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Analysis of Conceptual Understanding and Causes of Student Misconceptions Using the *Five-Tier Multiple Choice Test* on Static Fluid

Mita Carnesia[1] , Fatni Mufit [1*]

[1]*Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*
[2]*Department, University, Address, City, ZIP Code, Country*

Corresponding author. Email:fatni_mufit@fmipa.unp.ac.id

ABSTRACT

Misconception is a misunderstanding of the notion of learning material that can result in a mismatch between the conceptions held by someone and scientific concepts or concepts owned by scientists. Misconception can impede learning progress. The purpose of this study is to assess students' concept knowledge and misperception profile, as well as to identify the reasons of students' misconceptions about static fluid. The data was collected using a five-tier multiple choice test instrument with 14 items and five-level multiple choice questions. The respondents or samples in this study were 213 students from three different schools, categorized as low, middle, and high. This study used a purposive sampling strategy. Overall, the results showed the highest concept understanding in the material of the main law of hydrostatics, namely 54 students, in the category of understanding the concept partly in the material of viscosity, namely 128 students, the highest misconceptions experienced by students in the material of Archimedes' law concept as many as 144 students and the category did not understand the highest concept in the material of the main law of hydrostatics, namely 37 students. Concept understanding is in the low category in each school, the highest partial concept understanding is in high category schools followed by low category schools and medium category schools, the highest misconceptions occur in low category schools, not understanding the concept is in the low category in each school. The main cause of misconceptions is students' personal thinking.

Keywords: *Five-tier multiple choice;* static fluid; concept understanding; causes of misconception.

I. INTRODUCTION

Physics is a fundamental natural discipline that serves as the foundation for many other sciences. Physics, as a basic science, consists of facts, ideas, principles, laws, postulates, and hypotheses, as well as scientific technique [1]. Physics is learning that prioritizes mastery of concepts, if students have mastered the concept then it shows students have mastered the physics material well. Therefore, physics concepts embedded in students must be correct and in accordance with the actual concept [2]. If there is a wrong understanding of physics concepts in students then this will have an impact on the learning process of students in a sustainable manner [3].

As stated in the 2013 curriculum, the goal of learning physics is to grasp the ideas and principles, as well as the abilities required to build knowledge and a confident attitude in order to continue education at a higher level and advance science and technology. A thorough comprehension of the subject will be more lasting, significant, and applicable in everyday life. This might be a benefit to be able to adapt in the period of the 4.0 revolution that is still growing. The goal of learning physics is to enhance the ability to reason in students' analytical thinking by employing physics ideas and principles that explain events in everyday life and solve issues both qualitatively and quantitatively [4].

This research is focused on cognitive aspects, namely aspects related to intellectual aspects or thinking / reasoning, cognitive aspects are one of the assessments of students' understanding of concepts that can be

implemented in the classroom. To achieve this goal, a good and correct understanding of the concept is needed from students to avoid misconceptions in students [5]. Misconceptions and low concept understanding are problems that often occur in physics learning [6].

Misconception is a misunderstanding in interpreting the notion of learning material that can produce a mismatch between the conceptions held by someone and the theories or ideas held by scientists [7] [8]. Misconceptions can stymie learning progress, especially in physics, where learning has a significant impact on students. Misconceptions about physics learning by students will impair physics learning, and students' impoverished level of comprehension of the topic is still a huge difficulty for teachers [9].

Misconceptions will continually influence the efficacy of students learning processes in the future [10]. Misconceptions among students will impede the learning process since they will be more confident in their own beliefs and reject expert concepts [11], Misconceptions can impede the advancement of science and technology if they occur among a significant number of students [12].

There are many factors that cause misconceptions, including coming from the students themselves, educators/teachers, lesson content/context, textbooks and learning methods used by teachers [13]. As well as the use of inappropriate learning methods, the disclosure of incorrect applications of the concepts concerned, and the use of props that do not accurately represent the concepts described can also cause misconceptions in children [14].

Based on the research conducted, it was found that there were considerable misconceptions in static fluid material using the *Four Tier Multiple Choice Test.* The misconceptions of students for each sub-concept in a row are Explaining the concepts and factors that affect hydrostatic pressure and buoyancy force by 62.5%, Comparing the effect of density on the position of objects in static fluid by 51.3%, Applying Pascal's law to static fluid events and hydraulic pumps by 55%, Implementing the concept of Archimedes' law on buoyancy force on mass objects in everyday life by 50.6%, Connecting the concept of Pascal's principle with the amount of pressure and lifting force exerted on mass objects 59.4%. One way that can be used to identify errors in answering questions is with diagnostic tests [15].

Diagnostic tests are used to identify whether students suffer misunderstandings or the reasons students fail in the learning process. They are prepared in the form of multiple choice [16]. Multiple-choice tests are a more efficient way of identifying misconceptions than interviews [17]. The five-level multiple choice test adds sources used to answer because some learners may have difficulty in representing their thinking [18]. However, this multiple choice has several drawbacks, such as when working on the questions, students might guess the answers without the requirement to grasp the information from the questions [19]. Researchers employed a five-tier multiple-choice test on students to assess their grasp of ideas and the sources of misunderstandings. Furthermore, test can assist teachers improve student learning results by doing more in-depth analyses [20].

Analysis of concept understanding and causes of student misconceptions is important as a tool to identify students' concept understanding and causes of misconceptions, especially in static fluid material and as information about misconceptions in static fluid material for students [21]. If misconceptions are allowed, students will have difficulty in understanding the concepts conveyed by the teacher so that the new knowledge gained by students will be hampered [22].

II. METHOD

This is descriptive study that takes a quantitative approach. The primary goal of descriptive research is to present a clear and accurate account of the material or phenomena under investigation. The description is completed by identifying events that can be used for further investigation [23].

The quantitative method is a numerical strategy that begins with data gathering, then interprets the data, and then presents the results [24]. This study employed a survey approach to obtain information from respondents using a questionnaire.

A. *Population And Sample* .

A population is a generalization of items or persons with certain attributes and characteristics that researchers investigate and derive conclusions from [25]. This study used the Purposive Sampling approach.

The Isaac & Michael table was used to determine the number of class samples, using a 5% significance level and a total sample size of 213 students. To calculate the number of samples from each school, the formula described by [26] is utilized. The sample for each school is shown in table 1

Table 1. Research Sample

School name	School code	Number of samples
SMAN 1 Painan	A	68
SMAN 2 Painan	B	112
SMAN 3 Painan	C	33

B. Research Instruments .

The five-level multiple-choice questionnaire can be used to identify students' misconceptions about static fluid material. This instrument has been validated for validity, reliability, discriminating power, and difficulty index. The validity study findings show that 14 question items are valid. The results of the instrument reliability test are among the top requirements. As a result, we may infer that the instrument is reliable and usable. This instrument's differentiating power varies between 0.22 and one. The question's difficulty index is medium, with differences ranging from 0.5 to 0.7.

C. Data Analysis Techniques .

Data analysis occurs once all respondents or other data sources have been collected [25]. The objective of data analysis is to produce a description or description of the subject in the research based on relevant data acquired from the subject group investigated [27].

Student response data received following the use of the five-level multiple choice instrument was then processed and analyzed to determine the presence of misunderstandings in students and the reasons of misconceptions using the concept comprehension category table presented by [13], based on the table, the overall level of student understanding was grouped into four categories of conception levels consisting of, UC = Understand the Concept, PU = Partially Understand the Concept, MC = Misconception, NU = Not Understand the Concept. Students in the conceptual understanding category answer correctly at level-1 and level-3 and confidently at level-2 and level-4. Students in the partial conceptual understanding category answer correctly at level-1 and level-3 but are unsure at level-2 and level-4. Students in the misconception category answer incorrectly at level-1 and level-3 but are sure a.

III. RESULTS AND DISCUSSION

CONCEPT UNDERSTANDING PROFILE OF STUDENTS IN PHYSICS LEARNING STATIC FLUID MATERIAL.

Table 2 Frequency and Percentage of Learners' Comprehension Level

No. About	Concept Understanding (PK)		Partially Understand the Concept (MCC)		Misconceptions (M)		Not Understanding the Concept (TPK)	
	n	%	n	%	n	%	n	%
Investigating the Prime Law of Hydrostatics								
1	54	25 .4	67	31 .5	80	37 .6	12	5 .6
9	9	4 .2	108	50 .7	74	34 .7	22	10 .3
8	34	16.0	63	29 .6	79	37 .1	37	17 .4
Formulating Pascal's Principle								
7	4	1 .9	55	25 .8	124	58 .2	30	14 .1
Analyzing Archimedes' Law								
5	4	1 .9	32	15	144	67 .6	33	15 .5
11	18	8 .5	121	56 .8	65	30 .5	6	2 .8
Applying Archimedes' Law in Daily Life								
10	11	5 .2	49	23	129	60 .6	24	11 .3
13	23	10 .8	52	24 .4	104	48 .8	34	16
2	26	12 .2	126	59 .2	45	21 .1	16	7 .5
Applying the Concept of Capillarity								
3	11	5 .2	76	35 .7	100	46 .9	26	12 .2
Understanding Viscosity in Fluids								
6	34	16.0	88	41 .3	70	32 .9	21	9 .9
4	24	11 .3	36	16 .9	129	60 .6	24	11 .3
14	5	2 .3	128	60 .1	58	27 .2	22	10 .3
12	7	3 .3	75	35 .2	95	44 .6	36	16 .9

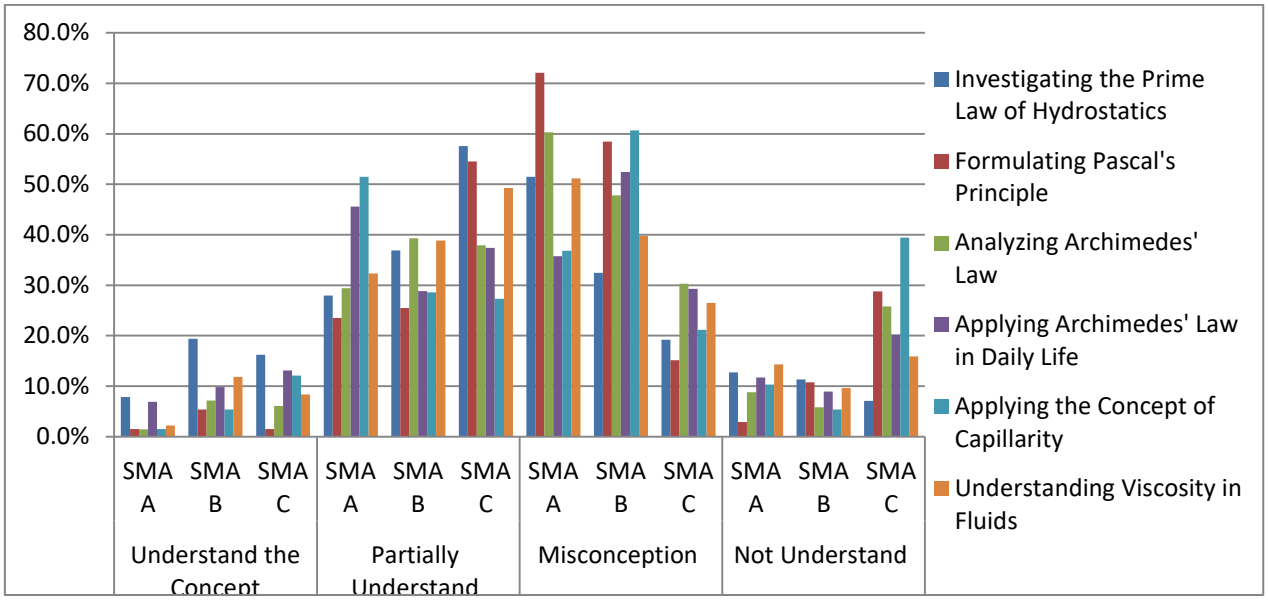

Image 1 Average Percentage of Learners' Comprehension Level in SMA A, SMA B and SMA C.

A. Main Laws of Hydrostatics

The main hydrostatic law material on this five-tier multiple choice test instrument consists of 3 items, namely items number 1, 9, and 8. Indika tor item number 1, which explains the direction of the force received by the cube in the fluid as many as 37.6% of students experience misconceptions.

The indicator in question number 9 discusses sorting the magnitude of hydrostatic pressure from the deepest point, with 34.7% of students identified misconceptions, the main cause of misconceptions is that students assume that the farther the depth of a point from the surface of the fluid, the smaller the hydrostatic pressure. Whereas based on the actual concept, the further the depth of a point from the surface of the fluid, the greater the hydrostatic pressure. In question no. 8 Discusses the topic on the link between pressure and depth 37.1% of students have misconceptions because they believe that the larger the mass, the greater the pressure on the real notion. The further the object is from the water's surface, the higher the pressure.

B. Pascal's Principle

Pascal's principle material on this five-tier multiple choice test instrument In question number 8 is the material of the hydraulic device that produces the greatest force, 58.2% of students experience misconceptions because they think that the smaller the cross-sectional area, the greater the force when based on the actual concept of the largest cross-section of the pipe and the force is directly proportional to the cross-sectional area.

C. Archimedes' Law

Archimedes' law material on this five-tier multiple choice test instrument consists of 2 items, namely items number 5 and 11. The indicator of item number 5 is the object's lifting force, and 67.6% of students have misconceptions about this item because they believe the mass of the object affects the lifting force, whereas the lifting force is only influenced by the volume of the submerged object, the density of the fluid, and the force of gravity. Item 11 describes the phenomena of items floating in a fluid, which has a 30.5% misconceptions rate.

D. Analysis of Archimedes' Law in Daily Life

The material for analyzing Archimedes' law in everyday life on this five-tier multiple choice test instrument consists of 3 items, namely item numbers 10, 13 and 2. Indicator item number 10, namely the position of similar objects in water when floating, identified 60.6% of students experiencing misconceptions because they think the mass of objects affects the buoyant force, even though what affects the buoyant force is the volume of the immersed object, the density of the fluid and the gravitational force. In item number 13 discussing the increase in water in the tube 48.8% of students were identified as having misconceptions because they thought that mass affected the increase in fluid even though the volume of marbles that were immersed was the same, so the water moved was the same. In item number 2 discussing the weight of objects in the air, 21.1% of students identified misconceptions.

E. Capillarity

Capillarity material on this five-tier multiple choice test is found in question item number 3. Question item discussing the phenomenon of capillarity identified 46.9% of students experiencing misconceptions.

F. Viscosity

Viscosity material on this five-tier multiple choice test instrument consists of 4 items, namely items number 6, 4, 14 and 12. Indicators of items number 6 and number 14, namely discussing the speed of dripping fluids of

different viscosity with misconceptions are 32.9% and 27.2%, respectively. in all questions students managed to determine the relationship between viscosity and the speed of falling fluid.

Indicator item number 4 is an object dropped into a container of oil. With a misconception of 60.0%, it is classified in the moderate category. This happens because students think that objects will move slowly even though in an object that falls into the fluid there will be something called terminal velocity where the object will move constantly when the object is in a balanced state.

The indicator for question number 12 is the change in ball speed in viscous fluid with the cause. Identified misconceptions of students amounting to 44.6%. students assume there is an upward force by the fluid so that the object moves while the actual concept of Stokes force continues to increase to a constant speed.

The data will then be shown in further detail in the three schools listed below, with low, medium, and high classifications.

A. SMA A

Based on data processing, the results of the research that has been carried out using a *five-tier multiple choice* instrument with 14 items tested on 68 students.

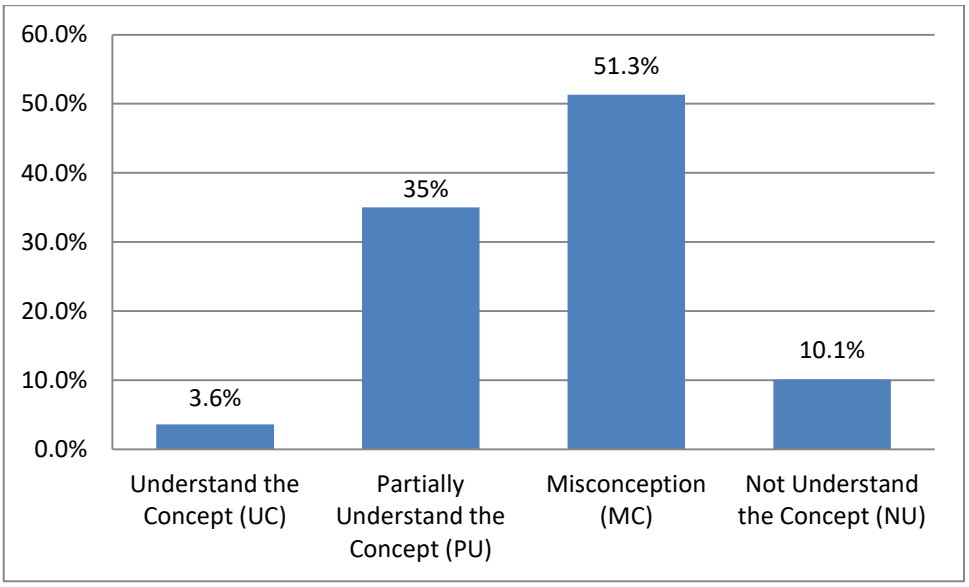

Image 2 Percentage of Comprehension Levels of Learners in Low Category High Schools.

The figure above shows that all students in SMA A have a conceptual understanding level of 3.6%, 11.5% of students in the category of not understanding the concept. Based on table 4, it is interpreted as low and misconceptions 50.0%, 34.9% of the conceptual understanding category, some of these percentages are interpreted as moderate.

B. SMA B

Based on data processing, the findings of a study conducted on 112 students using a five-tier multiple choice instrument with 14 items. The number of pupils who comprehend the subject, grasp it somewhat, have misconceptions about it, or do not understand it at all.

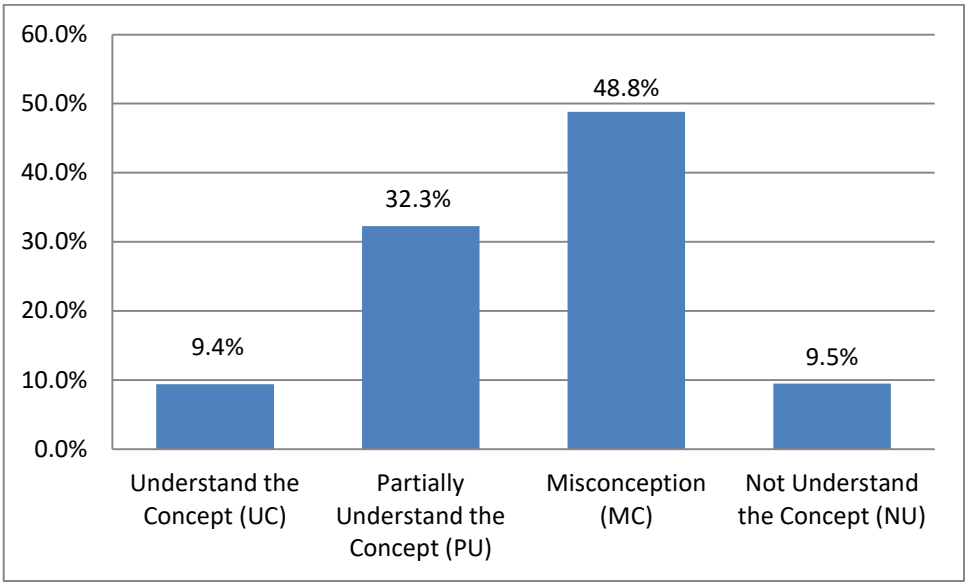

Image 3 Percentage of Comprehension Level of High School Learners in the Medium Category.

The figure above shows that all students in SMA B have a conceptual understanding level of 9.8%, 8.6% of students in the category of not understanding the concept Based on table 4, interpreted as low and misconceptions 48.6%, 33.0% of the conceptual understanding category some of these percentages are interpreted as moderate.

C. SMA C

Based on data processing, the findings of a study conducted on 33 students using a five-tier multiple choice instrument with 14 items. The amount of students who come within the category of understanding the concept, understanding the concept partially, misconceptions and not understanding the concept.

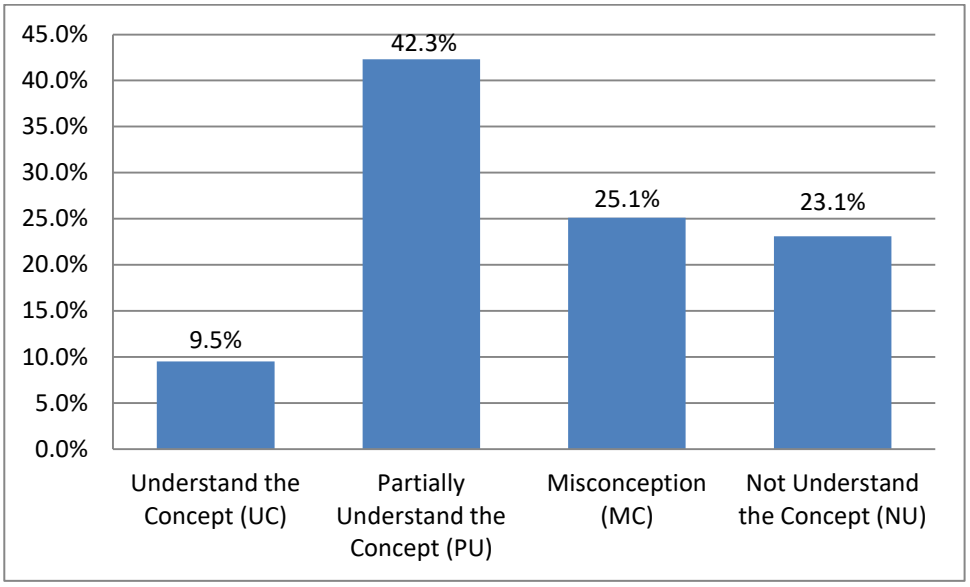

Image 4 Percentage bar of the comprehension level of high school students in the high category.

Figure 12 shows that overall students in SMA B have 9.8% concept understanding, 23.6% of students in the misconception category and 22.9% of students do not understand the concept, based on table 5, interpreted as low and 44.0% of the concept understanding category some of these percentages are interpreted as moderate. The following graph shows the concept understanding of each school category in general.

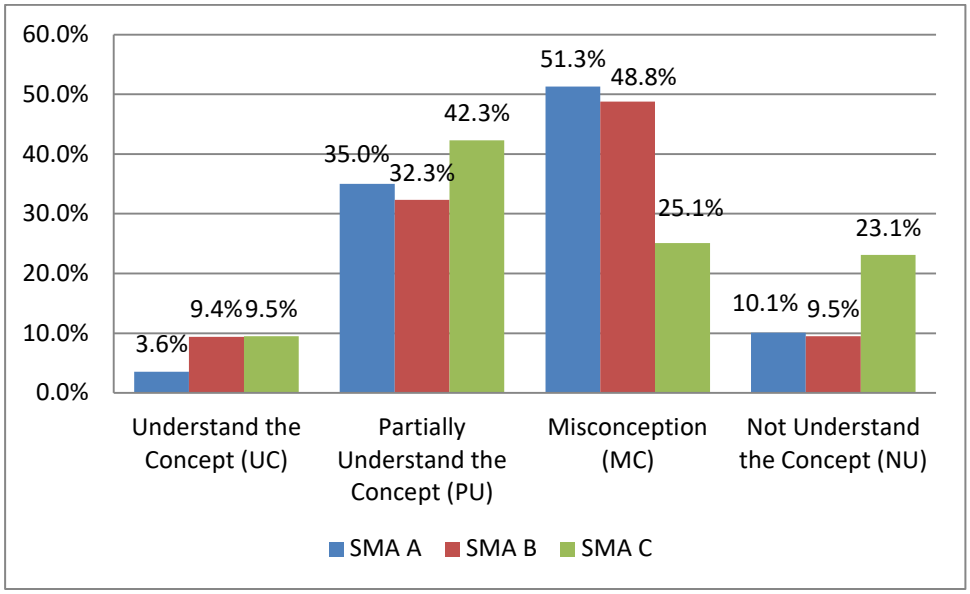

Image 5 Percentage of Concept Understanding in Each School

as shown in Figure 13, the proportion of concept understanding category in each school remains relatively low; the lowest is found in schools with a low category of 3.6%, medium category schools 9.4%, and high category schools 9.5%. The highest partial concept understanding is found in high category schools, namely 42.3%, low category schools 35% and medium category schools 32.3%. In the misconception section, each school has a fairly high percentage and the highest is in the low category school which is 51.3%, then the medium category school is 48.8% and the high category school is 25.1%. Not understanding the concept was highest in high category schools at 23.1%, followed by low category schools at 10.1% and finally medium category schools at 9.5%.

CAUSES OF MISCONCEPTIONS IN PHYSICS LEARNING OF STATIC FLUID MATERIAL.

Learners who have misunderstandings can identify the source of their misconceptions using the fifth tier. The fifth tier includes the sources of information needed to answer questions in tiers 1 and 3. Based on the sources of misinformation, including literature, teachers, personal ideas, friends, and the internet. Furthermore, the graphic below depicts the reasons of misunderstandings among students at each school.

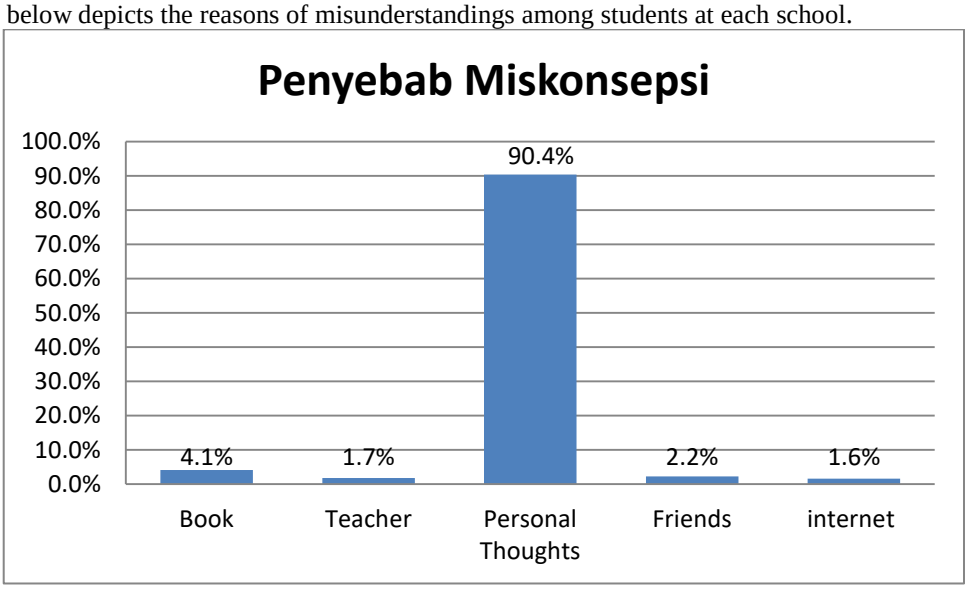

Image 6 Percentage of Causes of Misconception in Static Fluid Material

Figure 6 shows that the origins of misunderstandings or sources of information utilized by students in answering questions are dominated by personal views or thoughts from the students themselves, which account for 90.4%, books 4.1%, teachers 1.7%, friends 2.2%, and the internet 1.6%. The cause of misconceptions was also found as much as 42.05% which occurred due to students' personal opinions. Students only obtain information and concepts from the teacher's explanation, so they do not participate actively in the learning process and do not construct the understanding of physics based on their own experience [22].

IV. CONCLUSION

The concept understanding of students on static fluid material in District IV Jurai, as a whole, is categorized as low. Misconceptions identified on the concept of static fluid using the Five-Tier Multiple Choice Test are included in the medium category, overall the average percentage of misconceptions that occur is 31.3%. misconceptions had by schools with low categories, namely SMA A, amounted to 51.3%; schools with medium categories, meaning SMA B, suffered 48.8% misconceptions; and schools with high categories, namely SMA C, had 25.1% misconceptions. Low-category schools had the most misconceptions, followed by medium and high-category schools. The internet 1.6%, teachers 1.7%, friends 2.2%, literature 4.1%, and personal views 90.4% all contribute to student misconceptions. Personal opinions are the most common source of student misconceptions in static fluid materials.

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