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CONCEPT ENHANCEMENT OF JUNIOR HIGH SCHOOL STUDENTS IN HYDROSTATIC PRESSURE AND ARCHIMEDES LAW BY PREDICT-OBSERVE-EXPLAIN STRATEGY

F. X. Berek[1]*, Sutopo[2], Munzil[3]

[1]SMPN Satap Nusadani, West Solor, East Flores, East Nusa Tenggara, Indonesia
[2]Physics Department, Natural Sciences and Mathematics Faculty, Universitas Negeri Malang, Indonesia
[3]Chemistry Department, Natural Sciences and Mathematics Faculty, Universitas Negeri Malang, Indonesia

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ABSTRACT

This study explored effectiveness of Predict-Observe-Explain (POE) strategy to enhance concept comprehension of junior high school students in hydrostatic pressure and Archimedes law concepts. Subjects of this study were 31 students of a private junior high school in East Flores in even semester year 2015/2016. By mixed-method design, this study concluded that (1) average score of concept comprehension was significantly increase ($p = 0.000$) from pre-test (36.77) to post-test (63.26) with strong category of effect size (1.62), and moderate category of N-gain (0.40); (2) learning was also succeed identifying some misconceptions and remedied it. Those misconceptions were: (a) hydrostatic pressure was influenced by liquid volume and or the shape of the container, (b) an object was floated for there was air within, (c) a sunken object had no buoyant force, and (d) the magnitude of buoyant force was equal to liquid volume; (3) some of common problems around the students in applying hydrostatics concept and buoyant force were as follow (a) related to mathematical representation of hydrostatic force $Ph = P0 + \rho gh$, most all students interpreted h as the depth measured from the bottom of the liquid column (not from the surface of the liquid as it should be), (b) related to buoyant force, the problem depended on the context where the question given. In context of immovable objects in a certain fluid, almost all student was hard comparing buoyant force magnitude to the weight. In context of sliding object in liquid, almost all students failed to explain the object position to its buoyant force.

Keywords: POE Strategy, Misconception, Hydrostatics pressure, Archimedes Law

INTRODUCTION

Learning sciences is not merely for mastering knowledge which composed by facts, concepts or laws, but it is also the process to find it out (Rule of Educational and Cultural Ministry of Indonesia Number 22 Year 2006). In consequence, Sciences learning shuould be able to facilitate students in identifying objects and phenomenon, describing phenomenon, purposing question related to the phenomenon, constructing explanation, testing explanation by other different ways and commnunicating their arguments (NRC, 2012). By this series of process, it is expected that students would get the knowledge meaningfuly (Mayer & Moreno, 2003; Akinbobola, 2015). In order to let the students learn meaningfuly, teachers need to use a penomenon to trigger their active thinking (Longfield, 2009).

There are Many everyday phenomena around student-related topics and the principle of hydrostatic pressure and Archimedes law. Based on the constructivism learning theory, naturally the students tend to make of his own explanation when dealing with the observed phenomena, and

***Alamat korespondensi:**
Email: fransberek@gmail.com

often the resulting explanation was inconsistent with the principles of science that should (Docktor & Mestre, 2014) .It is usually due to limited observations and their science knowledge (Yin et al., 2008; Wonget al., 2010; Radovanovic & Slisko, 2013) .The misconception which was established by the students often are stable , difficult to change, and disturbing the students in understanding new scientific knowledge better (NRC 2001; Docktor & Mestre, 2014). Therefore, it is important for teachers to know students' misconceptions brought and making it an important input in designing learning.

Previous studies showed that many students had misconception in hydrostatic pressure and Archimedes law phenomenon. (Loverude*et al.*, 2003; Heron*et al.*, 2003;Unal & Costu, 2005; Hardy*et al.*, 2006; Yin*et al.*, 2008;Skoumios, 2009; Cepni*et al.*, 2010; Cepni & Sahin, 2012;Wong*et al.*, 2010; Chen*et al.*, 2013; Radovanovic & Slisko, 2013; Ozkan & Selcuk, 2015). Loverude*et al.* (2003) dan Heron*et al.* (2003) reported students' difficulties in solving problems related to Archimedes laws. Yin*et al.* (2008) was succeed identifying 10 common missconceptions in students when observing sinked and floated objects. While Wong*et al.* (2010) reported that missconception in bouyant force was not only happened in middle school students but also in teachers.

Some researchers had done to apply learning to remedy misconception by 5E learning (Cepniel et *al.,*2010; Cepni & Sahin, 2012). The result was not satisfying. It needs other effort more effective.

One effort can be done to remedy students' misconception is by POE strategy and its variances (White& Gunstone, 1992; Yin*et al.*, 2008; Costu, 2008; Costu*et al.*, 2012; Kala*et al.*, 2012; Radovanovic, & Slisko, 2013; Kibirige*et al.*, 2014). The main point of the learning is giving chances for students to be involved in observation, proposing questions, constructing hypothesis of proposed question, making prediction based on the constructed hypothesis, testing prediction, and repair hypothesis to get a valid explanation related to learned phenomenon. The learning is appropriate to essence of learning science as a process (NRC, 2012) and it is believed can enhance students' critical hinking skills (Riveros, 2012; Etkina & Planinsic, 2015)

Some studies had reported the effectiveness of learning based POE in remidiating students' misconceptions, For example, Costu (2008) and Costu*et al.* (2012) was succeed remediating students' misconception in condensation processs, Kala*et al.* (2012) was succeed remediating senior high school students' missconception in pH and pOH. Kibirige*et al.* (2014) was succeed remediating students' misconception in salt dissolving process in water. Related to hydrostatic, Radovanovic & Slisko(2013) reported effectiveness of POE learning to remediate junior high school students' misconception in bouyant force.

By this study, we constructed and applied POE learning strategy in hydrostatic pressure and Archimedes law . Generally, the learning sequence is shown by Figure 1. The core of the learning was to give a broad chance to the students to observe the phenomenon, describe it conceretely, proposing questions, making hypothesis on the proposed question, making a prediction based on constructed hypothesis, testing validity of the prediction by experiments, and reconstruct the hypothesis to get a valid explanation about related phenomenon.

As a concerete representation of the learning implementation, here is shown a learning sequence in hydrostatic pressure concept, especially related to the principle at any point is proportional to the depth of the point.Peristiwa-learning events that arise at each stage are also presented. Learning events appeared at each stage are shown bellow.

The teacher presented the phenomenon of water gushing through the holes in the bottle (Figure 2), and then asked students to describe the phenomenon. One description of the student was "water has increasingly distant glow when the

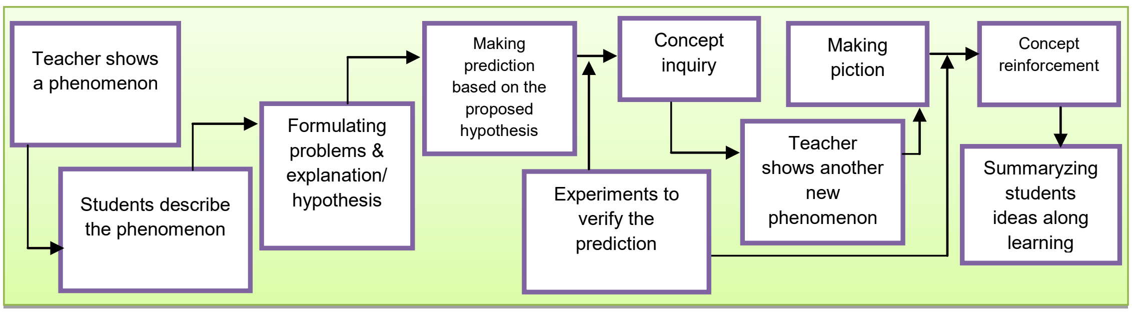

Figure 1. General Sequence of Learning by POE Strategy

hole in the bottle is deeper.

The teacher asked the students to formulate the problem based on the phenomenon that has been described. One formulation of the problem that the students were "why the water that comes out through the bottom holes have jets farthest?"

Figure 2. Water gushing Phenomenon from a Bottle

Teacher asked students to make hypotheses regarding the formulation of the problem created. Most students left the hypothesis: "the difference jets of water due to differences in the volume of water that is on every hole." Others proposed: "difference jets of water due to differences in water pressure at every hole".

Teachers guided students test his hypothesis by measuring the water pressure using the Hartl tool. (Previous teachers demonstrated the functions and workings of the tool) After experimentation, the students agreed that the difference jets of water coming out through the holes in the bottle due to differences in water pressure.

Teachers guided students to evaluate the accuracy of other hypotheses that have been raised student. Through FAQ student eventually concluded that "the difference jets of water not due to differences in the amount of volume that is on every hole, but due to the difference in pressure in the water".

Teachers guided students to formulate its findings in the form of mathematical models. Through interactive discussions, the students formulated the principle that the water pressure at any point is proportional to the depth ($Ph \sim h$).

The teacher asked the students to predict pressure ratios in the bottom of the water in several different columns as shown in Figure 3. In Figure 3 (a), all columns filled with water so that the water surface just as high. In Figure 3 (b), all columns filled with water at the same volume. Both problems are presented sequentially, first Figure 3 (a) and Figure 3 (b). Related to the situation in Figure 3 (a), all of the students thought that the biggest pressure in the container A, while the smallest in container B. They reasoned because the water in the container A container at most and at least Bs. Related to the situation in Figure 3 (b), the students said that the pressure in the container A most for its widest cross-section.

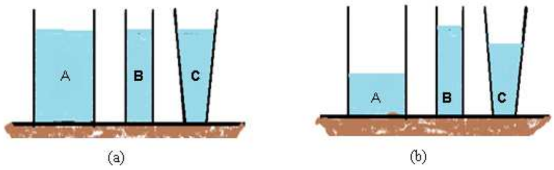

Figure 3. The Design Problem to Check Students' Understanding

The teacher asked the students to test their predictions with experiments using the Hartl tool. After experimentation, all students agreed that the pressure in the third bottom of the housing in Figure 3 (a) equal, whereas in Figure 3 (b) the greatest pressure occurs in the column B, followed by C and A. Based on these experiments, teachers emphasized once again that which determines the amount of pressure is the depth of the water, not the shape of the column and the amount or volume of water.

Learning sequence in other topics is generally similar. However, the activities depend on classroom environment and characteristic of the topic. Learning applied to all topics in concept of hydrostatic pressure and Archimedes law. The learning was conducted during even semester of academic year 2015/2016 (January – February 2016) at SMP Mater Inviolata, Larantuka, East Flores Regency, East Nusa Tenggara Province. This school is one of most favourite schools in this regency.

This article is mainly focused on (1) how far POE strategy can enhance students concept understanding in concept of hydrostatic pressure and archimedes law? (2) what missconception revealed during learning, and how far the learning can overcome it? (3) what is the common difficulty of the students and can not be solved yet by this learning (if it is exist)?

The research subject was 31 students of VIIIA SMP Mater Inviolata Larantuka. This class is the best class among others. POE learning strategy or something similar had never been applied in this classroom. So far, science learning was mostly conducted by conventional spproach. All students live at coastal area, eventhough their parents are not fishermans. Generally, the parents works at govermental offices and the small parts are entrepreneurs. The first author in this article is the teacher.

Table 1. Description of Measured Competences for Each question

Number	Measured Competence
1	Explaining the reason why a certain point in an aquarium has the biggest hydrostatic pressure
2	Explaining reason why points in horizontal line in some containers have different hydrostatic pressures
3	Counting hydrostatic pressure at fish's mouth
4	Explaining sequence of hydrostatic pressures of points in horizontal line under the can
5	Explaining bouyant force of static object in water
6	Explaining why an object is lighter when we put it underwater
7	Counting bouyant force of sinked object in the water
8	Comparing height of a ship above marine and freshwater
9	Explaining effect of object's position underwater to its bouyant force work on it

The research design used to response the proposed research questions is *mixed method-embedded experimental design* which is adapted from Creswell & Cark (2007). Quantitative data included students' pre-test and post-test score (multiple choices test), and the qualitative data included students' reasoning on their pre-test-and post-test answer, as well as events appeared during learning process, Pre-test was done a week before learning and post-test was a week after learning. Learning was conducted in four weeks with three hours learning in each week. The pre-test and post-test used the same instrument which is composed of nine multiple choice questions. Students' competence measured is described by Table 1. First until fourth questions were related to hydrostatic pressure, while questions number 5 until 9 were related to Archimedes law (Table 1)

Research instrumen were validated by sciences educational expert to observe its conformity with the construct of measured competences. It is also had been tested to 114 students with the results as follow. One question is in difficult category (Number 9), six questions are in middle category (number 1,3,4,5,6,and 8), and two questions are in easy category (number 2 and 7). Generally, the instrument had Alpha Cronbach value of 0,20 and could be categorized in low reability category (Everitt & Skrondal, 2010).

The first research question, answered through the analysis of quantitative data with a different test for paired samples (score pretest and posttest) followed by analysis of the level of learning effectiveness to use parameternormalized gain (*N-gain)*:<g> =) (Hake, 1998) and Cohen's d-effect size (Cohenet al., 2007; Morganet al., 2004; Ellis, 2010). The use of N-gain and d-effect size commonly used to assess the effectiveness of a lesson (see for example, Sutopo & Waldrip, 2014; Sinaga & Suhandi, 2015; Kleinet al., 2015; Finkelstein & Pollock, 2005; Colettaet al., 2007; Pursitasariet al., 2015).

The third research question to be answered qualitatively based on data obtained during the learning process and by students' reasoning test. Analisis directed to identify miskonsespsi that appears during learning and especially that still exist today postes.Selain it, also qualitative analysis to understand more deeply quantitative findings as directed by the first research question.

RESULT AND DISCUSSION

Enhancement of students' scientific concept understanding

Descriptive statistic of pre-test and post test scores is summarized in Table 2. It seems that the average of post-test score is far higher than the pre-test. To test its significancy need to do difference test to both data set. Considering that skewness distribution of the pre-test and the post-test is in interval of [-1,1], we refered to Morganet et al (2004) to use paired sample t-test.

Table 2. Statistical description of Pre-test and Post-test Score

	Pretest	Postest
Number of Data (N)	31	31
Average	36.77	63.26
Standart of Deviation	16.231	15.942
Skewness	0.342	-0.095
Lowest Score	11	33
Highest Score	78	89

Note: Score interval is 0-100

By using SPSS, obtained t (df = 30) = - 7.73

with p = 0.000 (two-sided). This analysis showed that the difference between pretest and posttest scores is statistically significant.Karena average post-test score (63.26) was higher than the average pretest score (36.77) it can be concluded that the learning is applied in this study effectively improve student mastery of topics hydrostatic pressure and Archimedes' law.

The result of the calculation of Cohen's d-effect of 1.62, was categorized in the category of strong or very high (Morganet al., 2004; Ellis, 2010). The calculation of the average value of the N-gain gave average of 40; included in the medium category (Hake, 1998) or the lower middle (Sutopo & Waldrip, 2014) It can be concluded that the POE strategy applied in this study provided strong positive impact of improving students' understanding.

Based on the record of learning,it is revealed indications of misconceptions that can then be remedied through the learning. Indication of the misconception related to hydrostatic pressure had appeared since the beginning of the learning when the teacher presents the phenomenon of water gushing from the holes in the bottle wall. As explained in the introduction, some of the students thought that the difference jets water was caused by differences in the volume of water on each hole, the more water over the hole faster and faster jets of water through the hole. This thought delivered students on the misconception that the hydrostatic pressure is influenced by the amount of water and not the water level in over a point to consider. The other misconceptions revealed during learning is that the water pressure is also influenced by the shape of the container. Misconceptions that have been improved through the experiment to measure the water pressure by using the Hartl tool.

Indications of misconceptions related to the buoyant force was revealed when the teacher presents the phenomenon of forced and encouraged balloon into the water. Most of the students thought that the balloon pushed up because there was air in the balon. The misconcetion had been successfully repaired with the demonstration of an empty balloon float (not blown) in water. Another misconception arised during the course are (1) objects which has no bouyant force will sink, and (2) the amount of water in the container affects the magnitude of the buoyant force: the more water in the container the greater the buoyancy experienced by the object. The misconception has been successfully removed by experiments measuring the buoyancy experienced by objects in the container contains a lot of water and a container containing a small volume of water.

Unresolved students' difficulties by the end of learning

The low N-gain value indicates there are still some concepts that have not been well understood until the end of the learning. Therefore, in order to further improvements, needs to be seen where the capabilities that have not been raised by optimal. Therefore, first of all needs to be a shift in the distribution of students' responses of the pretest to postest for each item.The results are summarized in the Figure 4. In topic of hydrostatic pressure (Figure 4a), students seemed that they still had not mastered the skills tested on question 3. In Archimedes Law topic, many students who have not mastered the skills tested on question 5 and 9. Therefore, it is still need to be deeply explored how students' thinking when answering such questions.

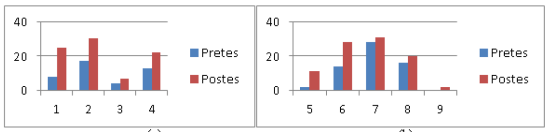

Figure 4. Distribution of correct answer for each question in pre-test and post-test (a) in topic of hydrostatic pressure, (b) in topic of Archimedes principle

Difficulties related to Hydrostatic pressure

Question number 3 aimed to explore students' ability in determining hydrostatical pressure at certain point inside of a container (Figure 5) o answer this question correctly, students must understand the formula of Ph = P0 + ρgh well. If there are no errors in the counting operations (algebra), students who answered A used the formula Ph = ρgh with h = 60 cm; students who answered B used the formula Ph = P0 + ρgh with h = 60 cm; students who answered C used the formula Ph = ρgh with h = 80 cm; and students who answered D used the formula Ph = P0 + ρgh with h = 80 cm, means it has been able to use the formula correctly. Shifting the students' answers from pretest to posttest are presented in Table 3.

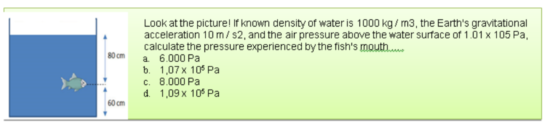

Figure 5. Question number 3

As shown in Table 3, the distribution of students' answers are not so changed from pretest to postes. Students who answered correctly only increased slightly, from 4 to 7 of students. On post-test, most students (11 of 31) chose the wrong answer B with 7 students of whom chose A when the pretest. The data shows that students do not yet understand well the meaning of the quantities that appear in the equation Ph = P0 + ρgh. Most students (16 of 31), who chose either A or B, interpreted the h as the height of the bottom of the vessel and not on the surface of the water (Figure 6).

Table 3. Crosstabulation of students' response in pretest and posttest for item number 3

		A	Postest			Total Pretest
			B	C	D*	
Pretest	A	2	7	1	2	12
	B	2	3	2	0	7
	C	1	1	4	2	8
	D*	0	0	1	3	4
Total Postest		5	11	8	7	31

NB : * = correct answer

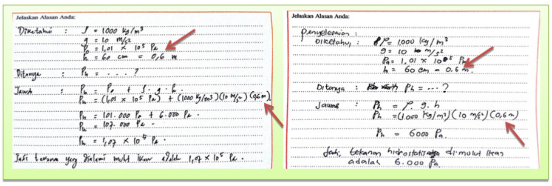

Figure 6. Example of Students Misconception in Understanding Depth Concept

This mistake indication was revealed during learning where students tend to understand depth concept as hight. Actually, the teacher had been doing an effort to repair it through questions example with pictures. Another weakness appeared is P_0 definition. Almost all student (who chose A and C), did not involve P_0 in their calculation. Many students who had those difficulties showed that the learning was not helpful enough for the students to understand formula $P_h = P_0 + \rho gh$ well.

Difficulties related to bouyant force

Students' difficulties related to bouyant force were indicated by many students who got wrong in answering question number 5 and 9. Question number 5 aimed to explore students' understanding about bouyant force of static objects underwater (Figure 7)

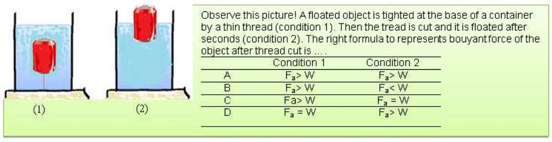

Figure 7. Question number 5

To answer this question correctly, students should apply Newton Law about movement, mainly in analysing forces in both conditions. Students who chose A, B or D are most likely did not put Newton law in solving the problem.They only used bouyant force principle with inappropriate understanding. For instance, students who chosed A thought that bouyant force at floated object is always bigger than its weight, whereas students who chosed D found that during the objects do not float nor sink to the bottom, the magnitude of the buoyant force is equal to the weight. On the other hand, students who choose B thought that the magnitude of the buoyancy of floating objects experienced less than its weight. Distribution and shift students' answers from pretest to posttest presented in Table 4.

Table 4. Crosstabulation Students' Answer on Pretest and Postest for Question Number 5

		Postest				Total Pretest
		A	B	C*	D	
Pretest	B	1	9	6	4	20
	C*	0	0	2	0	2
	D	0	3	3	3	9
Total Postest		1	12	11	7	31

Note: * = All anwer is correct

As shown by Table 4, distribution of students' anwer is significanly changed, from 2 students to 11 students. This increase came from six students who choose B plus 3 students who choose D when pretest. Data indicate that the number of students who had a right understanding increased after the learning. However, most students (12 of 31) chose the wrong answer B where 9 of them also chose B in pretest. Other students (7 of 31) chose the wrong answer D where 4 of them also chose D in pretest. Data showed that most students had not been able to solve the problem correctly. Some of them even stand on at the wrong initial understanding despite they had the learning process.

The possibility to get the difficulties had been predicted, because during learning process, students and teacher never relate the Newton law. It was intentionally done in order to see how far students are able to aplly Physics concepts or law which have been learned before when solving problems. Data showed that students were failed to do that. We have suggested the importance of involving Newton law in learning Archimedes principle (Berek et al, 2016)

Question number 9 aimed to explore students' understanding about effect of object position underwater to bouyant force worked on it (Figure 8)

A stone is dropped from a lake surface, then it slides to the base. When it is sliding underwater, the bouyant force of the stone when it gets deeper position is ....
a. constant
b. increase
c. decrease
d. decrease, increase, then constant

Figure 8. Question Number 9

To correctly answer this question, students should understand that the power of bouyant force of an object is equal to weight of fluid moved by the object; as long as there is no change in liquid volume moved by the object, the bouyant force is also constant. Students who chose B, C, or D may simply did not use the principle in answering the questions.The distribution of students' answers from pre-test to post-test is shown y Table 5. When pre-test, there was no one could answer it correctly, whereas in post-test there were only 3 students correctly answered the question. Generally, students chose C both in pre-test and post test.

Table 5. Crosstabulation of Students' Answer on Pre-test and post-test for question number 9

		Post-test				Total Pretest
		A*	B	C	D	
Pre-test	B	0	0	1	1	2
	C	3	5	18	1	27
	D	0	1	1	0	2
Total Post-test		3	6	20	2	31

Note: * = Right Answer

Least students who could correctly answer this question, both in pre-test and post-test, indicated that students had had wrong prior knowledge and the learning were not able to repair it yet. Many students who consistanly chose C, indicated that students had misconception related to bouyant force in context of slidedown object in homogeneous liquid. They thought that the deeper object position the smaller its bouyant force. Furthermore, the learning even added a number of students who think that the deeper object posiyion the bigger its bouyant force, from 2 students become 6 students (Table 5)

Based on the previous explanation, we found some students' difficulties in applying bouyant force principle into contexts. In static context object in liquid (Figure 6), almost all students were not able to compare the magnitude of bouyant force of the object with its weight. In slide object context in liquid (figure 7), almost all students (3 of 31 students) got difficulty to explain the effect of object position to its bouyant force. Those difficulties can not be solved by learning strategy used in thi study.

CONCLUSION

Based on the results and discussion above, it can be concluded that; The applied POE strategy in this study could significantly increase students' understanding in concept of hydrostatic pressure and bouyant force (p = 0.000) with effect size of 1.62 (strong or very high category) and N-gain of 0.40 (medium or low medium category)

The learning also could identify some missconception and repair it. Missconceptions which coud be repaired are: (a) hydrostatic pressure is influenced by liquid volume and or shape of the container, (b) an object can be floated because there is air within, (c) sinked objects have no bouyant force, and (d) bouyant force is equal to liquid volume.

The common students' difficulties in applying concept of hydrostatic pressure and bouyant force are: (a) mathematical representation of hydrostatic pressure $P_h = P_0 + \rho g h$, most students interpret h as the depth measured from the bottom of the columnl (not on the surface of the liquid as it should be), others did not take into P_0 to determine the pressure at a point in the liquid, (b) related to the buoyancy, the difficulty of students depends on the context in question which are given. In the context of stationary objects in a liquid, most students had not been able to compare the magnitude of the buoyancy experienced by the object with a heavy object. In the context of the sliding object in a liquid substance, almost all students had difficulty in describing the position of objects on the magnitude of the buoyancy experienced.

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