

# Analysis of Students' Conceptual Understanding of Physics on the Topic of Static Fluids

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**Abstract:** Physics misunderstandings still occur in high school students now. Therefore, it requires complete learning so that students' conceptual physics can be stable and embedded in everyone. This study aimed to diagnose the extent to which students' conceptual understanding of physics on the topic of static fluid is. This study used a survey approach to form a written test for 100 senior high schools in two schools in Central Maluku Regency. The results showed that there were still many students who experienced fluid misconceptions in cases 2, 3, and 5 to achieve a good level. Therefore, deep learning is needed so that students' conceptual physics will be good and not forgotten.

**Keywords:** Conceptual Change; Misconceptions; Static Fluids

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## Introduction

Physics learning has its characteristics and requires solving problems in theory and proven through a real experiment (Evagorou et al., 2015). It emphasizes experiential learning through the use and development of scientific process skills (Sato & McKay, 2020). In addition, learning is focused on the cognitive aspect of conceptual change. It produces a framework such as revolutionary cognitive change (McLure et al., 2020). One of the objectives of learning physics is for students to understand better the concepts of physics and the application of good science in everyday life (Sutopo, 2016). Therefore, students are expected to be able to understand and master the concepts of physics well.

The study of physics in Lebanon shows that 73% better understand the concepts of physics when taught by analogy or presuppositions, and only 3% like to learn without using analogies. This is because it can connect new concepts with previous knowledge and connect physics formulas with previously studied physics learning to encourage students with weak

conceptual and reduce misconceptions (Saouma et al., 2018).

Static fluid is one of the physics concepts taught in high school. Until now, students still have difficulty understanding concepts related to static fluids (Kusairi et al., 2017), especially the Archimedes concepts (Lima et al., 2014) and hydrostatic pressure (Loverude et al., 2003). It fails to meet minimum standards due to students' lack of conceptual understanding (Saouma et al., 2018), lack of in-depth physics training (Zacharia & de Jong, 2014), lack of teacher conceptualization and lack of refreshment for teachers in the form of training in deepening physics (Qhobela). & Moru, 2020). To overcome the difficulties faced by students, conceptual questions can be applied to diagnose the extent of students' understanding of the material being studied. In addition, the application of problem-based learning that is based on conceptual to stimulate students and connect them with the real world.

Teachers in England and Wales use a mastery-based assessment approach. This is because the teacher feels unsuccessful when moving to new material, and all students have not mastered the material. Therefore,

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the teacher makes a map of students' conceptual changes per day and is evaluated every week, and looks for the right formula to master the material well (Brock & Taber, 2020). They assume that conceptual change will lead students to new information and can be applied to other investigations (Johnson & Sinatra, 2014)

The phenomenon of physics can be related to everyday life, which greatly contributes to students' learning (Lutsenko, 2018). Therefore, it encourages the improvement of higher-order thinking skills and problem-solving (Kantar, 2014). By learning based on physics problems, students can be empowered to analyze, make quick answers, analyze data, and conclude a certain answer based on the data obtained (Wijnia et al., 2014). It means that problem-based learning can encourage students to think scientifically (Adulyasas & Abdul Rahman, 2014). In addition, it helps students in finding new information, trains collective work skills, and makes students as innovators (Mergendoller et al., 2006). Theories of conceptual change begin in childhood, and humans tend to draw relationships between different elements of knowledge. Someone who gains new knowledge from both formal and informal environments will select the information, and if the information can be measured scientifically, he will revise his previous knowledge (Eshach et al., 2018).

The study results in Italy explained that before students were faced with a physics case, the teacher brought the previous students' thoughts to explain the histories of physics related to the topic to be studied. The purpose of is to reconstruct students' understanding to bring prior knowledge before entering into deeper material (Leone, 2014).

Conceptual benefits are one of the appropriate alternative ways of learning for students. Conceptual understanding can help students increase knowledge, seek and find the concepts to be studied to develop thinking skills (Özmen & Yildirim, 2005). Physics problem-based learning is a technique offered today to stimulate thinking skills and encourage students to learn actively. The main goal to be achieved is that students can think openly and logically to find alternative problem-solving in order to foster a scientific attitude (Mantri, 2014).

Based on these characteristics, the application of diagnostic-based test questions to measure students' conceptual physics is very important to do. The concepts given emphasize students' physics literacy, skills, and logical thinking, one of which is the concept of static fluid. Several previous studies have researched the topic of fluid statics that can measure aspects of learning aid programs in the form of Web-based remedial (Kusairi et al., 2017). In addition, computer-

based learning patterns have also been developed to reduce students' misconceptions for pressure in liquids (Şahin et al., 2010). In another concept, it is found how students can explain the concept of pressure and compressive force based on a case (Kariotoglou & Psillos, 2019). The findings of another study also show that the most critical difficulties that arise from students are the inability to establish the relationship between kinematics and dynamics of moving fluids, and from a lack of understanding of how different regions of a system interact in the case of hydrodynamics (Suarez et al., 2017). Based on the records of previous research results, it is clear that there are still many things that have not been studied to explore students' understanding of students' old physics concepts on the topic of fluids. Therefore, an in-depth research study was conducted to measure students' conceptual on the static fluid by applying a diagnostic test to find the root cause of students' failure in learning physics. Therefore, the purpose of this study it was diagnose the extent to which students' conceptual understanding of physics on the topic of static fluid.

## Method

The research was conducted in survey research in two senior high schools in Central Maluku Regency. The research was carried out in eleventh-grade science at Public Senior High School Negeri 14 Central Maluku with 70 students and Senior High School 57 Central Maluku with 30 students. The instrument developed was a 5 number student conceptual diagnostic test question consisting of static fluid material, namely Archimedes' law, hydrostatic pressure, and Pascal's law based on everyday physics cases. This question had been tested previously for 120 grade eleven students from five high schools in Malang City in 2017. The students' answers were categorized based on knowledge assessment from level 1 to 5. Before the research, this question was validated by two learning physicists from Kanjuruhan University Malang and Pattimura University. Data collection techniques were in the form of test questions given to students, which were done in a few minutes. This question was given to students who have studied static fluid material to re-measure their conceptual understanding. After doing the test, an interview study was conducted for several randomly assigned students to check and re-confirm their abilities. The data analysis technique conducted was that after all the data has been collected, the student's abilities are mapped and provide alternative solutions in the future.

## Result and Discussion

Data information in Table 1 describes the results of students' answers from level 1 to level 5. Even though they were only given a test without being given treatment in the form of learning, there was student S20 who could answer perfectly and completely. The results of the interview with S20 are described as follows.

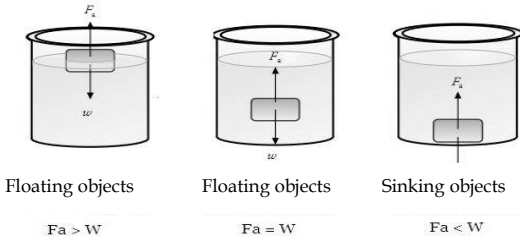
- T : *Why did you answer question number 5 well?*  
 S20 : *What the teacher taught; I usually repeat at home. I study on YouTube or other learning resources on the internet in order to understand the material. Besides that, physics is my favorite subject.*
- T : *Why do you answer question number 5 incompletely?*  
 S14 : *I usually forget what was taught. Moreover, this material was delivered when I was in grade 10. So, I did not repeat it. I only remember that, so the answer only reaches the floating stage.*
- T : *What can you do to make this material unforgettable?*  
 S14 : *I will try to redo it at home. If I do not understand, then I will find a teacher to explain the material. I find it difficult to understand from the book. The language of the book usually makes me confused because it is general and not explained in detail. Therefore, I try to look for a teacher to explain to me. I am very helped by the teacher when explaining the material.*

This is in line with the results of a study from the Nigerian Ministry of Education explaining that physics is very important for students because it supports science and technology. Therefore, students can acquire some conceptual knowledge of physics, theories, principles, and skills. The objectives of learning physics for Nigerian high school students should be (a) provide a basic literacy in physics for people's lives, (b) acquire basic concepts and principles of physics as preparation for a higher level, namely college, (c) acquire scientific skills and attitudes as preparation for application in technology, and (d) stimulate and enhance creative thinking (Madu & Orji, 2015).

In question number 1, the reason students did not answer well was due to several factors. First, a student may not have prior knowledge about the concept to be studied. However, they may have some related knowledge. In this case, previous knowledge is lost and learning consists of adding new knowledge. Second, a student may have some correct answers based on prior knowledge of the concept to be studied, but that knowledge is incomplete. In the case of incomplete knowledge, learning can be understood as filling in gaps. Student responses to the static fluid case problem are shown in Table 1.

**Table 1.** Student Answer Results on Archimedes' Law

Question	Answer	Level
According to Archimedes' law, there are three positions of objects in the water, namely floating, partially submerged, and fully submerged. This difference in the position of objects is due to gravity and buoyancy. When is an object said to be floating, partially submerged, and fully submerged? Put the pictures for each phenomenon!	1. Floating, an object is said to float if the buoyant force is greater than the weight of the object ( $F_a > W$ ) (without pictures) <b>S14</b>	1
	1) Floating, an object is said to float if the buoyant force is greater than the weight of the object ( $F_a > W$ ) 2) Partially submerged, an object is said to be partially submerged if the buoyant force is equal to the weight of the object ( $F_a = W$ ) (without pictures) <b>S75</b>	2
	1) Floating, an object is said to float if the buoyant force is greater than the weight of the object ( $F_a > W$ ) 2) Partially submerged, an object is said to be partially submerged if the buoyant force is equal to the weight of the object ( $F_a = W$ ) 3) Fully submerged, an object is said to be fully submerged if the buoyant force is less than the weight of the object ( $F_a < W$ ) (without pictures) <b>S40</b>	3
	1) Floating, an object is said to float if the buoyant force is greater than the weight of the object ( $F_a > W$ ) 2) Partially submerged, an object is said to be partially submerged if the buoyant force is equal to the weight of the object ( $F_a = W$ ) 3) Fully submerged, an object is said to be fully submerged if the buoyant force is less than the weight of the object ( $F_a < W$ ) (Only describes one phenomenon) <b>S8</b>	4

Question	Answer	Level
	1) Floating, an object is said to float if the buoyant force is greater than the weight of the object ( $F_a > W$ ) 2) Partially submerged, an object is said to be partially submerged if the buoyant force is equal to the weight of the object ( $F_a = W$ ) 3) Fully submerged, an object is said to be fully submerged if the buoyant force is less than the weight of the object ( $F_a < W$ ) (Describes two or three phenomena)	5
		

In the third condition, a student may have acquired ideas, either at school or from everyday experience that “conflict” with the concept to be studied in which prior knowledge is contrary to scientific knowledge. This is what is meant by conceptual misunderstanding (Oh et al., 2016).

A misunderstanding is a false belief in a person's mental model. A misunderstanding is also a wrong idea about a concept or belief. Misunderstandings stem from prior knowledge of everyday experiences or those gained from school. Some misconceptions are not only resistant but also persistent to change. This category of misunderstanding is called a strong misunderstanding. That is, a strong misunderstanding, persist and persistent to change (Lee & Byun, 2012).

Concept-based learning is very helpful, stimulates students' thinking power, and teaches students to discover themselves. In the implementation of concept-based and procedural learning, students are required to be actively involved in following the learning process to classify their physics knowledge. The purpose of the learning process is for interaction to occur in exchanging information and knowledge between high-ability students and low-knowledge students. In addition, students who have good learning experiences can help other students, thus helping in inculcating new thinking concepts (Serbin et al., 2020). Teachers as facilitators are expected to be able to prepare a good learning climate so that students are more comfortable in learning and improve their academic achievement.

Conceptual understanding is the cornerstone of professional expertise. It is very helpful for students to make predictions, explanations, observations, facts relation, the implication of new knowledge, choice of alternative procedures, and build new problem-solving strategies (Rittle-Johnson et al., 2015). Conceptual

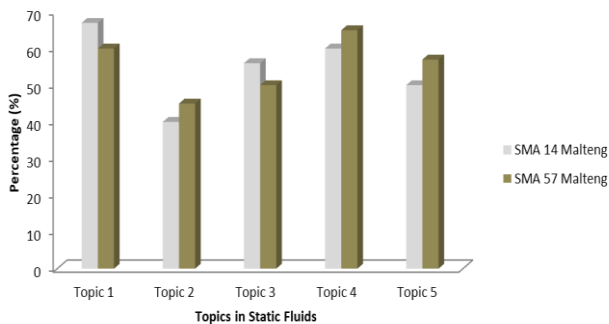
cultivation must be continuous from pre-school (Leuchter et al., 2014), primary school (Hardy et al., 2006), to secondary school (Linn et al., 2014). In conceptual learning, students are actively involved in the independent exploration of complex phenomena and situations, such as testing and evaluating the hypothesis of discovery-based activities. Teachers and teaching materials are an alternative in guiding students' attention towards learning objectives (Schalk et al., 2019). Several studies have developed the latest innovations in physics learning. One of them is in improving conceptual physics through computer-based learning. In physics, there are some materials that are difficult for students to understand such as: the atomic or molecular state of a material. Therefore, teachers provide relevant learning resources that support learning. For example, Phet Simulation or game-based learning to improve students' conceptual understanding so that things that are still abstract can be concreted and understood by students (Franco et al., 2012). Then, students can try and conduct deeper simulations to test the truth according to the theory they have learned (Echeverría et al., 2012).

Teachers can conduct contextual problem-oriented learning to encourage students to be able to find the problem. Students need to be trained to present their findings in the form of things they know and finally make them trained in communication and take responsibility for what they find. This is one of the formulations and alternatives for students and teachers in solving difficult physics problems together. In this situation, students act as work partners in finding physics problems, formulating problems, identifying empirical facts, and making questions as alternatives in solving problems (Seibert, 2021).

The knowledge that students get today cannot be separated from the knowledge that has been previously

obtained. There is a relationship between old knowledge and knowledge that students will receive to form new knowledge. Through the assimilation process, students can connect their initial knowledge with a complete one following scientific concept. Old and new information often undergo serious debate known as conflict cognitive (Makhrus et al., 2020). The learning process carried out can allow students to reason on their preconceptions and estimates to explain the strategies used in solving problems. Cognitive conflict can be used as an alternative in learning because it can improve students' thinking power. The results of this study strengthen the findings conducted by Liu & Nesbit (2018) which states that cognitive conflict can improve students' conceptual understanding.

The research findings based on Figure 1 prove that students are still very weak on topics 2, 3, and 5, while topics 1 and 4 are still in the good category.



**Figure 1.** The finding results of students academic per topic on static fluid test results.

There are some factors of students' low learning outcomes on the topic of static fluid. First, the teacher does not familiarize students with the physics phenomena around, so that students are in crisis of literacy to trigger their critical thinking (Longfield, 2009). Second, the limited knowledge of students from lower education so that it does not become good knowledge when students are in higher education. This triggers the occurrence of misconceptions and disturbs students in understanding new knowledge better (Docktor & Mestre, 2014). Therefore, it is important for teachers to know students' misconceptions and make them an important input in designing learning (Kaltakci-Gurel et al., 2017). Misconceptions are errors that are firmly held and supported with high conviction. In certain misconceptions, wrong answers and wrong reasoning are intertwined. Therefore, all misconceptions are errors, but all errors are not necessarily misconceptions. Students' answers to each item were considered misunderstandings when the wrong choice and the associated incorrect specific

reason were selected with high confidence (Abrahams et al., 2014). Third, prospective teachers in higher education do not deepen their physics knowledge well. Especially, when they finish their studies from higher education and don't get a job to become a teacher, the teacher's competence decreases. This is what interferes with the competence of physics teachers in the future in teaching and learning because what was received during lectures is lost. If this process continues, it will result in a decrease in students' competence and knowledge (Hellmann et al., 2021). Therefore, teachers can attend training, seminars, and workshops properly so that the cognitive warm-up process can occur (Gerich et al., 2016). Fourth, student learning outcomes become low because the material characteristics are one of the factors that make student competence decline. Students explain that they do not like all physics material because the formulas are difficult and require a high level of understanding so that physics is difficult to comprehend well (Batlolona et al., 2019; Batlolona et al., 2020).

Conceptual-based questions require a good knowledge of physics to complete and answer the questions given. This is in line with the results of previous studies, which explained that many students have high misunderstandings on the topic of hydrostatic pressure and Archimedes' law phenomena (Unal, 2008). (Zoupidis et al., 2021) reported students' difficulties in solving problems related to Archimedes' law. Yin et al. (2008) identified 10 common misconceptions among students when observing fully submerged and floating objects. Meanwhile, Purwaningsih et al. (2020) reported that misconceptions in buoyancy do not only occur among school students but also teachers.

In the case below, a traditional fishing gear called Rompong or in Ambonese sero is bamboo and equipped with a house. The coast people of Ambon Island use this tool to catch fish. The critical question is why this traditional tool can float above sea level? The answers have been recorded as follows.



**Figure 2.** Rompong as a fishing tool that can float above sea level.

- T : Why can Rompong float above sea level?.
- S35 : The buoyant force is greater than the object's weight ( $F_a >$

- W)
- S02 : The basic material is made of bamboo, so it is lighter above sea level. In addition, the mass of seawater is greater than bamboo.
- S50 : The density of bamboo is less than the density of seawater.
- S76 : The weight of the object is less than the lifting force of the water

## Conclusion

Based on the current findings, there are still many students who experience fluid misconceptions in cases 2, 3, and 5 to achieve a good level. Students are only able to do simple questions, namely cases 1 and 4. Therefore, deep learning is needed so that students' conceptual physics become good and not forgotten. This study implies that teachers can prepare quality learning materials in improving students' physics learning outcomes.

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