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The Identification of Misconceptions of Physics Education Students at Universitas Sriwijaya Using Four-Tier Diagnostic Test on Static Fluid Material

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Abstract

This study aims to identify students' misconceptions regarding static fluid material. It was conducted on 33 students enrolled in the fifth semester of the Physics Education Study Program at FKIP Universitas Sriwijaya during the academic year 2022/2023. Data was collected by giving a four-tier diagnostic test and conducting interviews. The Four-Tier Diagnostic Test consists of four-level multiple-choice questions with answers and reasons, as well as the level of confidence that can be used to identify misconceptions in students. The results of this study indicate that students who have misconceptions about static fluid materials fall into the moderate category, with the highest percentage compared to other conception categories. This demonstrates that misperceptions remain a problem that must be addressed promptly so prospective educators do not bring the incorrect concept. The sub-concepts that identified misconceptions from those with the highest percentage were: Hydrostatic Pressure, Pascal's Law, and Archimedes' Law.

Keywords: Four-Tier Diagnostic Test; Misconceptions; Static Fluid

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INTRODUCTION

Physics is a branch of science that studies natural events in daily life and emphasizes concept mastery (Diani et al., 2019). According to Oktaviani et al. (2018), a factor contributing to low physics learning outcomes is students' inability to comprehend and apply physics concepts used to solve problems in daily life due to a lack of concept mastery. In physics learning, comprehension of physics concepts is necessary because mastering the concept of knowledge makes students more likely to retain the material taught over a lengthy period of time and achieve optimal learning outcomes (Boro et al., 2020). Therefore, it can be concluded that understanding the concept is the most important skill for students to acquire.

Conceptual misunderstandings, also known as misconceptions (Santoso & Setryasis, 2021), are one of the obstacles that frequently arise during or even after the learning process due to students' lack of conceptual comprehension. According to Jubaedah et al. (2017), misconceptions are discrepancies between students' and experts' comprehension

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of a concept. Van Den Berg (1991) explained that a misconception is a continuous belief in an incorrect comprehension (Nabila & Rachmasari, 2020). Thus, a misconception can be defined as an understanding of a concept inconsistent with its actual meaning.

A number of factors can cause misconceptions. According to Widiyanto et al. (2018), some factors include the students themselves, the teachers, and the learning methods teachers employ in the classroom. Researchers have categorized the causes of misunderstandings into five categories: students, teachers, textbooks, context, and teaching methods. Misconceptions caused by the students themselves are due to their preconceptions, abilities, developmental stages, interests, methods of thinking, and other friends. Misconceptions triggered by teachers may be due to incompetence, lack of mastery of the subject matter, inappropriate teaching methods, or an unfavorable attitude toward the students. In the meantime, the context may be culture or language use. In contrast, if a teaching method only emphasizes the truth from one perspective, it frequently leads to student confusion (Zafitri et al., 2019). It should be noted, however, that each individual's misunderstandings may have distinct causes.

Comprehending concepts in physics learning is crucial because physics learning is fundamentally inseparable from facts, concepts, laws, and theories in solving everyday problems (Septiana et al., 2018). According to Diani et al. (2019), numerous studies have indicated that the field of physics is rife with misconceptions. This was also stated by Seoharto et al. (2019), who concluded from their research that physics is the science field where students encounter the most misconceptions. According to Suparno (2013), one of the greatest misconceptions in physics learning is in the field of mechanics, including static fluid. Static fluid is one of the physics topics that makes it difficult for students to grasp its concepts (Puspita et al., 2019). According to research by Saputra et al. (2019), there are quite a few misconceptions among students regarding static fluid material, specifically Hydrostatic Pressure, Pascal's Law, and Buoyant Force.

There is a tendency for misconceptions to be fixed, resistant to change, and profoundly rooted in certain concepts. Preventing or correcting misunderstandings immediately is crucial (Soeharto et al., 2019). However, misconceptions cannot be explicitly identified. Thus, a tool is required to identify misconceptions among students (Sulistiawarni, 2018). According to Gurel et al. (2015), there are numerous ways to identify students' misconceptions, such as interviews, open-ended tests, multiple-choice tests, and multiple-tier tests. However, each method type has its benefits and drawbacks. According to Soeharto et al. (2019), multiple-tier tests are frequently designed to identify physics misconceptions as assessment instruments. The four-tier diagnostic test is one of the multiple-tier tests that can be used to identify students' misconceptions. Jubaedah et al. (2017) state that one of the benefits of the four-tier diagnostic test is that teachers can distinguish the level of confidence in the answers and reasons chosen by students, which allows them to delve deeper into the strength of students' concept understanding, diagnose misconceptions experienced by students more thoroughly, determine portions of the material that require more emphasis, and plan better learning to help reduce students' misconceptions.

Based on this description, the researchers were interested in and considered it necessary to identify misconceptions regarding static fluid materials. Since it is feared that if this identification is not made, it will always bear the incorrect concept and have an effect on subsequent material associated with static fluid material. In addition, despite the significance of this study on misconceptions, there has been little identification of misconceptions in a static fluid material, particularly among physics students as future physics teachers. This study uses a four-tier diagnostic test to identify students' misconceptions regarding static fluid material, specifically Hydrostatic Pressure, Pascal's

Law, and Archimedes' Law. A four-tiered diagnostic test is used to delve deeply into students' conceptual understanding across multiple categories of concepts.

METHOD

This study employed a descriptive research method. In this study, the student misconceptions were identified based on many categories. This identification was conducted at the Physics Education of the Faculty of Teacher Training and Education at Universitas Sriwijaya on Jalan Raya Palembang-Prabumulih, Indralaya Ogan Ilir. Thirty-three physics education students enrolled in the fifth semester of the 2022/2023 academic year at Physics Education of the Faculty of Teacher Training and Education at Universitas Sriwijaya participated as the subjects of this study. A purposive sampling technique was used, which is a sampling technique based on the objectives.

Tests and interviews were utilized as data collection methods in this study. The test was a four-tier diagnostic test. The structured interviews were given to 7 (seven) respondents. The four-tier diagnostic test adapted from Cahyani et al. (2019) consists of thirteen questions and three sub-concepts: Hydrostatic Pressure, Pascal's Law, and Archimedes' Law. The diagnostic test consisted of four levels. The first level included answer options, the second level consisted of student confidence in answering the first level question, the third level was the reason for the first level answer, and the fourth level contained student confidence in answering the third level question. After administering a four-level diagnostic test, students who experienced misconceptions were interviewed according to established guidelines.

The quantitative and qualitative data obtained from the results of this study were analyzed. This study employed a four-step procedure for data analysis. First, the student's answers to the four-tier diagnostic test were classified into several categories: misconception, understanding the concept, partially understanding the concept, do not understand the concept, and cannot be coded. The description of the five categories (Amin et al., 2016) is presented in Table 1.

Table 1 The Combination of the Students' Answers to the Four-Tier Diagnostic Test

Category	**The Combination of the Answers**			
	Tier-1	***Tier-2***	***Tier-3***	***Tier-4***
Misconceptions	Incorrect	Confident	Incorrect	Confident
Understand the concept	Correct	Confident	Correct	Confident
	Correct	Confident	Correct	Doubtful
	Correct	Doubtful	Correct	Confident
	Correct	Doubtful	Correct	Doubtful
	Correct	Confident	Incorrect	Confident
	Correct	Confident	Incorrect	Doubtful
	Correct	Doubtful	Incorrect	Confident
	Correct	Doubtful	Incorrect	Doubtful
Partially understand the concept	Incorrect	Confident	Correct	Confident
	Incorrect	Confident	Correct	Doubtful
	Incorrect	Doubtful	Correct	Confident
	Incorrect	Doubtful	Correct	Doubtful
Do not understand the concept	Incorrect	Confident	Incorrect	Doubtful
	Incorrect	Doubtful	Incorrect	Confident
	Incorrect	Doubtful	Incorrect	Doubtful
Cannot be coded	Do not answer one of the tiers or provide more than one answer			

The next step after classifying students' answers and reasons according to the five categories was to calculate the percentage of each category using the following equation:

$$P = \frac{F}{N} \times 100\% \quad (1)$$

Notes:
P = The percentage of the students' answers
F = The total number of the students' answers
N = The total number of the students

Misconceptions were categorized based on the percentage obtained, as presented in Table 2.

Table 2 The Misconceptions Category Based on The Percentage

Percentage	Category
$0\% \leq P \leq 30\%$	Low
$31\% \leq P \leq 60\%$	Moderate
$61\% \leq P \leq 100\%$	High

(Suwarna, 2014)

The third step involved calculating the average percentage for each category in each sub-topics. The fourth was analyzing the results of interviews in the form of qualitative data to support the students' answers with misperceptions identified by the four-level diagnostic test.

RESULTS AND DISCUSSION

Data on the misconceptions regarding static fluid material were obtained on the basis of the study conducted. By analyzing students' answers on each tier, misconceptions were identified. Table 3 depicts the percentage of conception categories of 33 students regarding static fluid material.

Table 3 The Category of Students' Misconceptions Regarding Static Fluid Material

Concept	Item number	Misconceptions	Misconceptions Category (%)			
			Understand the concept	Partially understand the concept	Do not understand the concept	Cannot be coded
Hydrostatic Pressure	1	75.8	12.1	3	9.1	0
	2	42.4	18.2	12.1	24.3	3
	3	9.1	51.5	27.3	12.1	0
	4	39.4	30.3	24.3	3	3
	5	54.5	6.1	30.3	6.1	3
Average		44.24%	23.64%	19.4%	10.92%	1.8%
Pascal's	6	51.5	3	18.2	24.3	3
Law	7	15.1	15.1	45.4	15.1	9.1
Average		33.3%	9.05%	31.8%	19.7%	6.05%
Archimedes' Law	8	18.2	12.1	57.5	6.1	6.1
	9	48.5	15.1	21.2	15.1	0
	10	27.3	18.2	45.4	6.1	3
	11	18.2	18.2	42.4	21.2	0
	12	24.2	27.3	39.4	9.1	0
	13	24.2	39.4	36.4	0	0
Average		26.76%	21.72%	40.38%	9.6%	1.52%
∑		448.4	266.6	402.9	151.6	30.2
Average		34.5%	20.5%	31%	11.7%	2.3%

Table 3 demonstrates the percentage of misconceptions for each sub-concept and the percentage of students who experience conception categories, namely misconceptions, understand the concept, partially understand the concept, do not understand the concept, and cannot be coded. There are 34.5% of students who have misconceptions, 20.5% of students who understand the concept, 31% of students who only partially understand the concept, 11.7% of students who do not understand the concept, and 2.3% of students who cannot be coded because they did not answer one of the tiers or provided more than one answer.

This study's results show that 44.24% of students have misconceptions regarding the concept of hydrostatic pressure, 33.3% regarding Pascal's law, and 26.76% regarding Archimedes' law. Figure 1 is a diagram depicting the percentage of misconceptions for each sub-concept.

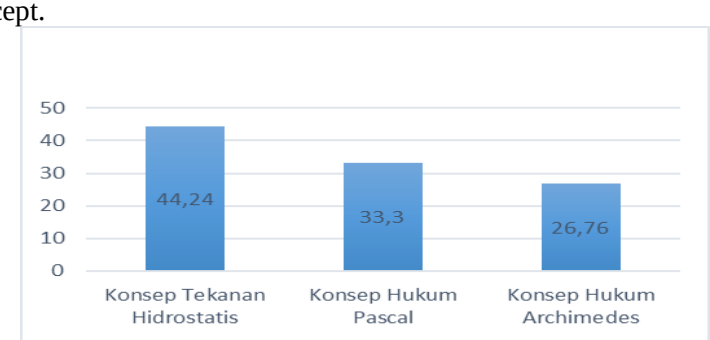

Figure 1 The Misconception Percentage Based on the Three Sub Concepts

Figure 1 demonstrates that the misconceptions had by fifth-semester physics education students fall within the moderate range of 36.76 to 44.24 percent. The hydrostatic pressure sub-concept is significantly different from the other two sub-concepts, as depicted in the figure. This makes it the sub-concept with the highest proportion of misconceptions. The sub-concept of Archimedes' law contains the lowest proportion.

It is evident from Table 3 that students have misconceptions regarding each item. Question number one has the most misconceptions, with a 75.8 percent rate. This falls into the category of high misconceptions because it falls between $61\% \leq P \leq 100\%$. The misconception with the lowest percentage is found in question number 3, with 9.1%. Therefore, it is included in the low category, as the P value is less than 30%. Figure 2 is a diagram depicting the percentage of misconceptions for each question.

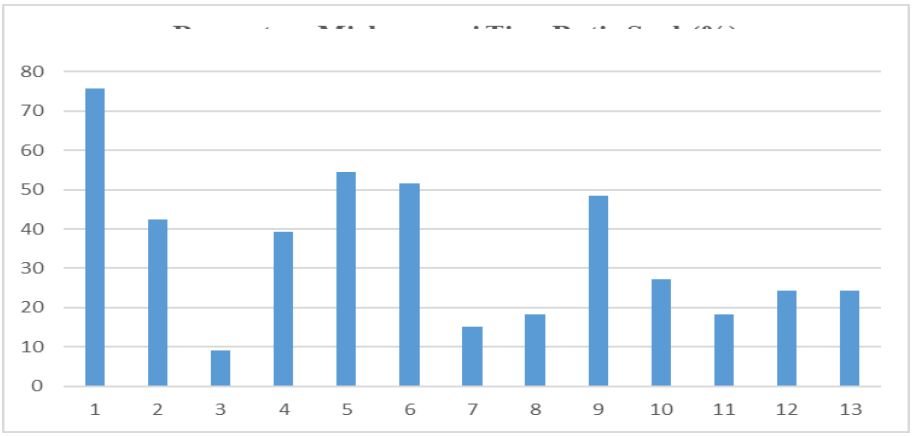

Figure 2 The Percentage of Misconceptions for Each Question

The results of the four-level diagnostic test indicate that students have misconceptions regarding the sub-concept of hydrostatic pressure. The sub-concept of hydrostatic pressure appears in questions 1 through 5, with the highest percentage of misconceptions of 75.8% in question 1, and the lowest percentage of 9.1% in question 3. According to the law of hydrostatic pressure, "the amount of hydrostatic pressure at any point located at the same depth in a single type of liquid in a balanced state is the same." However, the results of the study indicate that students have misconceptions regarding the concept of hydrostatic pressure. Students believe that hydrostatic pressure is influenced by the vessel's shape and cross-sectional area, erroneously believing that larger vessels experience increased hydrostatic pressure. This shows that students have misconceptions about the geometry and cross-sectional area of various vessels and are unaware that their depths are identical. In addition, students believe that hydrostatic pressure is directly proportional to the object's density when submerged. According to experts, the correct concept is that hydrostatic pressure is directly proportional to the fluid's density. The hydrostatic pressure equation is as follows (Giancoli, 2005):

$$P = \frac{F}{A} = \frac{\rho A g h}{A} \quad (2)$$

$$P = \rho g h \quad (3)$$

According to the equation, The cross-sectional area A has no effect on the pressure at a particular depth. The hydrostatic pressure is proportional to the liquid's density and its depth. Generally, the hydrostatic pressure at the same depth in a single type of liquid is the same and independent of the vessel's geometry and cross-sectional area.

Pascal's law sub-concept is found in questions 6 and 7, with the maximum percentage of misconceptions at 51.5% in question 6 and the lowest percentage at 15.1% in question 7. Pascal's law states, "The pressure exerted by a liquid in a closed space will be transmitted in all directions equally." The study results indicate that students have misconceptions about Pascal's law. Students with misconceptions believe the pressure is proportional to the pressure field's cross-sectional area. Moreover, students presume that the force exerted on the cross-section will be transmitted equally in all directions.

The sub-concept of Archimedes' law is found in questions 8 through 13, with the maximum percentage of misconceptions of 45.8% in question number 9 and the lowest percentage of 18.2% in questions 8 and 10. Students with misconceptions believe that an object's greater mass affects the magnitude of the buoyant force. In addition, students presume that the magnitude of the buoyant force is inversely proportional to the volume of the submerged object, meaning that the larger the submerged object's volume, the smaller the buoyant force. According to Archimedes' law, objects partially or wholly immersed in a fluid will receive an upward force equal to the volume of the immersed object or the displaced fluid. On the basis of the sound of Archimedes' law, it can be concluded that the fluid's density and the object's volume affect the buoyant force. Students erroneously determine the status of objects that undergo floating, sinking, and floating events. Students have misconceptions because they concentrate on the object's mass and ignore whether or not the density of the fluids is the same or different.

The test results for identifying misconceptions demonstrate that students have misconceptions about each item. When students select answers and reasons that are incorrect, yet they are confident in their selections, misconceptions may result. After administering a written test consisting of four-tier multiple-choice questions, students were interviewed to determine the causes of misconceptions. The researchers posed many questions concerning the test that had been administered to students. According to the results of the interviews, students struggle with the sub-concept of hydrostatic pressure because they believe that the cross-sectional area influences hydrostatic pressure. Most

students contend that question number 6 is challenging in the sub-concept of Pascal's law. Students believe they have difficulty comprehending the question's images and the effect of the compressive force from one cross-section to another. In the sub-concept of Archimedes' law, students have difficulty with questions 9, 10, and 11, according to the results of interviews. The students have difficulty determining the influence of buoyant forces on eggs placed in water with varying salt concentrations. Students struggle to determine the reason for the disparity in the states of the three eggs.

The results of interviews with students about static fluid material indicate that students find it difficult to comprehend it due to several factors, including the fact that the learning process is conducted online during the spread of the Covid-19 pandemic. According to Rachmat & Krisnandi (2019), 59.1% of students scarcely comprehend online learning, 39.8% do comprehend online learning, and 1.1% do not. It is difficult for students to master the material taught by the teacher because online learning is plagued by many obstacles, particularly internet access and the device employed. In addition, students' misconceptions are caused by their lack of comprehension of static fluid materials. This suggests that misconceptions result from students' lack of conceptual comprehension. According to Zafitri et al. (2019), students' misconceptions can stem from various factors, including initial preconceptions, abilities, developmental stages, interests, methods of thinking, and other friends. Based on the interview results, it can be concluded that some students have misconceptions due to their actions and the employed learning methods.

CONCLUSION

This study concludes that there is 34.5 percent of the fifth-semester Physics Education students at Universitas Sriwijaya have misconceptions, 20.5% of students included in the category of understanding concepts, 31% of students included in the category of partially understanding concepts, 11.7% of students included in the category of not understanding concepts, and 2.3% of students included in the category of cannot be coded. The order of sub-concepts with the highest percentage of identified misconceptions is as follows: 44.24% for the concept of Hydrostatic Pressure, 33.3% for the concept of Pascal's Law, and 26.76% for the concept of Archimedes' Law. In light of these findings, follow-up is required to remedy the incorrect concept to avoid enduring misconceptions. Therefore, it is necessary to identify misconceptions before or after the learning process pertaining to the concepts learned, particularly for students who will become teachers in the future, so that they do not always carry the incorrect concept. Thus, students' misconceptions can be immediately prevented or corrected immediately.

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