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The analysis of student' difficulties in mastering static fluid concept

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Abstract: This study aimed to analyze the difficulties experienced by students in mastering Static Fluid concept. This study used descriptive quantitative method with 48 students of Physics Education Department. The instrument of this research was 13 reasoned-multiple choice questions. According to the results, although there was an improvement, most students were difficult to understand certain concepts. This research revelaed some difficulties experienced by students on static fluid concept. Among others are students failed to portray the forces that worked on certain object in fluid, then as a result, they failed to determine the ratio of pressure. In addition, the students were difficult to determine the changing of water pressure on the closed vessel based on the main law of hydrostatics and Pascal's Law.

Keywords: conceptual understanding; static fluid; student' difficulties

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Introduction

The students concept mastery is one of the primary focus in a learning process. Students are considered successful in mastering a concept when they are able to understand and apply the concept during the process of problem-solving (Docktor et al., 2015b; Kustusch, 2016) particularly during the process of solving some types of conceptual questions (Lin & Singh, 2011). However, as a matter of fact, students remain encountering a difficulty in mastering several concepts (Shishigu et al., 2018; Wambugu & Changeiywo, 2008), even experiencing a misconception. In the context of Physics lesson, one of the concepts that is commonly difficult to be understand is Static Fluid

In the real-life context of students, some phenomenon could be related with the concept of Static Fluid. For instance the phenomena of immersed object (Thiam, 2017), the system of submarine that applies the Archimedes principle, the application of hydraulic pump that applies the Law of Pascal concept, and etc. During the learning process in classroom, most students have carried an initial knowledge that was acquired from their observation and then concluded from the phenomena they observed (Saifullah et al., 2017). However, predominantly, students' explanation and conclusion do not satisfy the verifiable scientific knowledge (Docktor et al., 2015a). Dissimilarity between conception acquired by students and the verifiable scientific knowledge is commonly referred as misconception (NRC, 2012).

In Static Fluid topic, students commonly encounter some difficulties. It is further confirmed by the previous research that have been conducted. Several previous research revealed that students substantially encountered a difficulty when mastering a fluid pressure concept (Goszewski et al.,

2013), Archimedes principle concept (Kusairi et al., 2020; Loverude et al., 2003), and Buoyancy force in Fluids (Wagner et al., 2014), as well as Static Fluids concept.

When students encountering difficulties in mastering certain concept during the learning process, it greatly influences students' learning motivation (Senko & Harackiewicz, 2005), and it obstructs the learning objectives (Bouchard & Denoncourt, 2005). The ability of students to master a concept directly proportional to students' learning motivation (Linuwih & Sukwati, 2014). If students have a poor conceptual mastery, their learning motivation is also poor and vice versa. In addition, students' mindset plays a significant role on the learning process (Ramadhan & Winaryati, 2016). In this context, what is meant by conceptual understanding is how students are able to understand certain concept properly and able to complete conceptual question items. Therefore, it is important for teacher to be able to identify and analyze a difficulty encountered by students in mastering certain concept during the learning process as one of the attempts to design appropriate and suitable learning strategies (Resbiantoro & Nugraha, 2017; Yulita, 2018). This research was conducted to identify and analyze the student' difficulties on static fluid topic. Assuredly, this study is conducted based on the previous research that confirm the difficulties encountered by students in mastering the concept.

Method

This research was a descriptive research used descriptive quantitative method to explain and discuss the results of the research. The instrument is 13 items of reasoned-multiple choice questions developed from the book and previous research conducted by Berek, F.X., (2016), Goszewski et al., (2013) and Pebriana et al. (2018). The items were given to 48 students of Physics Education department who are enrolling in fundamental Physics course. The average of item difficulty level is 0.55, it was categorized as medium. The average of item discrimination index is 0.38 and it was categorized as good. Overall, the reliability value of the instrument was calculated by using Cronbach's Alpha (Nieminen et al., 2010) and it obtained a value of 0.424, categorized as medium. The following Table 1 describes the description of test instrument on Static Fluids topic.

Table 1. Test Instrument Description

Test Item Indicator	Question Number
Applying $P_h = P_o + \rho gh$ and main law of hydrostatic concept to compare the magnitude of pressure of a point on certain fluid.	1, 4
Applying $P_h = P_o + \rho gh$ and main law of hydrostatic concept to determine the magnitude of pressure of a point on certain fluid within U-shaped pipe	2
Applying $P_h = P_o + \rho gh$ and main law of hydrostatic concept to analyze the formation of two fluids within U-shaped pipe	3
Determining changes in water pressure in a closed vessel according to the main law of hydrostatic and Pascal's law	5
Determining the magnitude of the forces occurred by objects in fluid according to the Archimedes principles and Newton's Law	6, 8
Determining the volume of objects immersed in fluid at different gravitational accelerations according to Archimedes principles and Newton's Law	7
Analyzing the lift force of an object in a fluid using the Archimedes principles and Newton's Law	9
Analyzing fluid density using the Archimedes principles and Newton's Law	10
Determining the weight of the measuring cup containing the fluid according to the Archimedes principle	11
Determining the volume of water transferred according to the Archimedes principles and Newton's Law	12
Determining the density of the object according to the Archimedes principles and Newton's Law	13

To identify the students' difficulties, it was observed by scrutinizing at the percentage of lower correct answer (less than 50%). After obtaining a question items with lower score, then the items

were analyzed and described comprehensively. Then, the reasons given by the students were analyzed qualitatively and described to support the quantitative analysis results.

Results and Discussion

The students test answers were analyzed by using scale values 1-13 on 13 reasoned-multiple choices questions as the instrument. The test was administered after the students obtaining Static Fluid topic on Fundamental Physics Course. The average score was 7.23 with the standard deviation values of 1.49. The minimum score was 2.00 and the maximum score was 9.00.

The results show that the number of correct answers in each item of test were not 100%. It further means that the college students still found difficulties in completing test related to Static Fluid topic. Then, to identify the concepts that have not yet mastered by the students, it required further analysis with qualitative procedure. The number of students who provided correct answer in each items are illustrated in the following Figure 1.

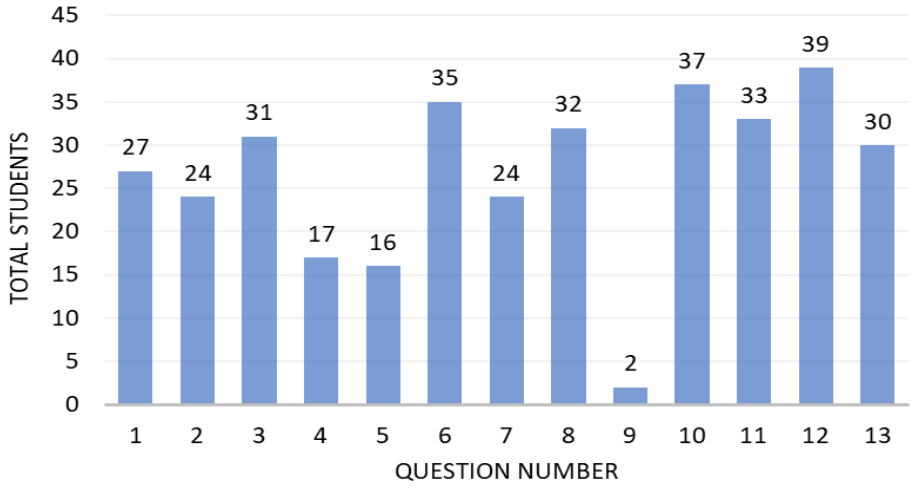

Figure 1. The Number of Students Providing Correct Answer in Each Test Items

According to the Figure 1, most students provided correct answer to some of the test items (more than 50%; test items of 1, 2, 3, 6, 7, 8, 10, 11, and 13). On the other hand, some test items obtained a lower result; less than 50% from the entire respondents. The test items with lower results were number 4 (35.4%), number 5 (33.3%), and number 9 (4.2%). Based on the figure 1, the lowest result of the test items was number 9. Only two students who answered correctly on test number 9. Therefore, a further comprehensive analysis was conducted to examine the test item number 9 and also number 5 along with the analysis of student resource in completing the test items.

Test Item Number 9

Test item number 9 aimed at accessing student's understanding about how substantial the lift force experienced by identical objects which are inserted on three different fluids. Students were asked to determine the comparison of bouyancy force from the three different fluids. To answer the test number 9, comparing the bouyancy force of the object on three different fluids, students must apply the concept of force that works on the object in the fluids based on Newton law and the concept Archimedes principle. The following Figure 2 is the test item number 9.

The state of an identical object that is put into three different types of liquid is shown in the following figure.

Comparison of buoyancy force (F_A) by the three liquid substances is ...

a. $F_{A-1} > F_{A-2} > F_{A-3}$
b. $F_{A-1} > F_{A-2} = F_{A-3}$
c. $F_{A-1} < F_{A-2} = F_{A-3}$
d. $F_{A-1} < F_{A-2} < F_{A-3}$
e. $F_{A-1} = F_{A-2} = F_{A-3}$

Figure 2. Test Item Number 9

The correct answer of test item number 9 is C. According to the Newton Law, the forces that worked on the objects within liquid 2 and 3 were liquid lift force (F_A) and weight ($W = mg$). Meanwhile, an object within liquid 1, in addition to buoyancy force (F_A) and weight ($W = mg$), normal force (N) also occurred since the object was immersed. Therefore, the equation applied for the objects within liquid 2 and 3 was $F_A = mg$. On the other hand, the equation applied for the object within liquid 1 was $F_A + N = mg$ hence $F_A < mg$. The three objects have similar mass and thus $F_{A-1} < F_{A-2} = F_{A-3}$. Students chosed option C were only two students (4.2%). The two students have been able to analyze the lift force of an object within fluid by applying the concept of Archimedes and Newton Law principle.

Four students (8.3%) who chose the option A provided a reason that the greater the density of an object (ρ), the greater the lift force that occurred (F_A). Therefore, it obtained $F_{A-1} > F_{A-2} > F_{A-3}$. The following Figure 3 illustrates student's reason in choosing the option A.

Students who chose the option D were 42 students (87.5%). Those students provided a reason that the higher the position of an object, then the higher F_A was obtained. Resource activated by students is related to the ratio of the density of objects with the density of fluids in each condition; the object will be fully immersed if $\rho_{object} > \rho_{liquid}$, partially immersed if $\rho_{object} = \rho_{liquid}$, and floating $\rho_{object} < \rho_{liquid}$. Therefore, the 42 students concluded that the ratio of the density of the three liquid in the question was $\rho_1 < \rho_2 < \rho_3$. In addition, students also activated resource related to the equation of Archimedes principle $F_a = \rho_f g V$. Thus, it obtained $F_{A-1} < F_{A-2} < F_{A-3}$. The students did not understand that the objects within the three liquid were identical and the volume of the objects within the liquids. Some reasons provided by the students that chose option D are presented in the Figure 4.

According to the explanation (Figure 4), the students remain difficult in understanding the Fluid topic, particularly related to Archimedes principle. This condition occurred since the students could not comprehend and portray the forces that work on the objects within the fluids, particularly when the object was fully immersed, students did not understand that the normal force (N) was also applied on the immersed object. In addition, the students activated an inappropriate resource with the context presented in the question.

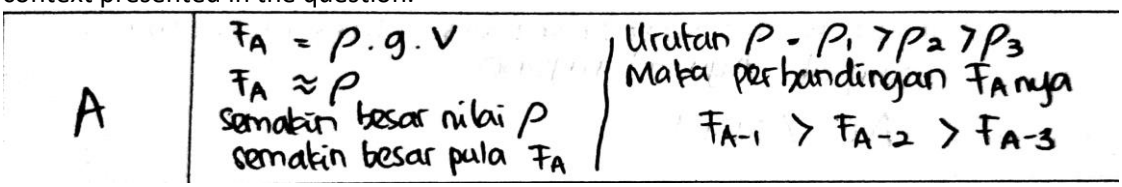

Figure 3. Student's Reason in Choosing Option A for Test Item Number 9

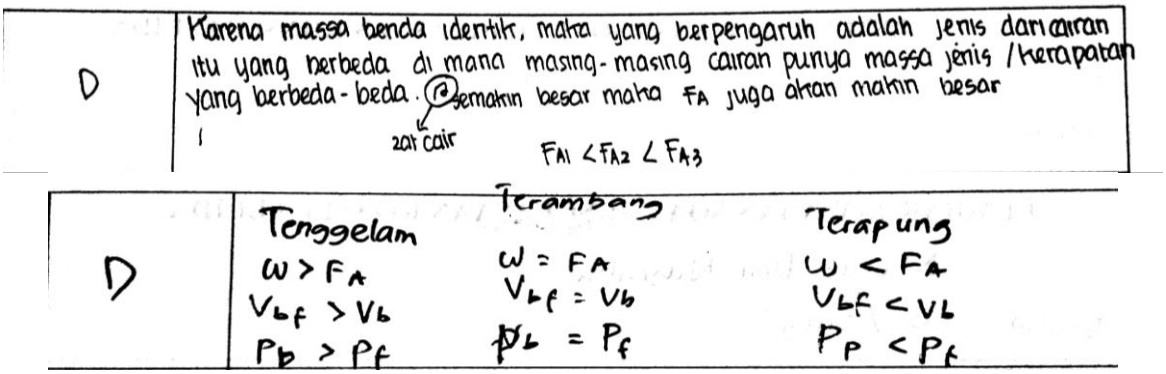

Figure 4. Reason in Choosing Option D for Test Item Number 9

Test Item Number 5

The context of the test item number 5 was a vessel containing water and closed by piston which placed an object on it, but the water cannot be compressed (incompressible). The students were asked to determine the ratio of pressure on each point. To answer this question, the students must acquire sufficient understanding about the main law of hydrostatics concept. The main law of hydrostatics concept states that the points that are in a horizontal line parallel to the surface of the earth have the identical pressure as long as they are on the identical fluid and the fluid is connected. The following Figure 5 illustrates the test item number 5.

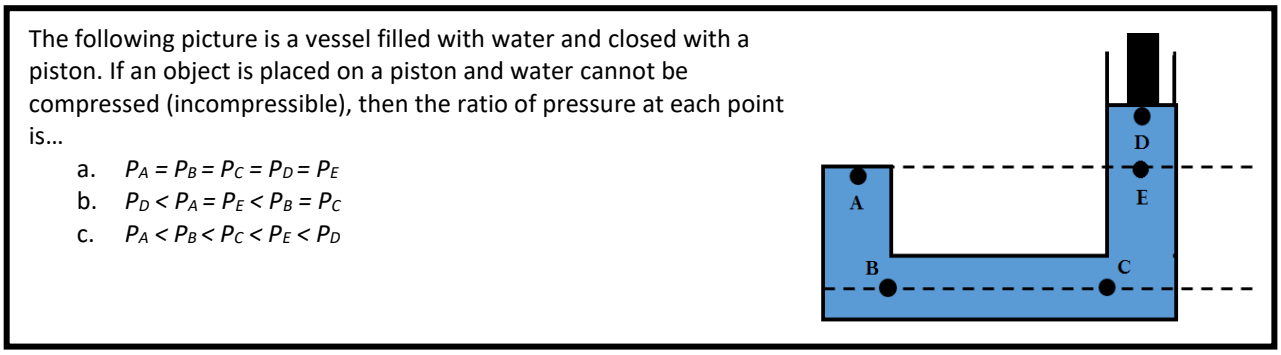

Figure 5. Test Item Number 5

Based on the results, as many as 16 students (33.3%) chose the correct answer to the question (Option B). In addition, they provided a proper and complete reasons; based on the major concept of hydrostatics, the equation applied is $Ph = Po + \rho gh$ and Pascal's Law. The students were able to determine the magnitude of hydrostatic pressure on a point (with a different reference) within a U-shaped pipe or a vessel; the points that line horizontally parallel to the surface of the earth have the identical pressure and magnitude according to the equation $P_h = P_o + \rho gh$ (main law of hydrostatics). In this context, the object on the surface of the piston provide additional pressure at each point of water in the vessel as much as $\frac{F}{A}$ or $\frac{mg}{A}$ (Pascal's Law). Therefore, the ratio of the pressure was $P_D < P_A = P_E < P_B = P_C$.

Meanwhile, as many as 26 students (54.2%) chose option A. They provided reasons that the pressure on the entire points were identical, the pressure was then continued to the entire direction and have identical magnitude ($P_A = P_B = P_C = P_D = P_E$). However, in this question, the students did not take into account the main law of hydrostatics concept. Meanwhile, as much as six students (12.5%) chose option C. They provided reasons that the point closest to the piston had the greatest pressure. Therefore, the students understood that the ratio of pressure was $P_A < P_B < P_C < P_E < P_D$.

According to the discussion of the test items above (test item number 9 and 5), it indicated that on Static Fluids topic by using 13 reasoned-multiple choices test items, the students remained difficult in understanding several related concepts. Firstly, most students were difficult in understanding Archimedes concept and Newton Law which were presented in the test items number

9. The students were not able to describe and portray the forces that worked on the objects within fluids, particularly when the object was fully immersed (Prastiwi et al., 2018). In addition, the students did not aware on the Normal force (N) that occurred on the objects. These findings are in line with the results of the research of Loverude et al., (2003). The results confirm that students are commonly difficult to identify the forces occurred on the object within the fluid. Second, the students were not be able to determine the changing of water pressure on the closed vessel based on the major concept of hydrostatics and Pascal's Law as stated by the previous research conducted by Goszewski et al., (2013). In addition, the students failed to activate their knowledge related to the main law of hydrostatics, Pascal's Law, and hydrostatics pressure concept which were illustrated in the test item number 5.

The analysis on the difficulty of students in understanding certain concept of lesson topic provides a meaningful information for the teacher or instructor to design and arrange appropriate learning strategy. In addition, it allows teacher to reconstruct the thought of students regarding the concept that was mastered initially and fuses it with the proper understanding in the classroom to avoid misconception. Furthermore, it is also important for the teachers to prepare a suitable learning strategy that enables students to avoid any difficulty in the process of knowledge acquisition (Thompson et al., 2011). For instance, teacher could provide students a conceptual exercise continuously to strengthen a proper knowledge acquisition (Fakcharoenphol et al., 2011) in the form of computer program exercises (Koenig et al., 2007), by using instructional multimedia (Diyana, et al., 2020; Yulianci et al., 2017), conventional classroom exercises, implementing Conceptual Problem-Solving in 5E learning cycles (Diyana, Haryoto, et al., 2020), 5E learning cycles approach (Çepni & Şahin, 2012), and by applying other appropriate strategies.

Conclusion

This study concluded that most students remain difficult in mastering certain concepts related to Static Fluids topic. The students were difficult in determining the ratio of pressure of the identical objects on the three different liquids and difficult in portraying the forces that occurred on the objects and as a result they failed to determine the magnitude of the pressure ratio. In addition, the students were also difficult to determine the changing of water pressure on the closed vessel based on the main law of hydrostatics concept and Pascal's Law. The analysis results of this research could be taken into account as further references for teacher to design and arrange proper learning strategy that enables to construct correct understanding.

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