



## Exploration of Physics Problem-Solving Ability in Physics Education College Student: The Concept of Buoyancy

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Article history	Abstract
Submission : 2022-01-04	This study explored the ability of college students to solve problems involving buoyant force materials. The method used was descriptive qualitative, with the research subjects of Physics Education college students at Halu Oleo University who have programmed the Basic Physics I course. The instrument used was a description of five questions and interview guidelines to explore quantitative findings. The results of the analysis showed that the overall problem-solving ability of college students was still relatively low, with an average score of 40.6. The low problem-solving ability of college students on the concept of buoyancy in expressing the ratio of the lifting force of objects in different fluids determined the lifting force of an object by applying an equation and selecting the buoyancy experienced by an object in a liquid. The difficulties experienced by a college student generally in understanding problems had an impact on completion due to a lack of mastery of concepts. Thus, they could impact appropriately.
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<b>Keyword</b>	
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### 1. INTRODUCTION

The concept of buoyancy as part of hydrostatic material is part of physics material that is still considered difficult for college students and is related to phenomena in everyday life (Wicaksono et al., 2019; Puspita et al. 2019). By studying the material, college students are expected to think, find problems, and solve problems based on theories and concepts (Suparmi, 2017). However, in reality, many college students have difficulty in mastering concepts and problem solving when studying hydrostatic material, especially the ability to solve problems related to buoyancy (Kusairi et al. 2017); and difficulties in understanding Archimedes' principles (Loverude et al. 2003; Heron et al. 2003; Wagner et al. 2013). Other challenges are also found in determining the buoyant force of objects with different masses, objects floating in different liquids, and distinguishing sinking and floating objects (Heron et al., 2003; Libarkin et al., 2003; Dewi et al., 2016; Wong et al. 2010). These difficulties are because college students only know mathematical equations without understanding the concept, so they often experience confusion and doubt

in solving problems (Adi et al. 2018; Chen et al. 2013; Saputra et al. 2019), most college students have not been able to find many solutions to problems and have not been able to think logically (Diyana et al. 2020; Nooritasari et al. 2020), and most college students tend to solve problems intuitively without articulating.

In the context of solving a problem, college students have difficulty in solving physics problems because of the limitations in determining important information in the issues (Berge & Danielsson, 2013; Rasyidi, 2021). Lack of various types of knowledge needed to solve scientific problems: declarative knowledge (facts and concepts), procedural knowledge (how to use the facts and concepts in methods or procedures), and strategic knowledge (knowledge needed to organize new problem-solving processes) (DeJong & Ferguson, 1996). Most of them try hard when facing complex and unstructured problems because the problem-solving strategies taught in schools and universities only find and apply the right formula or strategies to answer well-structured problems and algorithmic problems (Oglivie, 2010; Tuminaro & Redish, 2007).

Problem-solving ability is one of the skills that must be possessed by individuals in the 21st-century era (Özyurt, 2015). The development of problem-solving skills is an important element in the structure of understanding physics concepts (Van Der Veen, 2012). Therefore, in learning physics, teachers/lecturers are advised to integrate higher-order thinking skills by developing problem-solving skills (Ercole-Fricke et al., 2016). Through problem-solving skills, college students can control, develop, monitor ideas, define problems (Gok, 2010), and assist them in analyzing and evaluating physics problems. Therefore, the problem-solving skill must be mastered by students that can be gained through learning activities. College students with good problem-solving skills can analyze and evaluate problems in everyday life.

Therefore, research on the exploration of problem-solving abilities of students is pivotal to understanding to what extent students' problem-solving skills are based on the concept of buoyancy. If they cannot understand the concept, it will affect their conception of the knowledge studied. In addition, it can reinforce students' misconceptions, especially about static fluid. Therefore, this study aims to explore students' ability to solve problems involving buoyancy materials to contribute knowledge related to the concept of problem-solving ability and identify difficulties in solving problems for physics education students through the concept of buoyancy.

## 2. METHOD

This research is quantitative descriptive research. Quantitative data was obtained through a problem-solving test describing five items given to 32 college students who programmed the Basic Physics I course. This research procedure included the preparation stage of the problem-solving ability test instrument, the evaluation stage, and interviews with 12 college students. The data in the study were analyzed using quantitative descriptive techniques to determine the college student' level of problem-solving abilities, as presented in Table 1 and Table 2. Researchers used the data from interviews to confirm the quantitative findings.

Table 1. Test Result Score Range

Value	Criteria
0 – 20	Very low
20 – 40	Low
40 – 60	Medium
60 – 80	High
80 – 100	Very high

Lestari (2019)

Table 2. Percentage of Problem Solving Ability

Percentage Value	Criteria
$0\% < X \leq 39.9\%$	Very low
$40\% < X \leq 54.9$	Low
$55\% < X \leq 69.9\%$	Medium
$70\% < X \leq 84.9\%$	High
$85\% < X \leq 100\%$	Very high

Hasan et al. (2020)

### 3. RESULTS AND DISCUSSION

Data on college students' problem-solving abilities on buoyancy material were obtained from the analysis of the calculation of the percentage score for each item. Data on college students' problem-solving ability in the concept of buoyancy can be seen in Figure 1.

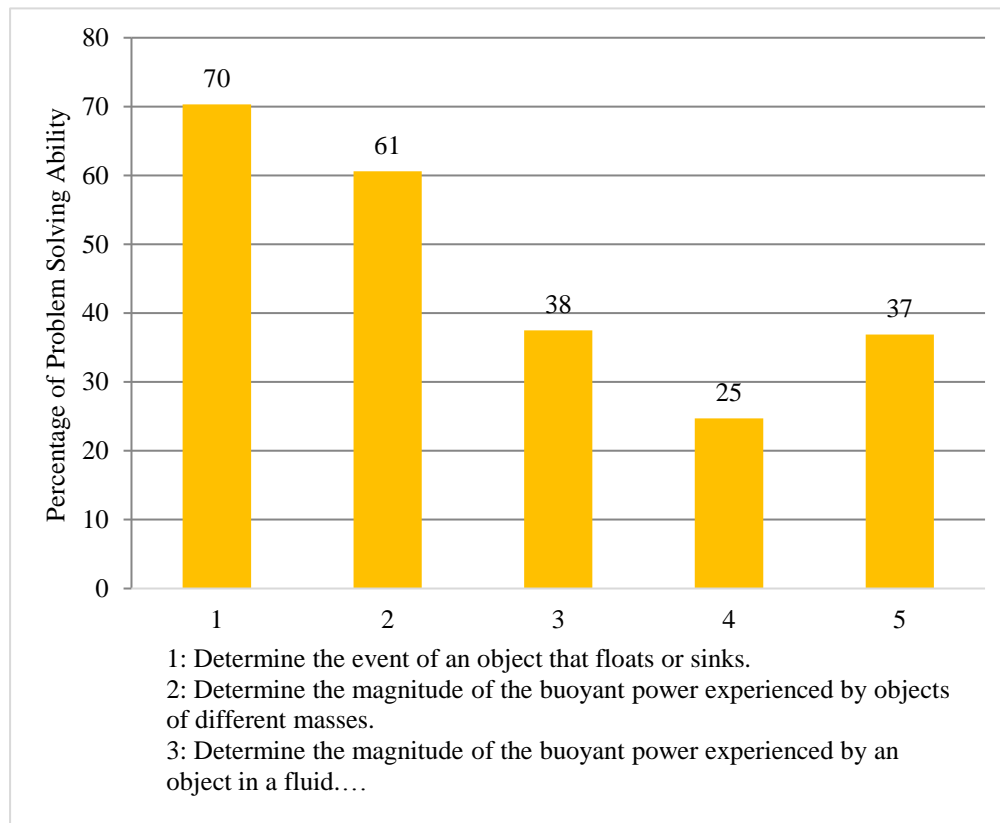


Figure 1. Problem solving skill in Each Question Item

It can be seen from Figure 1 that the problem-solving ability for each item showed the scholar's ability to handle floating, sinking, and sinking objects, as well as the magnitude of the buoyancy experienced by objects of different masses in questions 1 and 2 were in the high category of 70% and the medium category of 61%. While questions 3, 4, and 5 were in a very low category, especially the ability to the ratio of the lifting force of various fluids, namely 25%. In comparison, the average problem-solving ability of college students was 40.6 in the low category. This indicates that scholar problem solving is still lacking due to college students' tendency to work on questions without understanding the problem (Datur, 2017). Furthermore, the answers to each question can be seen in Tables 3, 4, 5, 6, and 7.

Table 3. Description and Answers to Question Number 1 regarding Determining Floating, Floating and Sinking Objects

Question number 1 :

If there are three liquids, A, B, and C, which have densities of 1000 kg/m<sup>3</sup>, 700 kg/m<sup>3</sup>, and 800 kg/m<sup>3</sup>, respectively. What will happen if an object with a density of 928 kg/m<sup>3</sup> is placed in the three liquids?

Answer:

The correct answer is 15 people. The answer is correct but incomplete: eight people, while the wrong answer is nine people.

Part 1.

Wrong answer, correct concept

Apabila suatu benda diletakkan ke dalam zat cair maka akan ada 3 kemungkinan yaitu diantaranya tenggelam, melayang, dan terapung.

$$\rho_A > \rho$$

1000 > 928, sehingga dapat dikatakan benda tenggelam saat massa jenis benda lebih besar dan pada massa jenis zat cair  $\rho_B > \rho$  benda akan tenggelam.

Part 2.

The answer is correct but incomplete.

Peuye: Mana benda tersebut akan terapung apabila dimasukkan dalam zat cair yang bermassa 800 kg/m<sup>3</sup> bergantung pada zat cair yang bermassa 700 kg/m<sup>3</sup>. Karena massa jenis benda tersebut lebih besar sehingga benda tersebut akan tenggelam dan berada di dasar permukaan zat cair tersebut.

The answer is correct, but the reason is wrong.

- Konsep Fisika  
 Hukum Archimedes  
 - Persamaan yang digunakan  
 $F_b = F_o - F_a = (\rho - \rho_c) g V$  |  $F_o - F_b = (\rho - \rho_c) g V$  |  $F_o - F_c = \rho - \rho_c$   
 $= 928 - 100$  |  $= 928 - 700$  |  $= 928 - 800$   
 $= 72 \text{ kg/m}^3$  |  $= 228$  |  $= 128$   
 - Kesimpulannya  
 Pada zat cair A, massa jenis 928 kg/m<sup>3</sup> akan mengambang. Sehingga dapat disimpulkan bahwa posisi benda ketika dimasukkan ke dalam zat cair akan mengalami kondisi terapung apabila perbandingan massa jenis benda yang dimasukkan lebih kecil dari zat cair massa jenis zat cair. Dan akan mengalami kondisi tenggelam apabila massa jenis benda lebih besar dari zat cair.

wrong concept (object experiencing lift/does not understand the question)

$$F_{a1} = \rho \cdot g \cdot V = 1000 \text{ kg/m}^3 \cdot 10 \text{ m/s}^2 \cdot 320 \text{ kg/m}^3 = 3.2 \times 10^6 \text{ N}$$

$$F_{a2} = \rho \cdot g \cdot V = 700 \text{ kg/m}^3 \cdot 10 \text{ m/s}^2 \cdot 928 \text{ kg/m}^3 = 6.4 \times 10^6 \text{ N}$$

$$F_{a3} = \rho \cdot g \cdot V = 800 \text{ kg/m}^3 \cdot 10 \text{ m/s}^2 \cdot 928 \text{ kg/m}^3 = 7.4 \times 10^6 \text{ N}$$

Jadi, karena benda tersebut di masukkan ke dalam tabung cairan maka benda akan mengalami gaya angkat keatas sama dengan berat fluida yang dipindahkannya.

• benda PA  
 $\rho_A = 1000 \text{ kg/m}^3$   
 $\rho = 928 \text{ kg/m}^3$   
 $\rho_A < \rho$   
 $928 < 1000$  jadi benda zat tersebut mengambang

• benda PB  
 $\rho_B = 700 \text{ kg/m}^3$   
 $\rho = 928 \text{ kg/m}^3$   
 $\rho > \rho_B$   
 $928 > 700$  jadi benda zat tersebut tenggelam

• benda PC  
 $\rho_C = 800 \text{ kg/m}^3$   
 $\rho = 928 \text{ kg/m}^3$   
 $\rho > \rho_C$   
 $928 > 800$  jadi benda zat tersebut tenggelam

Correct answer

Based on the answers in Table 3, it can be seen that the student responses varied greatly. Some students have understood the problem of writing the correct concept and already understand the difference between floating, sinking, and floating events. Unlike objects having the same shape and size when put in a liquid, students only need to compare the densities of an object and the liquid. However, some students still write the concept correctly, and the use of mathematical operations is correct. Some still do not write the units of these quantities. In addition, many students do not understand the concept. This can be seen from the answers provided requiring <https://jurnal.unimus.ac.id/index.php/JPKIMIA/index>

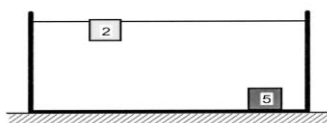
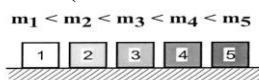
additional appropriate reasons, such as when an object with a density of  $928 \text{ kg/m}^3$ , is inserted into a liquid with a density of  $1000 \text{ kg/m}^3$  ( $\rho_b < \rho_{\text{water}}$ ), the object will float. In contrast, an object will sink in the other two liquids ( $\rho_b > \rho_{\text{water}}$ ).

These results indicate that some students still have not mastered the concept. Thus, the research was followed up by conducting interviews. One of the difficulties experienced by students is caused by a lack of understanding of the questions, a lack of knowledge of the concepts used, and a lack of thoroughness in reviewing the questions. In their study, Chen et al. (2013) reported that some students still have difficulties in explaining the sinking and floating events, and some have not been able to identify the force exerted by liquid. This is due to a lack of understanding of the concept affecting students' ability to solve a given problem (Kohl & Finkestein, 2008). Furthermore, question number 2 in Table 4 shows that students can understand the physics concepts well.

Table 4. Description and Answers to Question Number 2 related to determining the magnitude of the buoyant force with different masses of objects

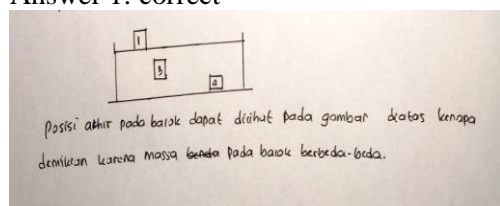
Question Number 2

Five blocks have the same size and shape but have different masses. The blocks are numbered according to the order of their mass. All blocks are submerged in water (in an aquarium), held about halfway, and released. The final positions of blocks 2 and 5 are shown as in the figure below. Provide reasons for the last part of blocks 1, 3, and 4 and draw them. (Assume that the water is incompressible).

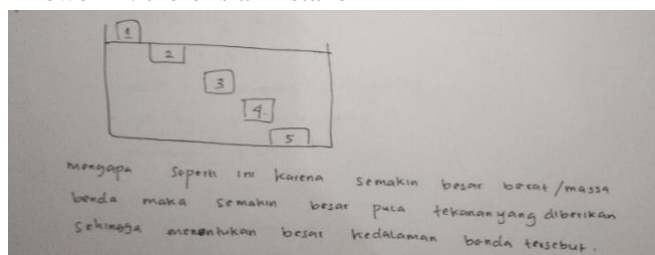


The number of student who answered correctly was 19 people and 13 students responded incorrectly.

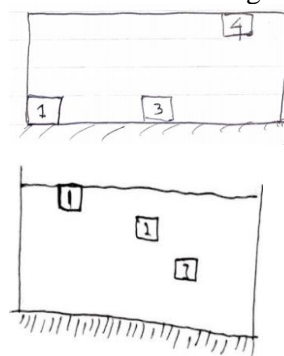
Answer 1: correct



Answer 2 : there is a mistake



Answer 1: Confusing answer

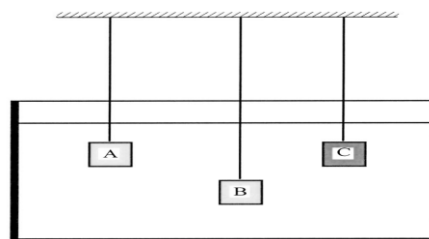


Based on Table 4, students can correctly draw the position of objects when the objects are in a liquid. The buoyant force is affected by the object density, the acceleration due to gravity, and the object volume immersed in a liquid. Objects of the same size and shape have the same volume, meaning the object volume is the same. When the acceleration of gravity of the earth and the volume of an object are considered constant, the magnitude of the object density can be seen based on the mass of the object. Based on the question, mass  $m_1 < m_2 < m_3 < m_4 < m_5$ , the object with the greatest depth is the 5th object, while the object with the lowest depth is the 1st object. There are differences in answers between students who understand the concept and those who do not. This difference is confirmed by the results of interviews that students who do not understand the concepts only answer and are confused because they do not interpret the questions correctly.

Table 5. Description and Answers to Question Number 3 related to determining the magnitude of the buoyant force experienced by an object in a fluid

Questions:

Three square blocks at equilibrium volume hang on a spring. Blocks A and B have the same mass, and block C has the least mass. Each block is lowered into the fish tank to the depth shown in the figure below. Rank the magnitude of the buoyant force acting on each block from largest to smallest.



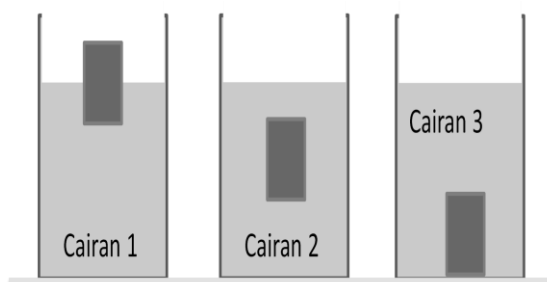
- Five students did not answer the question
- $F_C > F_A > F_B$  total of 5 students
- $P_A = P_B > P_C$  total of 2 students
- $F_A > F_C > F_B$  total of 3 students (the larger  $h$ , the greater the buoyant force experienced by the object).
- $F_C > F_A = F_B$  total of 6 students (the smaller the object's mass, the greater the buoyancy experienced by the object.)
- $F_C < F_A = F_B$  total of 7 students (the greater the mass, the greater the buoyant force experienced).
- $F_C > F_B > F_A$  total of 4 students (the smaller the mass, the greater the buoyant force and the deeper the object, the greater the buoyancy)

From the scholar answers in Table 5, it is clear that students do not understand the questions given and do not understand the concept causing errors in determining the solution. Based on the figure, three square blocks at equilibrium volume depend on a spring. Blocks A and B have the same mass, and block C has the least mass. Students only need to analyze the image to realize that three square blocks are floating in a liquid. The buoyant force is only affected by the liquid point (in this case, it is the same for the three blocks), so the magnitude of the buoyant force acting on the three blocks is the same. When the three blocks are suspended in a liquid, the magnitude of the buoyant force is determined, i.e.,  $F_A = F_B = F_C$ . The difficulties experienced by students in observing the position of objects in the image if the actual objects are all floating resulting in misinterpreting the answers.

Table 6. Description and Answers to Question Number 4 related to State the Comparison of the Lifting Force of Objects in 3 Different Fluids

Questions :

The position of an object when immersed in three different liquids is shown in the figure.



If  $F_i$  represents the magnitude of the lift by the liquid number  $i$ , then state the lift ratio for fluids 1, 2, and 3.

- Not answer by 14 students
- $F_1 > F_2 > F_3$  total of 9 students
- $F_1 < F_2 < F_3$  total of 8 students
- $F_2 > F_1 > F_3$  (1 student)

Based on Table 6, it can be seen that students could only provide a general description of the problem, however many students still misunderstood the concept. They could only provide an overview but could not relate the physics concept to the actual situation.  $F_i$  expresses the magnitude of the lifting force of liquid, so that in liquid 1:  $F_a > W_b$ ; in liquid 2:  $F_a = W_b$ , and in liquid 3:  $F_a < W_b$ . Thus,  $F_1 > F_2 > F_3$ . Several answers did not match the question. One of the causes of this difficulty is that they are not careful in interpreting the problems and figures. They assume that a floating object always has a smaller mass than a sinking object. Similar thing was found in students' answers to question number 5. There were still many mistakes in solving problems related to buoyancy. These results are supported by the analysis of the average learning outcomes in Table 7. The acquisition of scholar scores was still relatively low as presented in Table 7.

Table 7. Description and Answers to Question Number 5 Related to Calculating the Lifting Force of an Object by Applying the Lift Equation

Questions:

A block with a volume of  $18 \text{ m}^3$  floats on a liquid oil having a density of  $0.8 \text{ gr/cm}^3$ . If  $1/3$  of the block of wood appears on the surface of the oil, then what does the block of wood possess the lift force? ( $g = 10 \text{ m/s}^2$ ).

Answer:

- Correct answer (96.000 N) a total of 8 students
- Incorrect answer: 18 students (80 %)
  - 48.000 N a total of 3 students (not understand that equation volume  $F_a = \rho \cdot g \cdot V_t$  as a volume of an object that is immersed in a liquid)
  - 96 N for a total of 7 students (unit conversion error)
  - Wrong answer 8 students
  - Did not answer 6 students

Answer 1

ⓐ Persamaan yang digunakan

$$F_a = \rho \cdot g \cdot V_c$$

$$\Rightarrow V_{\text{balok}} = V_{\text{terapung}} + V_c$$

$$18 = 6 + V_c$$

$$V_c = 18 - 6 = 12$$

$$F_a = \rho \cdot g \cdot V_c$$

$$= 1000 \cdot 10 \cdot 12$$

$$= 120.000 \text{ N}$$

ⓑ Kesimpulan

Semakin besar volume suatu benda maka akan semakin besar gaya angkat yang dimiliki oleh benda tersebut

Answer 2

5. Dik:  $v_{\text{balok}} = 18 \text{ m}^3$

$$v_{\text{terapung}} = \frac{1}{3} \times 18$$

$$= 6 \text{ m}^3$$

$$\rho = 0,18 \text{ gr/cm}^3$$

$$= 0,00018 \text{ kg/m}^3$$

Dit:  $F_a = \dots?$

Penye:

$$v_{\text{balok}} = v_{\text{terapung}} + v_{\text{tercelup}}$$

$$18 \text{ m}^3 = 6 \text{ m}^3 + v_{\text{tercelup}}$$

$$18 - 6 = v_{\text{tercelup}}$$

$$12 = v_{\text{tercelup}}$$

$$v_{\text{tercelup}} = 12 \text{ m}^3$$

$$F_a = \rho \cdot v_{\text{tercelup}} \cdot g$$

$$= (0,00018 \text{ kg/m}^3)(12 \text{ m}^3)(10 \text{ m/s}^2)$$

$$= 0,0216 \text{ N}$$

Based on the answers in Table 7, it can be seen that students had written basic equations and completed mathematical operations correctly. This is because they are still using fundamental mathematical functions. Some students did not include the units of the quantities used. In addition, some students still paid less attention to the problem related to the volume of a block immersed in a liquid, which was 2/3 the volumes of an object. The difficulties experienced by the students from the results of interviews still show a lack of understanding of the concept of buoyancy if the object is only submerged or appears on the surface and lacks accuracy in observing problems. This has an impact on planning and problem-solving results. This result is in accordance with previous research. Purwanto & Yuliati (2017); Purnamasari et al. (2021) stated that problem-solving ability of students on static fluid material for the high category is less than 50%, and the rest classified as low criteria. In the same material, the problem-solving ability of high school students is still relatively low, with an average of 48.88 (Purwanto & Yuliati, 2017). This is because students have difficulty solving static fluid problems such as using the buoyant force formula, determining the resultant force and force on the plane in the fluid, and determining the depth of the field in liquids (Ringo et al. 2019). Datur (2016) stated that students have not described the problem correctly and are still using solutions with the wrong physics approach, thus affecting student' mathematical procedures.

Students with low problem-solving abilities generally still have difficulty understanding problems that impact plans due to a lack of mastery of concepts to solve problems correctly. Based on the interview results, it was found that the students' difficulty in solving problems in writing information that is known from the presented issues is a lack of accuracy in re-examining the answers given. They are not accustomed to solving problems by determining the concept to be used, so they tend to make errors in selecting the right concept. In addition, too complex questions are quite difficult for the students to solve due to their unfamiliarity with solving high-level questions. In addition, the misconceptions have resulted in many misinterpreting the given situation. This is as expressed by Cepni et al. (2012), Radovanovic & Slisko (2013), Late et al. (2017), who mentioned that the material for hydrostatic pressure and buoyancy is quite difficult for students at all levels to understand and even many of them experience misconceptions. Several misconceptions occur to students, including: (1) float objects in water because they are lighter than water or sink objects in water because they are heavier than water; (2) the shape of the container; the amount of liquid affecting hydrostatic pressure; and (3) fluid pressure only applies downwards (Fransiskus, 2016; Pratiwi, 2013; Suparno, 2013). This makes underprivileged students less able to solve the questions given.

Another difficulty also shows that students only focus on general equations without developing equations based on the given problems, so the results are incorrect. Thus, teachers/lecturers need to organize learning activities to practice problem-solving skills in various contexts, not just memorizing.



#### 4. CONCLUSION

Based on the exploration results of the problem-solving abilities, the college students' abilities in the buoyancy concept were included in the low criteria with an average value of 40.6. The difficulties experienced by some students in problem-solving still showed limitations in understanding the problems that impacted planning problems, so the problem-solving results were inaccurate. These results need further research on the exploration of problem-solving developed to overcome the difficulties experienced by college students.

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