Concept- Immersed Volume (Second Question Set) 5th-6th Questions		
	1	2	3	4	5	6	7
S1	D. L.	M./W.	D.O.	D.L.	I. V.	I. V.	I.V. ve S.
S2	I. V.	M./W.	M./W.	M./W.	I. V.	I. V. and D. O.	S.A.
S3	I.O.	S.O. and D O.	V. O.	D.L.	V.O. and D.O.	V.O. and D.O.	I.V. and D.O.
S4	M./W.	M./W.	V.O.	I.V. and D.L.	I.V.	D.O. and M./W.	S. and M./W.
S5	I.V.	D.L.	V.O. and D.O.	D.L.	I. V.	I.V. and V.O.	I.V.
S6	M./W.	M./W.	M./W.	D.L.	V.O., D.O. and M./W.	V.O., D.O. and M./W.	V. O.
S7	I.O.	D.L.	V.O. and S.A.	D.L.	V.O.	V.O.	V.O.
S8	M./W.	V.O. and D.O.	V.O. and D.O.	D.L.	V.O.	V.O.	V.O.

According to the Table 2, associations in the question set about the relationship between buoyancy and mass are as follows:

Student 1 associated buoyancy force with the concept of "density of liquid" in the first and fourth questions and "density of object" in the third question. The same student associated buoyancy with "mass/weight" in the second question. One of the most typical associations in the first question set which lead to inconsistencies in student's response is between the concept of "density of liquid" and the concept of "buoyancy". Student's statement is as follow; " ... *Well, buoyancy force changes according to the density of water... buoyancy force is greater for that floating substance* ... " and for the fourth question " ... *because denser liquid will be poured into the container, density will be very high… Thus buoyancy will increase too* ... ".

Student 2 associated buoyancy with the concept of "mass/weight" in the second, third and fourth questions. The same student associated it with "immersed volume" in the first question. The most typical association that caused inconsistency in **S2**'s answers was the association of buoyant force with the concept of immersed volume in question 1. The quotation that documents the association is: "... *here, there is more immersed volume... Buoyancy will be greater* ..." .

Student 3 associated second question with "shape of object"; third question with "volume of object" and fourth question with "density of liquid". Only the first question was associated with the concept of "mass/weight". For **S3,** the quotations of the associations that caused inconsistency in question 2 were as follows; "... *But the objects are different, too here*...", "… *Equal mass, it can be different in both. Both the fluids and the objects are different…*" while the quotations for the third question were, "**…** *May be different. Because since this one has greater volume, even if it is the same fluid, while floating, the difference is greater buoyancy…*" The quotations that proved inconsistency for the fourth question were , "… *If the fluid's density increases… Its buoyancy will increase, too…*".

Student 4 explained the third question with the concept of "volume of object" and the fourth question with the concepts of "density of liquid" and "immersed volume". The same student associated the first and second questions with the concept of "mass/weight". For **S4,** the quotations of the associations that caused inconsistency in the answers for the third question were as follows "… *When we consider the formula V immersed times d fluid, the fluids are the same, **their densities, errr,** since it says that these have equal masses, it is greater, this one is greater. This means that this one has greater volume than the other…*" while the quotations "… *Buoyancy depends on the density of the fluid. It depends on the immersed volume. And the density of the fluid. When we add a denser fluid in the container to the fluid, these mix together, right?* ..." and " … *there will be an increase in the density. Therefore V immersed times d fluid. If we think that the immersed volume is the same* …" were evidence for the fourth question.

Student 5 associated the first question with the concepts of "immersed volume" and the third question with the "volume of object" and "density of object" respectively. The same student explained the second and fourth questions with the concept of "density of liquid" respectively. As for the associations that were naive and that created inconsistency, the expressions for the first question, "... *Errr,… The formula of buoyant force is V immersed times d fluid. In the first figure, since the immersed volume is greater, the buoyant force is greater. In the second figure, mmm, since half of the volume is immersed, buoyant force is less…*"; the expressions for the third question, "… *the density of object K is equal to the density of the fluid. However, since object M has greater volume, it has smaller density. Thus, buoyant force is less than K…*" and for the second question the expressions, "... *Errr, whichever fluid is denser, it has the greater buoyant force…*" and for the fourth question, the expression "… *if a denser fluid is added, the density of the fluid will increase. The buoyant force affecting object K can decrease…*" can be presented as examples.

Student 6 associated buoyancy force with the concept of "mass/weight" in the first, second and third questions. For the fourth question, the answer was "density of liquid". Thus, for **S6,** the quotations for the question four that caused inconsistency in the answers "… *Since density changes… in fact buoyant force increases. It goes up. Buoyant force increases…*" and "… *Since it is mixed with a denser fluid, just in the middle, I mean… it will be between the density of the first fluid and the density of the added fluid. Thus, density increases*..." presented evidence.

Student 7 associated the first question with the "identcal object", and the second and fourth questions with the "density of liquid", and the third question the "volume of object" and "surface area" respectively. For **S7,** the quotations of answers that caused inconsistency were as follows: For the first question, "… *Because of this, I think that no matter in which fluid, the same object will be applied the same buoyant force…*" and "... *Here, since it is the same object, the same buoyant force will be applied* …"; for the second question, "… *Errr, I think that what makes more L float is denser fluid. Because it made it float more…*"; for the fourth question, "… *Err, since a denser fluid is added, the buoyant force will be greater…*"; for the third question, "… *Since M's volume was greater, I think it floated more. Because of that, since there was greater surface area for M, I think that it floated more in M. M has greater buoyant force*" and "… *K has less volume than M, so I think that less buoyant force affects…*"

Student 8 associated the first question with the "mass/weight", and the second and third questions with the concepts of "volume of object and density of object", and the fourth question with the "density of liquid" respectively. For **S8,** the quotations of answers that caused inconsistency were as follows; for the second question "*… Because the objects L and K have equal mass but different volumes. I think that L has greater volume. Thus, it will have less density. The fluids have different densities, too…*"; for the third question, "*… Err, they have the same buoyant force. They are the same fluid, but although they have an equal mass, since their volumes are different, their densities will also be different. Err, in fact their buoyant forces will not be the same. K's will be smaller than M's. Because, M's volume is greater. Thus, it will have less density. This time, the buoyant force that the water applies will be greater than K…*" and for the fourth question, "*… The last situation of the buoyant force… the one in the container is denser. K, buoyant force increases…*" and "*… Since the fluid poured from the fluid, err, the poured fluid will be greater than the fluid in the container, it will push the object K higher. This is related to density…*" According to these Results revealed that students used different concepts and gave inconsistent answers to the questions constituting the first question set.

For the question set regarding the relationship between buoyancy and immersed volume (5th - 7th questions), there were inconsistencies in the responses of the **student 2 and 4,** in other words, the students' responses were changeable throughout their reasoning for at least one concept (Table 2). It was determined that **student 1, 3, 5 and 6** showed consistency throughout the question set for at least one concept. However, there were inconsistencies in these students' reasoning within a single question (Table 2).

Associations and supportive quotations of the students exhibiting inconsistencies for the second question set are given below:

Accordingly, one of the students showing inconsistency for all question set; **Student 2** associated the concept of buoyancy with "immersed volume" in the fifth question. The same student associated the concept of buoyancy with the concepts of "immersed volume" and "volume of the object" in the sixth question and the "surface area" in the seventh questions respectively. **Student 4** associated this concept with the "immersed volume" in the fifth question, and the concepts of "mass/weight and density of object" in the sixth question, and the concepts of "sinking" and "mass/weight" in the seventh question. In addition, it was also determined that **Student 2** made reference to the concepts of "immersed volume" and "volume of object" in the sixth question and in this way had inconsistency by associating with more than one concept in the same question. Except for the concept of " mass/weight" both in the sixth question and the seventh question, **Student 4** also associated the concepts of "density of object" in the sixth question and "sinking" in the seventh question. Thereby same student had and inconsistency in those questions

Of the students exhibiting consistency in terms of at least one concept in whole question set but inconsistent within a single question, **Student 1** showed consistency with respect to the concept of "immersed volume" in the fifth, sixth and seventh questions but showed inconsistency by associating the concept of "sinking" as well as the concept of "immersed volume" in the seventh question. **Student 3** showed consistency throughout the question set with respect to the concept of "density of object" but exhibited inconsistency by associating the concepts of "volume of object" and "density of object" in the fifth and sixth questions, and "immersed volume" and "density of object" in the seventh question. **Student 5** showed consistency with respect to "immersed volume" concept in the fifth, sixth and seventh questions, but the same student showed inconsistency by making reference to the "volume of object" concept except for "immersed volume" in the sixth question. **Student 6** showed consistency with respect to the concept of "volume of object" in all question set but exhibited internal inconsistency in the fifth and sixth questions by making reference to the concepts of "volume of object", "density of object" and " mass/weight ".

The sample quotation, the evidence of inconsistencies, is as follows:

Accordingly, for **student 2**, answers leading inconsistencies are the answers given to the sixth and seventh questions. Student's answer for the sixth question is as follows, " ... *Since they suspend in liquids, their immersed volumes are equal. And volumes of them are equal, the question has already indicated this. Since density of liquid is equal, their buoyancy forces are also equal as well... and ... This is due to the fact that they have equal volumes...*" and for the seventh question, " ... *This is due to the surface area...*".

For **S4,** the answers that caused inconsistency were especially sixth and seventh questions. The examples for sixth question are, "… *No, err, we saw the same examples in class, buoyant force was said to be equal to the weight of the object when they were hanging. Now, it means that they have the same density, since they are both pending. Then, we can say that their masses are the same. Thus, they are the same...*" and "… *As I said, buoyant force equals the weight of the object...*" And the examples for seventh question are, " *It is here since it settled down, it means that the buoyant force is not greater than the weight of the object. Err, well, their weights are the same. It is the same here, too. Thus, I'm saying that the buoyant force affecting this is greater*".

The answers in which **S1** showed inconsistency in associations is only of question 7. For question 7, the answers "... *Again, it sank in the same density. Buoyant force will be equal again…*", "… *It is applied more in the immersed one…*" and "… *Being more immersed…*" are a proof to both conceptual associations and inconsistency.

The quotations that showed inconsistency for **S3** were *"… Then, object N will have greater volume..."* and *"… Then, N will have greater buoyant force applied. It will have less density than K..."* for question five; " … *They are equal. They are both pending and they both have the same volume. They will have the same density, too…*" for question six and "… *The volume in contact with the fluid changes"* and "... *Its density increases. Buoyant force increases, too…"* for question seven.

In the sixth question the quotation of **S5** in which he refers to "immersed volume" and "object volume" is "... *These are equal, too. Because their immersed volume is equal, too. And they normally already have equal volume..."*

The inconsistencies that **S6** showed in the fifth and sixth questions were respectively "… *Here, buoyant force… If it is equal, it is directly proportional to volume*", "… *Depends on their weight…*" and *"… If they have equal volume, since this floats, its weight, wait a second… Since the density of this is smaller, its weight is also smaller. Thus, the buoyant force applied is smaller …*" for the fifth question and "… *Because they both have the same density with the fluid. They both have to have equal density since they are both hanging. Since their volumes are equal, their weights are equal, too. Thus, their buoyant force is also equal...*" for the sixth question.

However visual materials and questions used in the interwiev process during the study (given in Figure 1) led to determined students' intuitive ideas and their relationships with *p-prim flotation* (Figure 2).

Table 3. The Codes and Their Frequencies Under the Influence of P-prim Flotation

Students/Codes	VO	DO	DL	M/W	SA	IO	SO	SV	S	Total
S1	-	1	2	-	-	-	-	-	-	3
S2	-	-	-	-	-	-	-	1	-	1
S3	3	4	1	-	-	1	1	-	-	10
S4	1	1	1	2	-	-	-	-	1	6
S5	2	1	2	-	-	-	-	1	-	6
S6	3	2	1	2	-	-	-	-	-	8
S7	4	-	2	-	1	1	-	-	-	8
S8	5	2	1	-	-	-	-	-	-	8
Total	8	11	10	4	2	2	1	1	1	50

The frequency of the conceptualizations in the students' answers given under the influence of p-prim flotation is presented in Table 3. According to this, there are a total of 50 frequencies which are expressed by the influence of p-prim flotation. High frequency concepts which were expressed by the influence of p-prim flotation were the concepts of "volume of the object", "density of the object" and "density of the fluid" with a repetition of 19, 11 and 10, respectively. The frequency of the concept of "mass and weight" under the influence of p-prim flotation is 4. In addition, it was determined that all the students were under the effect of p-prim flotation and **S3** was the student who formed the maximum number of answers influenced by p-prim flotation with a repetition of 10, while **S2** was the student who formed the minimum number of answers influenced by p-prim flotation with a repetition of 2 (Table 3).

The following quotations are proofs of answers given under the effect of p-prim flotation and related concepts which are presented in Table 3.

As can be seen in the quotation, **S1** attributes the change in buoyant force to the density of the fluid and shows that the thought which leads to this view is floating. According to this sample quotation for **S1** is as follows: "... *Well, buoyancy force changes according to the water density. Substance K is neither floating nor sunk, I mean it is balanced in one case. It is floating in the other case and suspended in the last one. Buoyancy force is greater in that one...*"

Again, **S1** is under the effect of p-prim flotation in his/her answer to the question. This situation is revealed with the following quotations: "... *the volume, sorry, the* ***density*** *of one is less, this explains why it is* ***higher****. Because of this, it was the same with the previous question. Only the fluids were different. Both were, … well, the buoyant force on M, sorry K, is more, but K is upward, M is* ***floating*** ...", " Researcher: *Then, why do you think that the buoyant force on K is greater?*","***K*** *is more immersed when compared to* ***M****. It is applied more buoyant force but since it has more* ***density****, I mean it is proportional to density* ..."

However **S2** gave the answer for the first question that buoyancy will change under the influence of p-prim flotation : "Researcher: ... *You mean that the buoyant force for the first situation is higher. Why do you think this is so?* ...", "... *Here, the* ***volume of the immersed part*** *is higher*..." and "... *Buoyant force will be higher*..." If these quotations are associated with the positions of objects in Figure 1, it can be seen that **S2** has a perception that flotation is inversely proportional to buoyancy.

S3 answered the questions two, three, four, five and seven under the influence of p-prim flotation, while **S4** answered the questions four and seven under the influence of p-prim flotation . The influence of p-prim flotation was oberved in **S5** for the questions two, three and four, in **S6** for questions four and seven, in **S7** for questions two, three, four, five and seven and in **S8** for questions two, three, four, five and seven. **S3** answers question three as follows: "Researcher: ... *How is the buoyant force for this one and this one?*", "*It may be different. Since this one has greater volume, even if it is the same fluid, while*

***floating** there will be greater buoyant force …*"; The answer to the last question is as follows: "... *It **floats** here**.** Since it floats, it has greater buoyant force* ..."

S4 can be seen to be under the influence of p-prim flotation in the last question with this answer: "*It is greater in the first figure.*", "Researcher: *Why?*", "*Umm, how shall I put it into words? The object is completely immersed here. Then, since it is immersed, its weight is equal. The weight of the object has to be greater than its buoyant force, otherwise, it will **go up** with the influence of buoyant force. It is here since it is completely immersed, the buoyant force is not greater than its weight. I mean, their weights are the same. It is equal here. Because of this, I am saying that the buoyant force is greater.*" **S4** shows that he/she is under the influence of p-prim flotation by mentioning the upward move of the object without saying that the size of buoyant force and the immersion of the object are related to the change in the volume of the immersed part.

It can be seen that **S5** explained the concepts of density of the fluid and object under the influence of p-prim flotation, and also explained the association of density of fluid with the buoyant force differently especially in the second and fourth questions. In these quotations, the dependence of the change in buoyancy on the fluid's density results from the change in the visual positions of the objects.

Thus, it can be said that **S5** was under the influence of p-prim flotation with his/her expressions in question two: "... *greater buoyant force belongs to the fluid that has greater **density***..." and with his/her expressions in question four: "… *If a denser fluid is added, the fluid's density will increase. Buoyant force that influences object K may **decreas***..."

S5's answers to the third question which refer to the object's volume and density are significant in terms of emphasizing the effect of p-prim flotation. According to this, the expression *"the density of the object K is equal to the density of the fluid. But since the **volume of object M is greater**, its density is smaller. Thus, its buoyant force is smaller than K's*..." is a result of student's being under the influence of p-prim fotation.

It can easily be seen that **S6** is under the influence of p-prim flotation when the quotations from question four are analyzed: Thus when the following expressions in question four were analyzed; "... *It will be the same since weight equals buoyant force."*, "Researcher: *What do you think the reason is?...*", Expressions such as "***Since the density changes**… in fact buoyant force increases. **It goes up.** Buoyant force increases*...", "... *Since it is mixed with a denser fluid, it will be just in the middle, I mean… between the density of the first fluid and the density of the added fluid. Thus, denisty increases*." and "... *The object **goes up higher***." proves that **S6** focuses on the object going up as the density of the fluid changes and he/she develops the answers under the influence of p-prim flotation and how effective p-prim flotation is on the instant changes in answers given.

In fact, **S6** is also under the influence of p-prim flotation in question 5. This proves that p-prims support different naive ideas and thus behave systematically under various contexts: "... *If they have equal volumes and since this one **floats**, the weight of this, wait a second… Since this one has smaller **density**, this one has less weight. Thus, the buoyant force applied is less* ..."

S7 answered the second, third, fourth, fifth and seventh questions under the influence of p-prim flotation and the following are example quotations from second, third and fourth questions: For the second question**,** "... *does not have the same density.*" and "... *OK. I think that the buoyant force applied on L is greater here. Because it is more **upward**. Umm, K, errr, is not **floating** right now. Because of this, it is not immersed, but what is it called? ... Suspended, yes. Since it is suspended, and since **L is floating**, I think that **greater force** is applied*..."**,** for the third question, "... *Since M has greater volume, I think it is more **upward**. Because of that, I think that M is more **upward** since M has greater surface area. M has **greater buoyant** force*..." and for the fourth question; "*Errr, since a denser fluid is added, bouyant force will be greater. And the **object will float** ...*".

S8 was observed to have answered the second, third, fourth, fifth and seventh questions under the influence of p-prim flotation. Especially in the second question, the student tries to answer the difference of buoyant force with having different objects and thus having different volume and density in question 2. The student states implicitly that greater buoyant force is applied to the object that floats more.

The student's answers to these questions were as follows: For the second question, "*Density… Errr, object L has greater buoyant force than object K*" and "*Because objects L and K have equal masses but* ***different volumes****. I think that L has greater volume. Thus, it will have* ***less density****. The fluids have different density, too ...*", for the third question, "*Errr, their buoyant forces are the same. Same fluid, but although they have equal mass,* ***their volumes and densities will be different****. In fact, their buoyant forces will not be the same. K's is smaller than M's. Because* ***M has greater volume****. It will then have less density. This time, the buoyant force applied by water is greater than K...*" for the fourth question, "*... the latest condition of the buoyant force… denser inside the container. K will have greater buoyant force...*" and "*... Since the fluid that is poured will be greater than the fluid in the container, object K will* ***be pushed upward****. This is* ***related to density****...*", for the fifth question, "*... buoyant force is equal for immersed objects. Thus, the buoyant force applied on N is greater than the one applied on K. K and N have equal immersed object volumes. Thus, the force applied to N by the fluid is greater...*" and for the seventh question, "*... Although mass is the same in the first one,* ***volume is greater****. In the second one, although mass is the same,* ***volume is smaller*** *when compared with the first one. Because of this, the first one has less density and the second one has greater density. Buoyant force applied to the first one is greater. Since the second one is immersed, buoyant force is less...*". The quotations from the second, third, fourth and fifth questions prove that a *p-prim* can be generalized to different contexts in the privacy of **S8**.

Adding a denser fluid to the fluid causes a change in the buoyant force. Depending on the resulting density, buoyant force applied to the object changes.

The buoyant force applied to different objects of equal mass in fluids with different densities varies depending on the volume of the objects.

The buoyant force applied to different objects of equal mass in fluids with different densities depends on the density of the fluid.

The buoyant force applied to different objects of equal mass in fluids with same densities depends on the volume of the objects.

The buoyant force applied to different objects with equal immersed volume in the same fluid depends on the density of the fluid: the object with less density (flotation) has more/less buoyant force.

Phenomenological Primitive (P-prim): Flotation

The buoyant force applied to different objects of equal mass in fluids with equal densities is greater in the flotation object.

The buoyant force applied to same objects in fluids with different densities is related to the immersed volume of the object.

On condition that the object is the same, the buoyant force applied to the immersed object is greater.

In identical objects that do not immerse in fluids with different densities, buoyant force is greater based on the density of the fluid.

In objects with equal masses that do not immerse in fluids with identical densities, buoyant force increases as the density of the fluid increases.

Figure 2. Intuitive Ideas that cause inconsistency in the students' answers and P-prim Flotation

Discussion, Conclusion and Suggestions

When the findings of the study were analyzed with respect to both the relationship between buoyancy and mass and buoyancy and immersed volume, it was determined that most of the students could have not exhibited consistent associations and showed inconsistencies in their responses (Table 2). Within the scope of qualitative data in the study, these findings indicate that knowledge structures of the participants regarding the concept of buoyancy are coherent with diSessa's theory of knowledge in pieces (1993).

In the first question set which examined the association between buoyant force-mass, inconsistencies were found in the answers of all of the eight secondary school eight graders who participated in the study (Table 2).

In the second question set which examined the association between buoyant force- immersed volume, inconsistencies were found in the answers of two (**S2** and **S4**) of the eight students in different questions. Apart from this, it was found out that four students (**S1**, **S3**, **S5** and **S6**) showed internal inconsistencies in their answers of a question during the interview process. This data proves that a change which depends on the questions or the context is formed in the students' answers and the cognitive structure of the students is coherent with diSessa (1994)'s knowledge in pieces theory. Inconsistencies within a question is significant and instant internal inconsistencies of the naive cognitive structure is in parallel with the literature (diSessa, 1993, 2002 and diSessa et al., 2004).

It can be seen that most of the students (except **S7** and **S8**) resorted to 9 concepts that caused them to show inconsistencies in their answers about buoyancy of water and the occurence frequency of these concepts was 50 (Table 3). It was determined that the students associated these answers that caused inconsistency with the concept of flotation either simultaneously or later in the same question. This finding is coherent with the evaluation that p-prims act as a guide in a naïve cognitive structure and cause the answers to change instantly (diSessa, 1993, 2002, 2004). From this point of view, it is probable to state that the phenomenon of flotation in the students' cognitive structure status assumes a p-prim responsibility and plays an active role in guiding their answers. Thus, the quotations of **S1** such as "... *the volume, sorry, the **density** of one is less, this explains why it is **higher**. Because of this, it was the same with the previous question. Only the fluids were different. Both were, … well, the buoyant force on M, sorry K, is more, but K is suspending, M is flotation* ..." and the quotations of **S3** such as "*It may be different. Since this one has greater **volume**, even if it is the same fluid, **while*** **floating** *there will be greater buoyant force* …" summarize that the cognitive status of the phenomenon of flotation has the characteristics of a *p-prim.*

Özdemir and Clark (2009) reported that students of four different education levels (preschool, primary school, secondary school and high school) showed inconsistencies in the explanations of force defined by Ionnanides and Vasniadou (2002). In the related work, the students' inconsistencies were compared according to the schemes of both Ionnanides and Vasniadou (2002) and diSessa et al. (2004) and it was found that the students showed inconsistency during their explanations of force in both code schemes. Similarly, in a study conducted by Özdemir (2007) with eigth primary school students, it was found out that only two of the students showed consistency while six of the students showed inconsistency in all question sets. Based on the findings of our study, it has been reported that students gave inconsistent answers to questions which created different perceptions and thus enabled contextual variety. Just like the concept of force which was dealt in the studies above, this situation shows that the students' conceptual structuralizations relating to buoyancy are fragmented and they are perceptively affected of context.

A great number of studies in literature support the fragmented knowledge structure theory (Abrams & Southerland, 2001). For example, in studies relating to weight and free fall (Sherin, 2001), heat energy and thermal equilibrium (Clark, 2006), biological adaptation and migration behavior (Shoutherland et. al., 2001), force (diSessa et.al., 2004) and air pressure (Turcotte, 2012) it has been revealed that students show contextual inconsistencies.

The findings of the study are in parallel with the static physical universe perception identified by Ueno (1993) and diSessa (1993). According to this perception, while immobility is a state that does not require an explanation, motion is a state that requires an explanation and it is a sign of the presence of a force or a sign that the quantity of force changes. In our study, the perception in the first six questions and especially in the fourth question presented in Figure 1, is the perception that a force exists which enables the movement of the object from its first position to its second position. This state was defined as *force as a mover* p-prim by diSessa (1993). The qualitative findings from this study support the hypothesis that may be associated with *force as a mover* p-prim. Naive ideas that may be related to were presented in Figure 2. The students' standardized naive ideas generally have hypothetical association such as "... *it floats here. Since it floats, it has greater buoyant force*..." This structure of associated hypothesis in fact shows that is a synonym of the definition of *floating force of buoyancy*. The definition of *floating force of buoyancy* makes the association of with *force as a mover* p-prim clearer. The association of p-prim flotation with *force as a mover* p-prim and the association of *force as a mover* p-prim (that is, if there is force, there is movement and the more force, the more movement) with "*the heavier, the slower or the lighter, the faster*" p-prims show that similar contexts will cause similar *p-prims* to take action and *p-prim*s will cause new *p-prim*s to emerge (diSessa, 1993, 2002).

When the codes in Table 2 are reviewed, it can be seen that especially **S3, S7** and **S8** generalized p-prim flotation in five questions with or after initiator oral statements. S7 and S8 developed the correct association for buoyancy and mass concepts in the first question; but they did not present same information in other questions; however, they gave inconsistent answers under the influence of p-prim flotation and thus generalized p-prim flotation in five different questions/contexts (Q2, Q3, Q4, Q5 and Q7) related to the same physical phenomenon (buoyancy). This situation that was seen in almost all of the students and exemplified in **S7** and **S8** confirms the notion that *p-prims* can be generalized in different contexts (Turcotte, 2012; diSessa, 1993). Although a formal learning process is expected to be able to generalize the scientific concepts learned to different contexts related to same or similar phenomenon, with the influence of *p-prim*, different answers come out in every different context and this situation supports diSessa (1993)'s knowledge in pieces theory.

Within a great number of studies of science education, the studies of Demastes, Good and Peebles (1996) about the theory of evolution presented findings that the students' thought structures are fragmented and multiple structures. In addition to this, studies of authors such as Tytler (1998), Sherin (2001) Southerland et al. (2001), Palmer (2001), Louca et al. (2004) and Clark (2006) emphasize that students' naive thought structures are fragmented, context sensitive, complicated and layered. The aforementioned studies state that students change their answers instantly as the context changes and this situation which can not be explained by theory-like knowledge structure theories can be satisfactorily explained by knowledge in pieces theory and *p-prims*. In his study, Tytler (1998) stated that students' factual experiences have a great influence on a new factual experiences, for example their experiences related to matter and air have a great effect on their explanations and ideas related to air pressure while he referred to the notion that their epistemological past and their way of perceiving the physical universe was effective in explanations about a new phenomenon or context. This comment is consistent with aforementioned diSessa (1993) and Ueno (1993)'s *static universe perception* or *p-prim* comment. The finding of our study that guided different explanations is in parallel with related comments (Table 3). At the same time, 10 naive ideas that emerged around and presented in Figure 2 can cause a consistent comment with Tytler (1998).

Different theories about conceptual change imply that change is process and evolutionary rather than sudden and revolutionary, and this view is a reference to the notion that students' cognitive structure is composed of flexible, semi-independent, conceptual and sub-conceptual components rather than being a strict structure (Posner et al., 1982; Vosniadou, 1994; Vosniadou & Ioannides, 1998, 2001). Especially when Posner et al. (1982)'s conceptual ecology theory is reviewed, it can be concluded that the theory in fact supports knowledge in pieces theory. Posner et al. (1982) emphasize that participants can barely actualize the process of accomodation and new information is assimilated in old information.

The reason for this is the difficulty of achieving the terms of the accomodation process. Based on the findings of Posner et al. (1982)'s studies and our studies it can be concluded that conceptual change can not take place instantly or revolutionary by facing a few contradictory situations. Such approaches support the claim that expected conceptual change occurs by taking different contexts and context variability into consideration.

According to a different point of view, Ueno (1993) accepts *p-prims* and asserts that as a result of their nature, p-prims are not only related to our individual cognitive structure, but also they are socially shared thought structures. In this sense, with one example, Uneo states that experimental activities which are realized cannot cause conceptual change. This view in a way confirms the approaches that conceptual change can not take place with studies of only reasoning, confirming or rejecting one or more hypotheses through standard texts. Because, according to Ueno, students cannot understand the great contextual structure of, for example Newton physics, with only such an experience. Contextual variety should be increased as much as possible for this. Thus, students' different answers for every different context of this study and the fact that these answers developed under the control of *p-prim* is in parallel with Ueno's approach.

When this study is considered with Lawson's approach, it can be seen that buoyancy is a theoretical concept (Lawson, Alkhoury, Benford, Clark; & Falconer, 2000). Comprehensive and complicated science concepts such as gene, ecology, atom, force, evolution and natural selection, which are defined by Lawson et al. (2000) as theoretical concepts in terms of their epistemic status, are formed through non-demonstrative observation and they interact with a great other number of conceptual structures. diSessa (1993) states that a great number of scientific concepts are not simple, isolated and absolute and defines such concepts as coordination classes (diSessa & Sherin, 1998; diSessa, 2002). Students' inconsistent answers to questions of buoyancy with different contexts can be resulting from the fact that the related concept is consistent with the aforementioned characteristics. Thus, it is natural for theoretical concepts to be constructed as naive ideas initially during learning experiences that take place in informal settings and to be associated with a great number of elements from different experiences or contexts. These elements defined by diSessa as *p-prim* step in during various experimental experiences and cause students' answers to be inconsistent. The participant students made associations with the flotation during the processes of informal or formal conceptualization of theoretical buoyancy. This situation has caused flotation to be structured as a *p-prim* and the emergence of naive ideas associated by this p-prim (Figure 2).

In conclusion, identification of such theoretical concepts and their associated *p-prims* is very important in terms of education applications. Because having examples of experimental activities effectively used for the determination of *p-prims* in these studies show that these examples can be used as an effective material for the creation of scientific concepts in teaching-learning process. Thus, applications examples used in *p-prim* diagnosis stage will provide contextual diversity and serve as a cognitive therapy. The findings of this qualitative study, despite limited number of participants, are expected to trigger the studies on conceptual change theory in our country. In addition, increases in the number of studies will make great contribution to the development of science curriculum and contextual richness of the content.

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