Investigation of undergraduate student concept understanding on Hydrostatic Pressure using two-tier test

C. Cari¹*, Scundy Nourma Pratiwi², Harry Affandy², and Dewanta Arya Nugraha³

¹ Physics Department, Universitas Sebelas Maret, INDONESIA
² Master of Physics Education, Universitas Sebelas Maret, INDONESIA
³ Doctorate Program of Science Education, Universitas Sebelas Maret, INDONESIA

e-mail: ¹cari@staff.uns.ac.id

Abstract: Investigating students’ understanding of the concept of hydrostatic pressure is based on the importance of this understanding to be able to master static fluid material. This study uses qualitative methods to investigate the understanding of student concepts on the topic of hydrostatic pressure. The sample used in this study was 206 undergraduate student physics and undergraduate student physics education at Universitas Sebelas Maret, and Universitas Islam Negeri (UIN) Sunan Kalijaga Yogyakarta. The results of the analysis show that ten items developed were declared valid in content based on expert judgment. This is evidenced by the acquisition of $V$ index of 0.99, while the $V$ table is 0.92. The reliability estimation results obtained by the value of person reliability ($testee$) of 0.82, and reliability items of 0.75. It can be concluded that the consistency of the answers from either the $testee$ or from the item in question has high reliability. The results of the investigation showed that there were many undergraduate students after studying physics, not being able to understand even in the simplest parts. Some concepts have been misunderstood; this has led to undergraduate students considering physics as a difficult, complicated, and time-consuming science to be able to understand it.

1. Introduction

The concept of hydrostatic pressure is the basis for understanding static fluid material. Investigating students' understanding of the concept of hydrostatic pressure is based on the importance of this understanding to be able to master static fluid material. In this study, we focus on students' ability to reason with equality and apply it to simple problems in everyday life. Students' conceptual can develop from their daily experiences [1].

The results of a study conducted by Loverude on undergraduate students show that many students have difficulty in applying the relation $P = P_0 + \rho gh$ given by the pressure in the liquid at a depth $h$ below the reference point with atmospheric pressure $P_0$ [2]. Many students respond regarding the interpretation of hydrostatic pressure in terms of fluid weight above the point. Although this interpretation is partly correct in many situations, there are situations where such interpretations can lead to wrong answers or misconceptions, namely the hydrostatic paradox. The hydrostatic paradox is a well-known example of such a situation [3].

The level of understanding generally consists of several categories, namely no understanding, partial understanding, misunderstanding and understanding [4]. Investigation students' understanding is very important to be able to teach physics effectively [5]. Teaching strategies based on conceptual
change must be taught in physics classes to enhance deep conceptual understanding among students. Conventional learning is mostly ineffective. So a new learning strategy must be planned and carried out carefully because inappropriate learning strategies can add more alternative conceptions to students [5]. To understand the concepts of physics, students must have the skill to express concepts in many representations [6]. Representational skills are abilities that students must possess to interpret and apply concepts as strategies for solving problems correctly [7].

Investigating the understanding of student concepts is very important, because as an evaluation material so that further learning can be better. In other words, knowing the concept of understanding students to evaluate the learning process [8][9].

Diagnostic tests for understanding concepts in the form of reasoned multiple choices are one form of modification of multiple choice questions consisting of stem, choice of answers, and reasons [9]. Research on the form of two-tier tests can be carried out for a diagnostic understanding of concepts and misconceptions [10] so that students can know how far the ability of students is good by using the theory of modern tests or seen qualitatively [11][12]. Based on our theoretical study, we are interested in investigating students’ understanding of concepts in hydrostatic pressure using a two-tier test.

2. Methods

This study uses qualitative methods to investigate the understanding of student concepts on the topic of hydrostatic pressure. The sample used in this study was 206 undergraduate physics student and undergraduate physics student education at Universitas Sebelas Maret, and Universitas Islam Negeri (UIN) Sunan Kalijaga Yogyakarta. The instrument for collecting data was used to investigate the understanding of concepts, using two-tier test accompanied by interviews. Interviews were conducted to determine the extent of understanding the concept of students by giving questions related to the concepts and problems given. Before being used in the field, the instrument was validated by 5 validators which were reviewed based on the content validity of Aiken [13] with the equation (1):

$$V = \frac{\sum s}{n (c-1)}$$

The criteria used to determine the valid item content is by comparing the price of $V$ count with the Table $V$ in the Right-tail Probabilities table (p) for selected values of the validity coefficient (V) [14]. $V$ index values range from 0 to 1, high values that indicate that items have high content validity or that a set of items has high content validity in the judgment of an expert [13]. The next instrument test is the test reliability test, using the Alpha Cronbach technique [15].

Test reliability analysis in this study aims to see the characteristics of the test which refers to the consistency of the measurement results. If a test can produce steady measurements or measurement stability [15][16], it does not change if used repeatedly on the same target; it can be said that the instrument is reliable [17]. Test reliability of the test using the QUEST program, where the reliability coefficient is very good if the amount approaches +1.00. The magnitude of reliability is seen from the results of the QUEST analysis in the summary of items estimates; cut off value used is ≥0.70.

| No | Indicator Item Problem | Number Question |
|----|------------------------|-----------------|
| 1  | Determine Hydrostatic Pressure in Vessels of different sizes | 1 ; 3 ; 5 ; 7 |
| 2  | Determine the direction of pressure on the beam in water | 2 ; 4 ; 10 |
| 3  | Scientific Observation | 8 ; 6 ; 9 |

Scoring a concept understanding follows the four categories of PCM pattern. PCM 4 categories to diagnose students’ understanding of concepts consist of Irresponsiveness, Misunderstanding, Limited
Understanding, and Understanding. In the first category, if students are wrong in writing the concepts used and the results are wrong [11],[18]. This can be seen from the answers given by students on multiple-choice wrong, and the arguments given are also wrong. In this category students are said to be unresponsive (Irresponsiveness). This is based on the results of research Akbas, Abdulkadir, and Ebru [19]; Abraham, Eileen, John, and Edmund [20] who describe understanding concepts not responsive when students give an argument only repeat answers, I don't know, or I forget.

The second category, if students are correct in writing the concepts used and the results can be correct [11], [18]. This can be seen from the answers given by students on multiple-choice correct, and the arguments given are wrong. In this category students are said to experience a misunderstanding (Miss Understanding). This is based on the results of research Akbas, Abdulkadir, and Ebru [19]; Abraham, Eileen, John, and Edmund [20] who provide a description of understanding concepts can be varied and not by scientific facts.

The third category, if students are correct in writing the concepts used and the end result is wrong [11], [18]. This can be seen from the answers given by students on multiple-choice wrong, and the arguments given are correct. In this category, students are said to experience limited understanding (Limited Understanding). This is based on the results of research Akbas, Abdulkadir, and Ebru [19]; Abraham, Eileen, John, and Edmund [20] who provide a description of the limitations of understanding when the answers are written contain only one or only a few of the scientific facts.

The fourth category, if students are correct in writing the concepts used and the end result is correct [11], [18]. This can be seen from the answers given by students on multiple-choice correct, and the arguments given are correct. In this category, students are said to understand (Understanding). This is based on the results of research Akbas, Abdulkadir, and Ebru [19]; Abraham, Eileen, John, and Edmund [20] who described the students' understanding when the written answers contained all the scientific facts.

3. Results and Discussion

3.1. Analysis of instrument quality

Instrument quality analysis is carried out to assess the quality of the test instruments used, which are in the form of two-tier tests. The assessment was carried out by five experts namely material experts, educational evaluation, and language. This assessment sheet is filled in by experts to evaluate and validate each item. The assessment criteria given by experts use a Likert scale of four categories, ranging from the lowest to the highest, namely irrelevant, less relevant, relevant, and very relevant. A summary of the results of expert assessments of the two-tier instruments used is presented in Table 2.

| Number | V  | Category |
|--------|----|----------|
| Question | Count | Table |
| 1 | 0.93 | 0.87 | Valid |
| 2 | 0.93 | 0.87 | Valid |
| 3 | 0.93 | 0.87 | Valid |
| 4 | 0.93 | 0.87 | Valid |
| 5 | 1.00 | 0.87 | Valid |
| 6 | 0.93 | 0.87 | Valid |
| 7 | 0.93 | 0.87 | Valid |
| 8 | 0.93 | 0.87 | Valid |
| 9 | 0.93 | 0.87 | Valid |
| 10 | 0.93 | 0.87 | Valid |
| Average | 0.937 | 0.87 | Valid |
The results of the analysis show that ten items developed were declared valid in content based on expert judgment. This is evidenced by the acquisition of \( V \) index of 0.93, while the \( V_{\text{table}} \) is 0.87. The results of Aiken's content validity analysis show that overall the items developed by the argumentation assessment instrument have met the content validity requirements. The next analysis is to determine the quality of the instrument based on the value of reliability. The results of the analysis are presented in Table 3.

| No | Quality Review | Estimates for Items | Estimates for Testee |
|----|----------------|---------------------|---------------------|
| 1  | Average values and standard deviations | 0.01±0.70 | 0.53±0.58 |
| 2  | Reliability | 0.73 | 0.86 |
| 3  | The mean value and standard deviation of INFIT MNSQ | 1.00±0.19 | 1.02±0.43 |
| 4  | The mean value and the MNSQ OUTFIT standard deviation | 1.01±0.21 | 1.01±0.41 |
| 5  | Average values and standard deviations of INFIT t | 0.04±1.25 | 0.08±1.54 |
| 6  | The average value and standard deviation of OUTFIT t | 0.03±1.79 | 0.02±1.13 |

The reliability estimation results obtained by the value of person reliability (testee) of 0.86, and reliability items of 0.73. It can be concluded that the consistency of the answers from either the testee or from the item in question has high reliability. The two-tier test instrument used has a mean INFIT MNSQ of 1.00 and a standard deviation (SD) of 0.19 meaning that the overall items developed were fit with the Rasch model. This is in accordance with the opinion of Aminah [21] which states that with a mean INFIT MNSQ of 1.01 and SD 0.09 has the meaning that overall the items are in accordance with the Rasch model.

3.2. Undergraduate Student Concept Understanding of Hydrostatic Pressure

In this section, the findings obtained from the results of data analysis are then discussed. The answers given by students are analyzed based on the reason for choosing the answer, then the interview phase is carried out. Interviews were conducted not for all students who did the test, but only randomly selected by the researcher. This is due to limited time in conducting research.

Understanding is the ability of someone to understand or understand something. In other words, understanding is knowing about something and being able to see it from various perspectives. A student is said to understand if he can give an explanation and imitate it using his own words. Understanding one level higher than memorization. Understanding requires the ability to grasp the meaning or meaning of a concept. For this reason, it is necessary to have a relationship between the concept and the meaning or meaning of a concept.

A person's interpretation of the concept can vary, which is called conception. Some previous studies show that students already have a conception of physics concepts before they take physics lessons. This conception is called preconception. Student preconceptions obtained before lessons are learned from formal lessons (junior and senior high schools), and everyday experiences that form intuitive patterns and theories about the concept.

The concept of pressure contained in a liquid is hydrostatic pressure, which is influenced by its depth or by its own weight. So that the deeper the location of a part in a liquid, the greater the pressure received on that part. Water that stays in a vessel has hydrostatic pressure. A profile of the undergraduate student conceptual understanding of hydrostatic pressure is presented in Figure 1.
Understanding the concept of hydrostatic pressure discussed in this study include Determine Hydrostatic Pressure in Vessels of different sizes, Determine the direction of pressure on the beam in water, and Scientific Observation. The results of the investigation showed that the majority of students were in the limited understanding category, the largest being Determine Hydrostatic Pressure in Vessels of different sizes. While the mean understanding of the concept of students based on categories starting from the highest is in the limited understanding category of 36.15%, misunderstanding 24.84%, understanding 24.80%, and irresponsiveness by 14.18%. The results of the analysis of students’ understanding of the concept in determining Determine Hydrostatic Pressure in Vessels of different sizes are presented in Figure 2.
In this question, students are asked to conclude the observations of a container filled with water with different water levels. Students try to find a statement for hydrostatic pressure as a function of depth or height. These questions are presented in Figure 3.

Consider the following picture!

Based on these images it can be concluded that ....
   a. The pressures on figures (a) and (b) are all the same
   b. The pressures in figures (a) and (b) vary
   c. The pressures in figure (a) are all the same, the pressures in the picture (b) vary
   d. The pressure in figure (a) varies because of the volume of water, the pressure in figure (b) are all the same
   e. The pressure on the image (a) varies because of the shape of the jar, the pressure on the image (b) is all the same

Your reason: ........................................................................................................................................

**Figure 3. Sample Question of Determine Hydrostatic Pressure in Vessels of different sizes**

Examples of student answers show that some students have not been able to provide the right conclusions, related to hydrostatic pressure as a function of depth or height. One example of the results of student answers is presented in Figure 4.

**Figure 4. (a) Example Results of Student Answer "A" in Problem Number 1; (b) Interview with Student "A"**

The results of the Student Answer "A" are in category 1, which is wrong in answering and the reason is wrong. This is the wrong argument. This is indicated when the student answers the wrong question and gives the wrong argument, and an excerpt from the clinical interview is given Figure 4b.
Based on the results of the answers and interviews with students "A", it shows that these students experience errors in concluding the observations. The mistake in concluding is an indication of an error in understanding the use of equations in solving problems.

Students are required not only to be able to convey what is obtained (reproduces) from learning outcomes on campus, but also must have the ability to transform the acquisition of knowledge. This is in accordance with the role of students as prospective teachers who are required to be able to understand the development of science through scientific explanation and convey to students through a pedagogical explanation.

The function of scientific explanation is as a means for scientists to publish their findings; this can be in the form of books or scientific publications in the form of journals or proceedings that can be accounted for in terms of quality and quantity. While the function of explanatory pedagogy aims to make it easier for students to understand scientific knowledge [22], [23]. Pedagogical explanation combines pedagogy and psychology [24], so the material taught is by the level of students' thinking skills [25]. The main prerequisite that must be considered by both prospective teachers is that pedagogical explanations do not conflict with scientific explanations. So a prospective teacher must master the material taught well through absorption of the material put forward by scientists.

Teaching physics is an explanation of pedagogy given by scientists, experts, or instructors to students based on scientific explanations by scientists [24], [26]. This issue becomes a problem in education; this is because the concepts put forward by scientists are too abstract, so students have difficulty in understanding them. The result is a limited understanding of the concepts students understand. The first thing that can be done by the teachers is to know and understand the misconceptions appear in students [27]. Understanding of concepts is the most important part of learning physics, especially in sub-material hydrostatic pressure, increasing understanding of concepts needs to be improved for the success of students in learning. In understanding the concept of hydrostatic pressure, the ability to generalize and abstraction is quite high. Whereas currently students' mastery of the concept of physics is still weak and even understood incorrectly, one of which is some students appear to associate pressure with confirmation whether for a gas or liquid [2].

4. Conclusion
The conclusion of the investigation shows that there are many undergraduate students after studying physics, have not been able to understand even the simplest parts. Some concepts have been misunderstood; this has led to undergraduate students considering physics as a difficult, complicated, and time-consuming science to be able to understand it. Understanding the concept is the most important part of learning physics. In other words, in learning physics students must understand concepts in advance to be able to solve questions and be able to apply to learn in the real world. Concepts in physics are arranged systematically, logically, and hierarchically from the simplest to the most complex. Understanding the concepts of physics is the basis for meaningful physics learning. Further research studies can be used in other instruments to diagnose undergraduate students' understanding of concepts in solving problems. And, the use of learning models that can empower the understanding of the concepts of undergraduate students on static fluid material.

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