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ANALYSIS OF MISCONCEPTIONS OF STUDENTS OF SMP NEGERI 6 INDRALAYA UTARA USING THE FOUR TIER DIAGNOSTIC TEST ON THE MATERIAL OF SUBSTANCE PRESSURE

Sariya Melati[1*], **Murniati**[2],
[1]Program studi Pendidikan Fisika FKIP, Universitas Sriwijaya Palembang, Indonesia, sariyamelati3@gmail.com
[2]Program studi Pendidikan Fisika FKIP, Universitas Sriwijaya Palembang, Indonesia
* Corresponding Author

Abstract
Physics education often poses challenges due to its conceptual complexity. This research analyzes student misconceptions on the topic of substance pressure using a Four-Tier Diagnostic Test at SMP Negeri 6 Indralaya Utara. A descriptive quantitative approach was applied with 64 Grade IX students. The instrument used included a multiple-choice question, answer confidence, reason selection, and confidence in reasoning. The results revealed that 82% of students exhibited misconceptions. A detailed analysis identified frequent misunderstandings related to hydrostatic pressure and the relationship between force, area, and pressure. The study underscores the importance of addressing conceptual errors and suggests the use of interactive teaching strategies and diagnostic tools to improve conceptual understanding. Limitations such as sample scope and instrument specificity are acknowledged to strengthen future research

Keywords: *Misconceptions, Four Tier Diagnostic Test, Substance Pressure*

Abstrak
Pembelajaran fisika sering kali menjadi tantangan bagi siswa karena kompleksitas konsep yang diajarkan. Penelitian ini bertujuan untuk menganalisis miskonsepsi siswa pada topik tekanan zat dengan menggunakan instrumen Four-Tier Diagnostic Test di SMP Negeri 6 Indralaya Utara. Penelitian ini menggunakan pendekatan deskriptif kuantitatif dengan subjek sebanyak 64 siswa kelas IX. Instrumen yang digunakan terdiri dari soal pilihan ganda, tingkat keyakinan terhadap jawaban, alasan pemilihan jawaban, dan tingkat keyakinan terhadap alasan. Hasil penelitian menunjukkan bahwa sebanyak 82% siswa mengalami miskonsepsi. Analisis lebih lanjut mengungkapkan bahwa miskonsepsi paling sering terjadi pada konsep tekanan hidrostatis dan hubungan antara gaya, luas permukaan, dan tekanan. Temuan ini menekankan pentingnya penanganan kesalahan konsep melalui strategi pembelajaran interaktif dan penggunaan alat diagnostik yang tepat. Keterbatasan penelitian seperti lingkup sampel dan karakteristik instrumen diakui sebagai pertimbangan untuk penelitian selanjutnya.

Kata kunci : *Miskonsepsi, Four Tier Diagnostic Test, Tekanan Zat*

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INTRODUCTION

Physics is often perceived as a complex subject by students due to the abstract nature of its concepts. This leads to a common issue in learning: misconceptions—incorrect understandings that deviate from scientific truths. Students often develop preconceptions from daily experiences, which, if not corrected, can persist even after formal instruction (Diyen et al., 2021). Concepts form the foundation of scientific knowledge (Çaycı, 2018), and poor concept mastery has been linked to low student performance in physics (Febrianti et al., 2019). Misconceptions are particularly problematic because they resist change, even when students are presented with accurate information (Syuhendri, 2019; Nursyamsi et al., 2018).

The topic of substance pressure is not only foundational for further learning in physics but also closely related to everyday life applications such as air pumps, tensiometers, and fluid dynamics. Previous studies have shown that misconceptions regarding pressure are common. Mustikasari et al. (2018) identified nine types of misconceptions in middle school students, and Nisa et al. (2022) found a 27% misconception rate in similar topics.

To address such misunderstandings, diagnostic assessments are vital. The Four-Tier Diagnostic Test stands out as an effective tool, as it assesses student answers, confidence levels, reasoning, and confidence in reasoning (Zulfikar et al., 2017). Unlike traditional tests, it enables educators to uncover not only whether students are right or wrong, but also *why* they think so. Although previous research has used other diagnostic models, such as two-tier and three-tier tests, these often fail to capture the full depth of students' reasoning. The four-tier format provides a more nuanced analysis, helping educators to better tailor interventions (Maison et al., 2020).

This study was conducted at SMP Negeri 6 Indralaya Utara, a school with a diverse student population but no prior exposure to diagnostic testing. The school's context makes it a suitable setting to explore misconceptions using the four-tier approach, aiming to provide evidence-based insights to improve teaching strategies.

METHODS

This study was conducted at SMP Negeri 6 Indralaya Utara in the odd semester of the 2024/2025 academic year to analyze students' misconceptions on the material of substance pressure. The subjects of the study were 64 grade IX students (IX.1–IX.3). The instrument used was a four-tier diagnostic test modified from Sherina Nurul Ihzza's instrument (UIN Suska Riau) which has been proven valid (65%) and reliable (0.70461). Initially a three-tier test, this instrument was developed into four levels by adding a level of confidence to the reasons. Initially a three-tier diagnostic test, this instrument was modified into four levels in this study to classify students' understanding into three categories: understanding the concept, misconceptions, and lack of understanding. Data were collected through tests and analyzed descriptively.

Table 1. Standards for examining the four- tier items

Criteria	Explaination of Criteria
Understand the concept	Tier-1 and Tier-3 are correct and confidence rating at Tier-2 and Tier-4 are “sure”
Lack of understanding	• Tier-1 and Tier-3 are correct and confidence rating at Tier-2 and Tier-4 are “not sure” • Tier-1 and Tier-3 are correct and only one confidence rating (Tier-2 or Tier-4) is “not sure” • Only one (Tier-1 or Tier-3) is correct and only one

	confidence rating (Tier-2 and Tier-4) are "not sure" • Only one (Tier-1 or Tier-3) is correct and confidence rating at Tier-2 and Tier-4 are "sure" • Tier-1 and Tier-3 are wrong and confidence rating at Tier-2 and Tier-4 are "not sure" • Tier-1 and Tier-3 are wrong and only one confidence rating (Tier-2 or Tier-4) is "not sure"
Misconception	Tier-1 and Tier-3 are wrong and confidence rating at Tier-2 and Tier-4 are "sure"

After that, an analysis was conducted to obtain the percentage of each category of student understanding level, namely understanding the concept, lack of understanding, and experiencing misconceptions, according to the predetermined criteria. This process uses the formula proposed by Sudijono (in (Sheftyawan et al., 2018) as follows:

$$P = \frac{f}{n} x\, 100\,\% \tag{1}$$

Description:
P = Percentage value of student answers
F = Frequency of student answers in each category
n = Total number of students who were used as research subjects

After obtaining the percentage results related to the level of student misconceptions, the next step is to categorize the percentages. Then, the results of the categorization will be arranged in the following table.

Table 2. Categorization of Student Misconception Levels

Percentage of misconceptions	Misconception categories
61%-100%	Tall
31%-60%	Medium
0%-30%	Low

(istighafarin,2020)

RESULTS AND DISCUSSION

- **Overview of Student Conceptual Understanding**

Based on the results of the four-tier diagnostic test administered to 64 ninth-grade students, their conceptual understanding was categorized into three groups:

understand the concept, misconception, and lack of understanding. As summarized in Table 3, a total of 1,045 misconceptions were identified, with only 67 correct understandings, and 168 categorized as lack of understanding.

Table 3. Number of Students in the Concept Understanding, Misconception, and Not Understanding Concept Categories

Question Number	Number of Students		
	Understand the Concept	**Misconception**	**Lack of Understanding**
1	7	55	2
2	2	58	4
3	1	56	7
4	8	51	5
5	1	41	22
6	5	43	16
7	0	53	11
8	0	55	9
9	3	54	7
10	5	49	10
11	0	57	7
12	3	53	8
13	0	56	8
14	0	54	10
15	5	55	4
16	8	52	4
17	3	56	5
18	3	54	7
19	13	42	9
20	0	51	13
Amount	67	1045	168

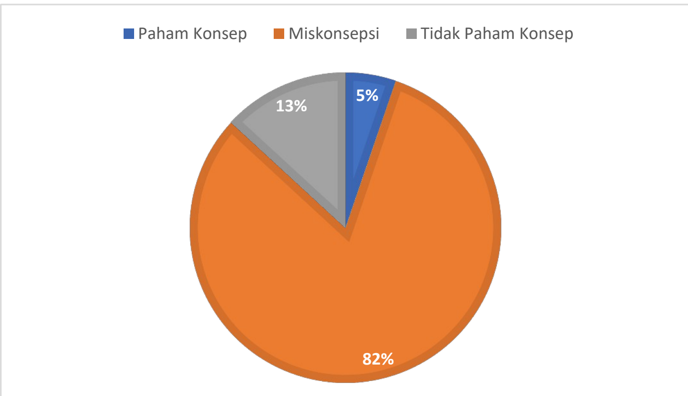

Figure 1. Average Percentage of Concept Understanding of Grade IX Students

Figure 1 illustrates that 82% of student responses reflected misconceptions, while 13% showed a lack of understanding, and only 5% demonstrated correct conceptual grasp. This reveals a dominant presence of conceptual errors among students regarding substance pressure.

- **Misconception Patterns**

The item breakdown is presented in Table 4, which shows that the highest level of misconception is 90.62%, while the lowest level of misconception is 64%. Although the percentages vary, misconceptions are consistently high across all items, indicating a systemic misunderstanding of the concept of all pressure

Table 4. Average Percentage of Students in the Category of Understanding Concepts, Misconceptions, and Lack of Understanding

Question Number	Average Percentage of Student Understanding		
	Understand the Concept	**Misconception**	**Lack of Understanding**
1	10.90%	85.90%	3.12%
2	3.12%	90.62%	6.25%
3	1.56%	87.50%	10.90%
4	12.50%	79.60%	7.80%
5	1.50%	64%	34.30%
6	7.80%	67.10%	25%
7	0	82.80%	17.10%
8	0	86%	14%
9	4.60%	84.30%	10.90%
10	7.80%	76.50%	15.60%
11	0	89%	10.90%
12	4.68%	82.80%	12.50%
13	0	87.50%	12.50%
14	0	84.30%	15.60%
15	7.80%	85.90%	6.25%
16	12.50%	81.25%	6.25%
17	4.68%	87.50%	7.80%
18	4.68%	84.37%	10.90%
19	20.31%	65.62%	14%
20	0	79.60%	20.30%
Amount	5.22%	81.60%	13.10%

Table 5 groups misconceptions based on subconcepts. The highest misconception (88.01%) is in the basic concept of pressure, while the lowest (71.80%) is in the subconcept of the relationship between force and surface area. All categories are included in the high level of misconception.

Table 5. Student Misconceptions for Each Question Item

Sub Concept	No. Question	Frequency	Presentation		Criteria
Concept of Pressure	1	55	85.90%	88.01%	Tall
	2	58	90.62%		Tall
	3	56	87.50%		Tall
Relationship between force	4	51	79.60%	71.80%	Tall

and surface area to the magnitude of the pressure	5	41	64%		Tall
Archimedes' Law	6	43	67.10%	80.30%	Tall
	8	55	86%		Tall
	9	54	84.30%		Tall
Pascal's law on objects in everyday life	10	49	76.50%	82.77%	Tall
	12	53	82.80%		Tall
Pressure with the process of transporting plant solid substances and blood pressure	13	56	87.50%	85.90%	Tall
	14	54	84.30%		Tall
	15	55	85.90%		Tall
The principle of pressure of substances on objects in everyday life	16	52	81.25%	84.38%	Tall
	17	56	87.50%		Tall
Application of Archimedes' Law to objects floating, hovering, and sinking in liquids	18	54	84.37%	84.37%	Tall
Pressure of liquid at a certain depth (hydrostatic pressure)	19	42	65.62%	72.61%	Tall
	20	51	79.60%		Tall
Average		81.60%			Tall

- **Discussion per Subconcept**

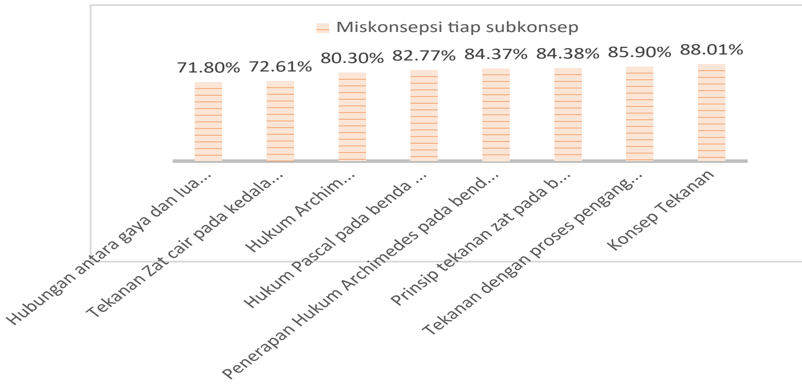

Figure 2. Percentage of Misconceptions of Grade IX Students for Each Sub-Concept

In addition, the most dominant forms of misconceptions in students' answers can be seen in the following table.

Table 6. Forms of Student Misconceptions for Each Question Item

No. Question	Forms of Misconception		Misconception Percentage	No. Question	Forms of Misconception		Misconception Percentage
	Tier 1	Tier 3			Tier 1	Tier 3	
1	A	A	7.80%		B	B	7.80%
	B	A	7.80%		B	C	17%

	B	B	9.30%
	C	B	9.30%
	C	E	4.60%
	D	A	17%
	D	B	6.25%
	D	D	9.30%
2	A	A	12.50%
	A	B	7.80%
	A	D	3.00%
	B	B	7.80%
	B	C	6.25%
	C	A	15.60%
	C	D	10.90%
	D	D	9.30%
3	A	A	6.25%
	A	B	4.60%
	B	C	6.25%
	B	D	4.60%
	C	C	7.80%
	D	A	4.60%
	D	B	3%
4	A	A	18.75%
	A	B	6.25%
	A	C	4.60%
	B	A	4.60%
	B	B	17%
	C	A	3%
	D	D	6.25%
5	B	-	25%
	C		11%
	D		14%
6	A	B	7.80%
	A	C	7.80%
	B	C	6.25%
	C	A	6.25%
	C	C	11%
	D	B	3%
7	A	-	11%
	B		30%
	C		20%
	D		19%
8	A	-	17%
	B		19%
	C		17%
	D		14%

	B	D	11%
	C	C	3%
	C	D	3%
13	A	A	14%
	A	D	4.60%
	B	A	12.50%
	B	C	4.60%
	C	A	15.60%
	C	B	14%
	C	C	6.25%
	D	A	6.25%
14	A	A	7.80%
	A	B	9%
	B	A	7.80%
	B	B	14%
	B	C	6.25%
	C	B	3%
	D	A	12.50%
	D	B	19%
15	A	A	11%
	A	B	7.80%
	A	C	9%
	B	A	6.25%
	B	B	5%
	C	A	12%
	C	B	14%
	C	C	7.80%
16	A	A	17%
	A	B	9%
	A	C	7.80%
	B	A	5%
	B	B	5%
	B	C	3%
	C	A	9%
	C	B	1.50%
	D	A	5%
	D	D	6.25%
17	A	A	11%
	A	B	28%
	B	A	6.25%
	B	B	19%
	B	C	7.80%
	C	B	14%
	C	C	6.25%
	D	A	3%

9	A	A	23%	18	A	B	9%
	A	B	7.80%		A	C	3%
	B	B	14%		A	D	3%
	C	A	6.25%		B	A	11%
	C	B	9%		B	B	7.80%
	D	B	2%		B	C	6.25%
10	A	B	12.50%		B	D	7.80%
	A	C	3%		C	B	13%
	B	B	6.25%		C	C	6.25%
	B	C	9%		D	B	5%
	C	A	9%	19	A	B	7.80%
	C	B	6.25%		B	B	9%
	D	B	14%		C	C	3%
11	A	-	25%		D	A	17%
	B		33%		D	C	7.80%
	C		19%		D	D	5%
	D		11%	20	A	-	23%
12	A	B	14%		B		23%
	A	C	6.25%		C		27%
					D		6.25%

The high level of misconceptions can be seen in various subconcepts tested, such as substance pressure, Archimedes' law, Pascal's law, hydrostatic pressure, and their application in everyday life. Here is an in-depth discussion for each subconcept:

1. **Concept of Pressure**

Many students mistakenly assume that pressure only depends on force, without considering surface area. This is most likely influenced by intuitive but incorrect everyday experiences. Mustikasari et al. (2018) also found that students often ignore the inverse relationship between pressure and surface area.

2. **Relationship between Force and Surface Area**

Students often misapply the pressure formula, assuming that pressure increases as force and surface area increase. This error indicates a weak understanding of mathematical relationships, as also found by Nurmanitari (2020)

3. **Archimedes' Law**

In questions related to buoyancy, students fail to understand that buoyancy is equal to the weight of the displaced liquid. Misconceptions above 80% indicate that students do not yet have a deep understanding of fluid principles. This is due to a lack of visualization and direct practice.

4. **Pascal's Law in Everyday Life**

Students make mistakes in understanding how pressure works in closed systems such as hydraulics and blood pressure. Saputra (2019) highlighted that this misconception occurs due to the lack of connection between theory and its application in real life.

5. **Pressure with the process of transporting substances in plants and blood pressure**

Many students think that root suction is the main factor in transporting water in plants, when in fact the correct one is cohesion and adhesion. In the blood pressure question, students also misunderstand how pressure is distributed in a closed system. Nisa et al. (2022) suggest the importance of integrating biological contexts in physics teaching.

6. **Application of Pressure in Everyday Life**

Students misunderstand the concept of air pressure and buoyancy, for example assuming that pressure increases with increasing altitude. This indicates confusion in students' mental models of atmospheric pressure.

7. **Application of Archimedes' Law to Floating, Hovering, and Sinking Objects in Liquids**

Students often equate mass with density, so they misjudge which objects float and which sink. This shows the need to emphasize the concept of density and its application in Archimedes' law.

8. **Pressure of a liquid at a certain depth (hydrostatic pressure)**

Although students were introduced to the formula P = ρgh, misconceptions persisted. Many believed pressure decreases with depth, reflecting cognitive inversion. This aligns with findings by Putri et al. (2021), who emphasized the need for hands-on demonstrations to reinforce this concept.

- **Causes of Misconceptions and Their Implications**

The high level of misconceptions in all subconcepts of substance pressure indicates several main factors that influence students' understanding. First, erroneous initial assumptions from everyday experiences are often the source of misconceptions, for example the assumption that pressure is only influenced by force without considering surface area. Second, limited conceptual reasoning abilities make it difficult for students to understand proportional relationships and the application of physical laws in closed systems.

Third, the lack of visual media and practical experiences makes it difficult for students to imagine abstract concepts such as hydrostatic pressure or buoyancy. Fourth, learning strategies that emphasize memorization without conceptual understanding make students tend to apply formulas mechanically and incorrectly. Fifth, the lack of formative diagnostic assessments makes it impossible for teachers to detect misconceptions early on.

The combination of these factors shows that misconceptions are not just individual errors, but reflect a learning process that is not yet optimal. Therefore, improvements in physics learning need to be directed at a diagnostic, visual, and contextual approach to build more meaningful understanding.

CONCLUSION

Based on the data analysis, most ninth-grade students at SMP Negeri 6 Indralaya Utara have significant misconceptions about substance pressure, with an average misconception rate of 81.60%. These misconceptions are concentrated in specific subconcepts, particularly the basic concept of pressure (90.62%), where students fail to understand that pressure depends on both the magnitude of force and the surface area. Additionally, many students incorrectly believe pressure is proportional to surface area, rather than inversely proportional. Misconceptions also occur in Archimedes' law, Pascal's law, hydrostatic pressure, and real-world applications such as substance transport in plants and blood pressure. These issues indicate difficulty in connecting physics concepts to real-world contexts. The main causes are incorrect assumptions, limited abstract reasoning, lack of visual aids or experiments, and an emphasis on rote memorization. To improve understanding, it is recommended that teachers use diagnostic and interactive methods, such as the Four-Tier Diagnostic Test, along with visual media, simulations, and contextual experiments. This approach promotes conceptual understanding over mere memorization.

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