

## Research Article



# First-Year Students' Initial Understanding of The Basic Concept of Static Fluid

<sup>1</sup>Dios Sarkity\*, <sup>2</sup>Metta Liana, <sup>3</sup>Cicyn Riantoni, <sup>4</sup>Putri Dwi Sundari, <sup>5,6</sup>Bakhrul Rizky Kurniawan

<sup>1</sup> Biology Education Department, Universitas Maritim Raja Ali Haji, Tanjungpinang, Riau Island, 29124, Indonesia

<sup>2</sup> Mathematics Education Department, Universitas Maritim Raja Ali Haji, Tanjungpinang, Riau Island, 29124, Indonesia

<sup>3</sup> Physics Education Department, Universitas Jambi, Jambi, 36122, Indonesia

<sup>4</sup> Physics Institute for Science Education and Communication, University of Groningen, Groningen, Netherlands

<sup>5</sup> Graduate Institute of Science Education, National Taiwan Normal University, Taipei City, Taiwan.

<sup>6</sup> Pendidikan Fisika, Universitas Negeri Malang, Malang, Jawa Timur 65145, Indonesia.

## ARTICLE INFO

### Article History:

Submitted: 18-04-2025

Revised : 13-07-2025

Accepted : 16-11-2025

Published: 19-12-2025

### Keywords:

Contextual Learning;

Initial Understanding;

Maritime Context;

Physics Learning;

Static Fluids

### Kata Kunci:

Pembelajaran Kontekstual;

Pemahaman Awal;

Konteks Maritim;

Pembelajaran Fisika;

Fluida Statis

© 2025 the author(s)



## ABSTRACT

Indonesia is one of the largest maritime countries in the world. Learning should be carried out contextually by linking knowledge with contexts relevant to students' daily lives, such as the maritime context. This research is descriptive to determine students' initial understanding of the basic concept of static fluids. This research involved 66 first-year students in biology education as research subjects. The data collection technique used in this research is a test that uses 6 questions that represent the concepts of density, hydrostatic pressure, and buoyant force. Data was analyzed descriptively, quantitatively and qualitatively. The research results show that many students still experience problems understanding the basic concepts of static fluids, including density, hydrostatic pressure, and buoyant force. This indicates the need for implementing learning that can improve students' understanding of basic concepts of static fluid and enable them to link their knowledge with conditions and situations related to the maritime context in their daily lives. One of the effective approaches to address this issue is implementing a problem-based learning model. This study highlights the importance of contextualized general physics instruction to bridge students' experiential and conceptual understanding, especially in maritime-based learning contexts.

## ABSTRAK

Indonesia merupakan salah satu negara maritim terbesar di dunia. Pembelajaran sains, khususnya fisika, perlu dilaksanakan secara kontekstual dengan mengaitkan materi dengan situasi yang relevan dalam kehidupan sehari-hari mahasiswa, termasuk konteks kemaritiman. Penelitian ini merupakan penelitian deskriptif yang bertujuan untuk mengetahui pemahaman awal mahasiswa terhadap konsep dasar fluida statis. Subjek penelitian terdiri atas 66 mahasiswa tahun pertama pada program studi pendidikan biologi. Teknik pengumpulan data menggunakan tes yang terdiri atas enam butir soal yang mewakili konsep massa jenis, tekanan hidrostatis, dan gaya apung. Data dianalisis secara deskriptif, kuantitatif, dan kualitatif. Hasil penelitian menunjukkan bahwa sebagian besar mahasiswa masih mengalami kesulitan dalam memahami konsep dasar fluida statis, khususnya terkait massa jenis, tekanan hidrostatis, dan gaya apung. Temuan ini menunjukkan perlunya penerapan pembelajaran yang dapat meningkatkan pemahaman konsep dasar fluida statis sekaligus mendorong kemampuan mahasiswa untuk mengaitkan pengetahuan tersebut dengan kondisi dan situasi kemaritiman dalam kehidupan mereka. Salah satu pendekatan yang dinilai efektif untuk mengatasi masalah ini adalah model pembelajaran berbasis masalah (*problem-based learning*). Studi ini menegaskan pentingnya pembelajaran fisika umum yang dikontekstualisasikan untuk menjembatani pemahaman pengalaman dan konsep mahasiswa, terutama dalam konteks pembelajaran berbasis kemaritiman.

\*Corresponding Author

Email: diossarkity@umrah.ac.id

## INTRODUCTION

The more advanced technological developments become, the higher the demand for skills each person must have. Among the skills that everyone in the 21st century must have are critical thinking skills (Heard et al., 2020; Rios et al., 2020; Thornhill-Miller et al., 2023). This skill allows someone to face various challenges in the world of work by criticising and finding solutions to problems (HACIOĞLU & GÜLHAN, 2021; Shaw et al., 2020; Wale & Bishaw, 2020).

To create a generation that is critical in responding to and finding solutions to various problems in everyday life, various efforts are made through education (Bellaera et al., 2021; Cáceres et al., 2020; Ho et al., 2023). Among the efforts made is implementing contextual learning (Irhasyuarna et al., 2022; Lestari et al., 2021; Toheri et al., 2020). Contextual learning allows students to link their knowledge with experiences or situations related to their everyday lives (Afni & Hartono, 2020; Juniwati et al., 2020; Maynastiti et al., 2020; Satriawan et al., 2020).

Physics is a part of natural science whose field of study closely relates to various phenomena and events related to everyday life (Martawijaya et al., 2023; Sari et al., 2022). To strengthen students' conceptual understanding of physics material and improve students' ability to use physics concepts to solve problems or explain various phenomena, learning must be linked to real problems that exist in everyday life. (Astra et al., 2020; Farhodovna et al., 2020; Massolt & Borowski, 2020; Silitonga et al., 2020). This makes physics learning more meaningful because students can feel the benefits directly (Juniwati et al., 2020; Oladejo et al., 2022, 2023).

Indonesia is one of the maritime countries in the world. This is because Indonesia's territory is dominated by the ocean (Iskandar et al., 2020; Liandi & Andryawan, 2022). Because of these conditions, the learning should be linked to the maritime context, including physics learning. There are many maritime contexts related to physics, one related to static fluid concepts (Widyastuti & Sahal, 2023). There are many maritime phenomena related to physics, particularly in static fluid concepts, such as hydrostatic pressure and buoyant force (Kim & Paik, 2021; Liu et al., 2022).

Previous studies have widely examined students' misconceptions in static fluid concepts (Cari et al., 2020a; Jamaludin & Batlolona, 2021). However, few have explored how students' initial understanding develops within a maritime context, where such phenomena are part of their everyday lives. Addressing this gap, this study focuses on first-year students in maritime regions to investigate how local experiences shape their understanding of basic static fluid concepts. The maritime context provides a unique setting to examine how students' real-life experiences influence their conceptual understanding in physics. Such contextual situations offer authentic phenomena—like floating, sinking, and pressure changes—that can reveal how experiential knowledge connects (or fails to connect) with scientific reasoning.

General Physics is a compulsory course taught to first-year students in natural science-related majors. The participants in this study were students who entered university in the 2023–2024 academic year, whose previous learning experiences were affected by the COVID-19 pandemic (Cucinotta & Vanelli, 2020; Phan, 2020; Wang et al., 2020). Learning disruptions during the pandemic caused difficulties in mastering physics concepts (Fardiah et al., 2023; Puspitasari & Mufit, 2021; Sarkity & Fernando, 2021), which may have influenced their initial understanding when starting university courses.

When starting a course, some or even all students must initially understand the lecture topic being studied. This initial understanding can be obtained from learning at previous education levels (Puji et al., 2020) or previous learning (Adeel et al., 2023). This student's initial understanding plays an important role in learning because this students' initial understanding can influence students' learning outcomes (Shangguan et al., 2020).

Therefore, this study aims to identify first-year students' initial understanding of static fluid concepts within the maritime context of the Riau Islands. The findings are expected to contribute to the improvement of contextual general physics instruction by revealing how maritime-based experiences influence students' conceptual understanding. The novelty of this study lies in its focus on students living in maritime regions,

who, despite their daily exposure to ocean-related phenomena, still demonstrate conceptual difficulties in understanding basic static fluid principles.

## METHODS

This research employed a descriptive quantitative approach with supporting qualitative analysis through content analysis. The quantitative analysis was used to describe the distribution of correct and incorrect answers, while the qualitative analysis was used to explore the reasoning given by students. Descriptive research focuses on finding a variable, which, in this case, is the student's initial knowledge, without comparing it or linking it with other variables (Sugiyono, 2019). In descriptive research, the researcher does not treat or manipulate the variables and only takes actual measurements of the variables (Siedlecki, 2020).

This research was conducted in March 2024 at Raja Ali Haji Maritime University. This research involved 66 Biology Education Students in their first year of study as research subjects. The sample was determined using a total sampling technique, since all 66 students enrolled in the General Physics course during the second semester of the 2023/2024 academic year were involved as research participants.

Data were collected through a test designed to assess students' initial understanding of static fluid concepts within a maritime context. The test was administered during the first lecture meeting, before any formal instruction on the topic. The question grid is presented in Table 1.

**Table 1.** Question Grid

No	Topics	Items Number	Question form
1	Density	1	Reasoning multiple choice
		2	Reasoning multiple choice
2	Hydrostatic pressure	3	Reasoning multiple choice
3	Bouyant force	4	Essay
		5	Essay
		6	Essay

To illustrate the maritime context embedded in the test, one example of an item used is: "A wooden block and an iron nail are both placed in seawater. Which one will float and why?" This item connects students' prior experiences with floating and sinking objects in seawater to the scientific explanation of density and buoyant force, allowing the assessment of their contextual understanding of static fluid concepts. The validity and reliability of the instruments were analyzed before being used. The multiple-choice test obtained a validity coefficient of 0.87, while the essay test obtained a validity coefficient of 0.73. Both coefficients fall into the high validity category (Cohen, Manion, & Morrison, 2018). The reliability analysis also confirmed that both test formats were reliable, indicating that the instruments were appropriate for use in this study.

Students' responses were analyzed descriptively using both quantitative and qualitative approaches. Quantitative analysis was performed by displaying the distribution and percentage of correct and incorrect answers (Sidel et al., 2018). This study displays the percentage of correct and incorrect answers. Qualitative analysis was conducted through content analysis (Vaismoradi et al., 2013), focusing on students' reasoning in both multiple-choice and essay items. Each response was categorized into one of three groups, as presented in Table 2.

**Table 2.** Criteria for Categorizing Students' Answers in Qualitative Analysis

No.	Category	Description
1	Correct answer with correct reason	The student selected the correct option (for Multiple choice) or gave the correct response (for essay) and explained using the appropriate physics concept
2	Correct answer with incorrect/incomplete reason	The student selected the correct option/response but the reason was inaccurate, incomplete, or based on daily experience without referring to the physics concept.
3	Incorrect answer	The student selected the wrong option/response and the reason given did not reflect the correct physics concept.

In the qualitative analysis, students' written explanations were examined using open coding procedures. Each response was categorized into one of the three groups shown in Table 2. The coding process was carried out carefully and consistently by the researchers to ensure analytical accuracy. To enhance credibility, the categorization results were reviewed and discussed among the research team until a consensus was reached regarding the interpretation of students' reasoning.

## RESULTS AND DISCUSSIONS

### RESULTS

The results of this research will be presented based on each question topic with the following details.

#### 1. Density

To measure students' initial understanding of the density concept, 2 questions were given, as seen in Table 1. The results of each question will be presented to determine students' initial understanding of the density concept.

##### Question 1

The first question used to measure students' understanding of density is shown in Figure 1. The correct answer to question 1 is A. This is due to the difference in density where the density of nails made of iron is greater than the seawater density, causing the nail to sink. In contrast, wood's density is smaller than seawater's density, causing the wood to float.

1. A nail made of iron with a mass of 9 grams and a wood with a mass of 10 kg are dropped into the sea. What will happen in this event?

A. The nail will sink and the wood will float on the surface of the seawater.  
 B. The nail will float on the surface of the sea water and the wood will sink.  
 C. Both nail and wood will float on the surface of seawater.  
 D. Both nail and wood will sink.

Choose and explain your answer!

Figure 1. Question 1

Student answers to each option in Question 1 are presented in Figure 2. As shown, 81.82% (54 students) selected the correct option. However, based on the reasons provided, only 20 students were able to justify their answers using the correct concept of density, while 34 students relied on daily experiences without explicitly

referring to the density concept. Examples of these misconceptions are illustrated in Figure 3. A more detailed categorization of students' answers into three groups—correct answer with correct reason, correct answer with incorrect or incomplete reason, and incorrect answer—is summarized in Table 3.

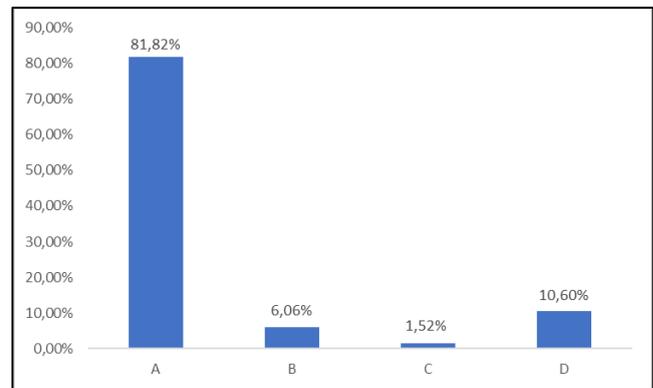


Figure 2. Percentage of Students Who Chose Each Answer Option for Question 1

Table 3. Categories and Distribution of Students' Answers for Question 1

No.	Categories of answer	Percentage of students
1	Correct answer with the correct reason	30.30 %
2	Correct answer with incorrect reason	51.52 %
3	Incorrect answer	18.18 %

For students who choose B, these students focus on the object's mass so that objects with a small mass are considered to float, and objects with a large mass will sink (Figure 3b). Students who answered C focused on the very large area of the ocean, which would cause all small objects to float on it (Figure 3c). For students who answered D, the reasons given were unclear and stated that the wood continued to sink with a mass of 10 kg (Figure 3d).

#### Question 2

Question 2, which still measures students' initial understanding regarding density, is shown in Figure 4. In this question, the correct answer is C. In this case, the seawater put into vessels A and B comes from the same place; therefore, the density of the seawater is the same.

1) a) Paku akan tenggelam dan kayu akan mengapung diatas permukaan air laut. karena, paku yang terbuat dari besi akan pasti tenggelam tidak tergantung massanya, sedangkan kayu dengan massa 10 kg akan mengapung diatas permukaan karena kayu tergantung pada massa, kecil massanya maka kayu akan mengapung dan jika besar massanya maka kayu akan tenggelam

EN: Because the nail is made of iron will sink regardless of its mass, while wood with a mass of 10 kg will float on the surface because wood depends on its mass, if the mass is small then the wood will float, and if the mass is large then the wood will sink.

(a)

1) b) Paku akan tenggelam mengapung diatas permukaan air laut dan kayu akan mengapung. karena kayu lebih berat dari paku. Jadi Paku akan tenggelam

EN: because the weight of the wood is greater than the nail, the nail will float

(b)

1). Sebatang paku (5 gram) dan sebuah kayu (10 kg) dijatuhkan ke tengah laut.

Jawab: (c) Baik paku maupun kayu, keduanya akan mengapung di atas permukaan air laut. Karena, volume air di tengah laut lebih besar dibanding massa sebatang paku 5 gram dan sebuah kayu 10 kg.

EN: because the volume of water in the middle of the sea is greater than the mass of a 5 gram nail and a 10 kg piece of wood

(c)

1. D. Baik paku maupun kayu, keduanya akan tenggelam.

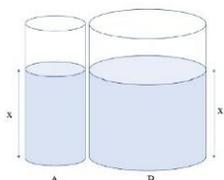
alasan: paku merupakan komponen benda besi yang tidak memiliki rongga udara yang membuat sebatapapun ukurannya pasti tenggelam, sedangkan kayu meskipun memiliki berbagai jenis ada yang mengapung dan tidak jika beratnya 10 kg ya pasti akan tenggelam.

EN: The Nail is a component in the form of iron that does not have air cavities, which means that no matter what size it is, it will sink, while wood, although there are various types, some of which float and which do not, if it weighs 10 kg, it will sink

(d)

Figure 3. Example of an error in the answer to question 1

Sea water taken from Trikora beach is put into two vessels as shown in the picture. The height of seawater entered into vessel A and vessel B is the same when measured from the bottom of the vessel.



2. Which of the following statements is correct regarding the density of seawater in the two vessels?

A. The density of seawater in vessel A is greater than the density of the seawater in vessel B

B. The density of seawater in vessel A is smaller than the density of seawater in vessel B.

C. The density of seawater in vessel A is the same as the density of seawater in vessel B.

Choose and explain your answer!

Figure 4. Question 2

The results of Question 2 show that only 19.70% (13 students) selected the correct answer, as presented in Figure 5. However, only 3 students provided the correct reasoning using the concept of density, while 10 students gave incomplete or incorrect reasons, focusing mainly on the height of the water. The majority of students (53 students or 80.30%) answered incorrectly, as illustrated in Figure 6c. The categorization of students' answers for Question 2 is summarized in Table 4.

Table 4. Categories and Distribution of Students' Answers for Question 2

No.	Categories of answer	Percentage of students
1	Correct answer with the correct reason	4.55 %
2	Correct answer with incorrect reason	15.15 %
3	Incorrect answer	80.30 %

In Figure 5, it can be seen that the highest percentage of students chose answer B. For the reasons given, students chose answer B because they focused on the amount of water in the vessel, so a larger amount had a greater density (Figure 6b). Students who chose answer A gave the opposite reason, where students stated that the smaller the amount of water, the greater the mass of the object, even though what was asked in this question was density, not mass (Figure 6a).

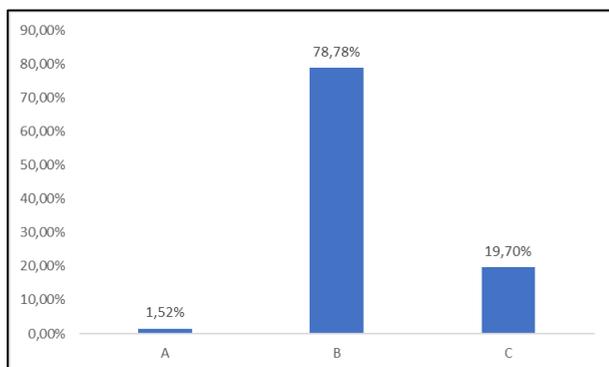
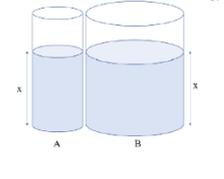


Figure 5. Percentage of Students Who Chose Each Answer Option for Question 2.

## 2. Hydrostatic Pressure

Sea water taken from Trikora beach is put into two vessels as shown in the picture. The height of seawater entered into vessel A and vessel B is the same when measured from the bottom of the vessel.



3. Which of the following statements is correct regarding the hydrostatic pressure at the bottom of vessel A and vessel B?

A. The hydrostatic pressure at the bottom of vessel A is greater than the hydrostatic pressure at the bottom of vessel B.

B. The hydrostatic pressure at the bottom of vessel A is smaller than the hydrostatic pressure at the bottom of vessel B.

C. The hydrostatic pressure at the bottom of vessel A is the same as the hydrostatic pressure at the bottom of vessel B.

Choose and explain your answer!

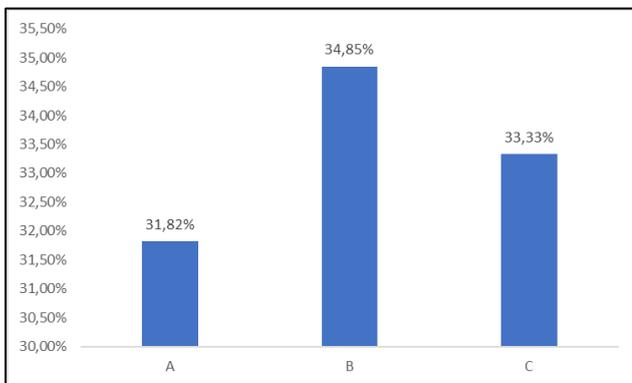
Figure 7. Question 3

Measuring students' initial understanding of hydrostatic pressure was carried out using one question, namely question 3. This is a child

2) A. Karena : Semakin kecil suatu benda maka semakin besar pula massa yang dimilikinya
EN: The smaller an object, the greater the mass it has
(a)
2. B. Karena bejana B memiliki volume yang lebih besar daripada bejana A. Jadi, walaupun ketinggian air didalam bejana A dan B sama, massa jenis air laut bejana B lebih besar <sup>dan diameter</sup>
EN: Because vessel B has a larger volume and diameter than vessel A, so even though the water level in vessels A and B is the same, the density of seawater in vessel B is greater
(b)
2. C. Alasan : Karena ketinggian air laut sama dan diukur dari dasar bejana sebab massa jenis bergantung pada tinggiya kolom air yang diukur.
EN: because the height of the seawater is the same and is measured from the bottom of the vessel because the density depends on the height of the water column being measured
(c)

**Figure 6.** Example of An Error in The Answer to Question 2

question, the same as question 2, as shown in Figure 7. The correct answer to question 3 is C because hydrostatic pressure depends on the density of the fluid, gravity acceleration, and the height of a point from the surface of the fluid. These three factors have the same value for seawater in vessels A and B.



**Figure 8.** Percentage of Students Who Chose Each Answer Option for Question 3.

As presented in Figure 8, 33.33% (22 students) selected the correct answer to Question 3. Of these, 12 students provided correct reasoning in line with the concept of hydrostatic pressure, while 10 students gave incomplete or incorrect reasoning, focusing only on the type of water. The majority of students (44 students or 66.67%) answered incorrectly, as illustrated in Figure 9. A summary of the categorization of

students' answers for Question 3 is presented in Table 5.

**Table 5.** Categories and Distribution of Students' Answers for Question 3

No.	Categories of answer	Percentage of students
1	Correct answer with the correct reason	18.18 %
2	Correct answer with incorrect reason	15.15 %
3	Incorrect answer	66.67 %

### 3. Buoyant Force

Students' initial understanding of buoyant force was measured using 3 questions. Descriptions of the questions and answers given by students will be presented as follows.

#### Question 4

The first question given to measure students' initial understanding of the concept of buoyant force is shown in Figure 10. The pain felt by the foot when stepping on a small pebble is due to the pressure exerted on the foot due to the gravity acting on the surface of the pebble, which has a large cross-sectional area. Following the concept of pressure, a large gravity value and a small cross-sectional area of the gravel being stepped on will produce large pressure. The answer to this question is, of course, that the pain felt in the feet will not be the same because there will be a reduction in the pressure placed on the

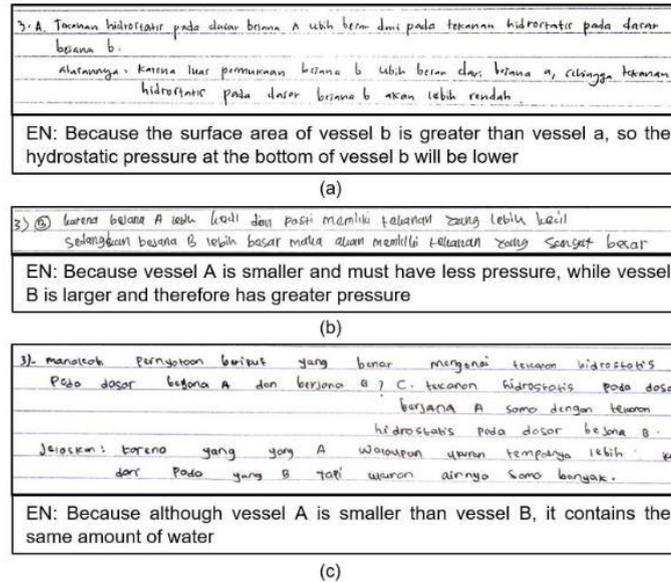


Figure 9. Example of An Error In The Answer to Question 3

feet. This is because the force acting on the pebbles, which produces pressure on the feet when we step on the pebbles in the sea, is the resultant force of gravity and buoyant force (uplifting force). This buoyant force will reduce the force acting on pebbles to reduce the pressure generated on the feet.

4. When you step on small pebbles on the side of the road, your feet will feel sore if you step on them without wearing any footwear. If you do the same thing to pebbles in seawater, will the pain your feet feel still be the same? Explain!

Figure 10. Question 4

in Table 6. The results show that only 6.06% (4 students) provided answers accompanied by correct reasoning. Although 69.70% (46 students) selected the correct answer, their reasoning was incomplete or inaccurate, generally stating that water reduces the pain in the feet without explaining the underlying principle (Figure 11a). Meanwhile, 24.24% (16 students) answered incorrectly, focusing on irrelevant aspects such as the structure of the rocks or the condition of the human body mass. For instance, some students stated that there would be no difference between stepping on rocks on land or in seawater because

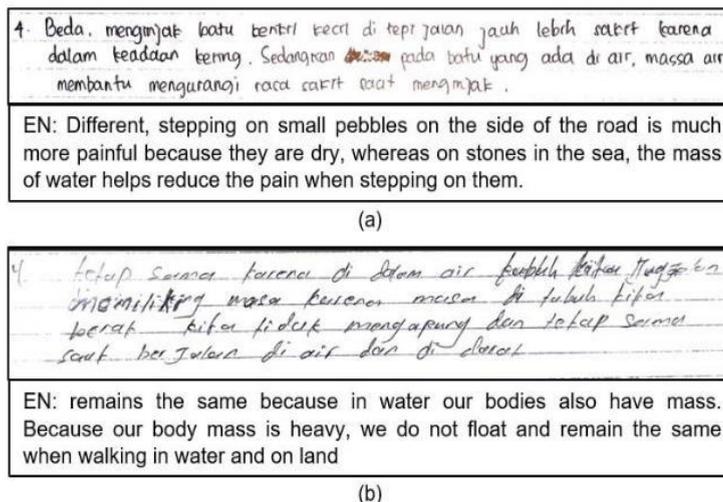


Figure 11. Example of an error in the answer to question 4

The answers given by students to Question 4 were categorized into three groups, as presented

body mass remains the same in both conditions (Figure 11b)

**Table 6.** Categories and Distribution of Students' Answers for Question 4

No.	Categories of answer	Percentage of students
1	Correct answer with the correct reason	6.06 %
2	Correct answer with incorrect reason	69.70 %
3	Incorrect answer	24.24 %

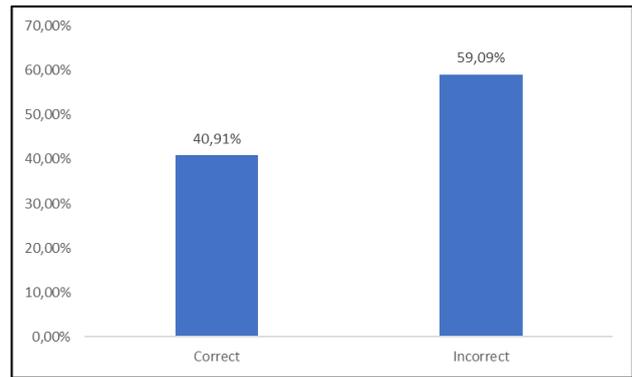
**Question 5**

The second question used to measure students' initial understanding regarding the concept of buoyant force is shown in Figure 12. As explained in the answer to question 4, a stone in water will feel lighter because of the buoyant force. If measured, the weight of a stone in seawater will be lighter because the measuring instrument reads as the resultant of gravity (which is directed downwards or towards the centre of the earth) and buoyant force (which is directed upwards). With the opposite direction of force, the resulting force will be smaller, so lifting the stone in the water will feel lighter.

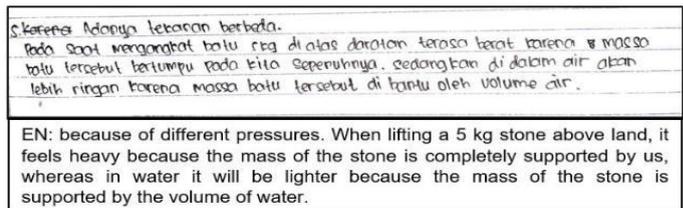
5. When you are on land, you will feel that lifting a stone with a mass of 5 kg feels heavy. If you lift the same stone in seawater, you will feel that the stone feels lighter. Why is that? Explain!

**Figure 12.** Question 5

Based on students' answers to Question 5, responses were categorized into correct and incorrect, as shown in Figure 13. The results indicate that 40.91% (27 students) were able to provide correct answers accompanied by appropriate reasoning using the concept of buoyant force. On the other hand, many students gave inaccurate explanations that were not linked to physics concepts. Their reasoning generally stated that on land, the entire weight of the rock rests on the person, whereas in seawater the rock feels lighter, without connecting this observation to the principle of buoyant force (Figure 14). This type of explanation reflects experiential knowledge, such as swimming or feeling lighter in water, but does not demonstrate an understanding of the underlying physics. The categorization of students' answers for Question 5 is summarized in Table 7.

**Figure 13.** Percentage of Students Who Chose Each Answer Option for Question 5.**Table 7.** Categories and Distribution of Students' Answers for Question 5

No.	Categories of answer	Percentage of students
1	Correct answer with the correct reason	40.91 %
2	Correct answer with incorrect reason	0 %
3	Incorrect answer	59.09 %

**Figure 14.** Example of An Error in The Answer to Question 5**Question 6**

The final question used to measure students' initial understanding of the buoyant force concept is question 6, shown in Figure 15. This question is also related to the density concept. Drums made of iron, when empty, can float on seawater because the empty cavity in the drum can be filled with air. The air that fills the drum can reduce the total density of the drum so that the total density of the drum containing air is smaller than the density of seawater. This also results in the buoyant force acting on the drum being greater than the weight force of the air-filled drum. This is what causes empty drums filled with air to float on the surface of seawater.

6. When a small nail made of iron is dropped into seawater, it will sink. We often see that an empty drum made of iron can float on the surface of seawater. Why can a drum, which is also made of iron, float on the surface of seawater? Explain!

Figure 15. Question 6

For Question 6, none of the students provided the correct answer. Several students explained that the drum could float because there was an empty cavity inside. However, they did not elaborate on how the air cavity affects the overall density of the drum, which enables it to float (Figure 16). In addition, students did not relate their reasoning to the concept of buoyant force. The categorization of students' answers to Question 6 is summarized in Table 8.

Table 8. Categories and Distribution of Students' Answers for Question 6

No.	Categories of answer	Percentage of students
1	Correct answer with the correct reason	0 %
2	Correct answer with incorrect reason	0 %
3	Incorrect answer	100 %

determine what kind of learning should be done to correct this (Bada & Olusegun, 2015). Errors in students' initial understanding can be corrected by implementing learning so that students can use concepts and answer questions related to phenomena in everyday life scientifically (Supena et al., 2021).

Unlike previous studies that mainly investigated students' misconceptions in general classroom contexts (Cari et al., 2020b; Madsen et al., 2017), this study provides new insight by exploring students' initial understanding of static fluid concepts in a maritime context. The results highlight that even students who live in maritime regions and are familiar with ocean-related phenomena still exhibit substantial misconceptions. This finding indicates that contextual familiarity alone does not automatically lead to scientific understanding. This finding represents a novel contribution by contextualizing conceptual understanding within maritime physics learning, providing new insight into how local experiences shape students' comprehension of scientific concepts.

The concept of static fluid is closely related to maritime phenomena and has been introduced since junior high school (Sarkity & Fernando,

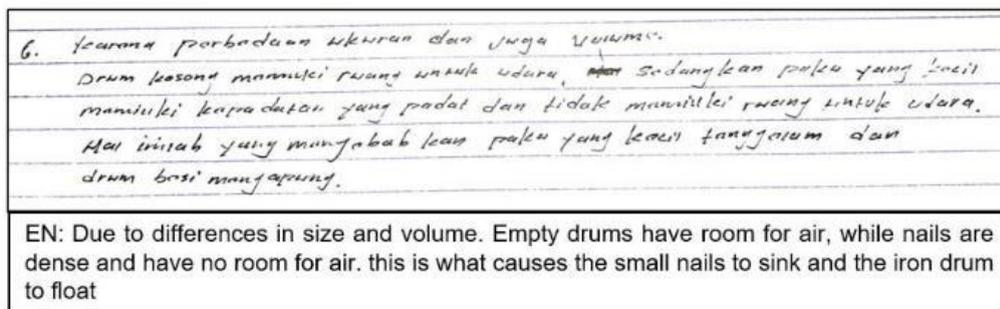


Figure 16. Example of An Error in The Answer to Question 6

## DISCUSSION

Students' initial understanding needs to be explored with the demand for independent learning at the university student level. Students' initial understanding is often dominated by the students' learning environment (Basham et al., 2016). By measuring students' initial understanding, teachers can get an idea or description of students' understanding of the concept being measured through the questions (Dhanil & Mufit, 2021; Sarkity et al., 2022; Sarkity & Sundari, 2020). If there are errors in the students' initial understanding, lecturer or teacher can

2023). However, many students still struggle to understand even the basic concept of density and often confuse it with mass (Gregorcic & Bodin, 2017; Madsen et al., 2017; Seah et al., 2015). Previous studies consistently reported similar findings, showing that density is a common source of misconception in physics learning (Niss, 2017; Zouhor et al., 2016). In the maritime context, misconceptions about density are critical because they affect how students explain why steel ships can float while smaller, denser objects may sink. The findings of this study confirm that students failed to connect such familiar maritime

experiences with scientific reasoning, revealing a gap between experiential knowledge and conceptual understanding.

Apart from the basic concept of density, students also experienced difficulties understanding hydrostatic pressure. Similar to previous research (Berek et al., 2016; Cari et al., 2020a; Saputra et al., 2019), many students were unaware that hydrostatic pressure increases with depth. This misconception also affects their critical thinking skills (Jufriadi et al., 2021) and indicates the need for conceptual change strategies (Ozkan & Selcuk, 2016). These findings have strong maritime relevance, since understanding pressure changes is essential in diving and swimming activities. Even though students have personal experiences related to these phenomena, such experiences were not transformed into scientific understanding.

Another concept in static fluids is Archimedes' law, which explains the buoyant force acting on immersed objects (Consales et al., 2018; Pisano, 2021; Rusoke-Dierich, 2018). Although this concept is central to maritime life - such as in ships, ferries, and fishing vessels - many students still fail to apply it scientifically (Buteler & Coleoni, 2016; Jamaludin & Batlolona, 2021; Koes-H et al., 2018; Ozkan & Selcuk, 2015). The findings show that students in maritime regions, despite their daily exposure to such phenomena, were unable to transfer contextual experiences into conceptual understanding. This emphasizes the importance of explicitly integrating maritime contexts into physics learning to promote conceptual change (Aydin-Gunbatar et al., 2020; King & Ritchie, 2012).

Errors in students' initial understanding can be influenced by various factors, including their previous learning experiences during the COVID-19 pandemic, which limited opportunities for meaningful conceptual development (Puspitasari & Mufit, 2021; Sundari & Dewi, 2021). Students' informal interpretations of everyday phenomena may also contribute to misconceptions (Neidorf et al., 2020; Pieschl et al., 2021; Setiani & Dewi, 2023), and these misconceptions tend to persist when personal experiences are not linked to scientific reasoning (Kulgemeyer & Wittwer, 2023; Menz et al., 2021). Therefore, teachers' and lecturers' pedagogical skills play a crucial role in designing learning

activities that promote conceptual reconstruction (Pramana et al., 2024).

From a pedagogical perspective, these findings emphasize the importance of explicit instructional strategies that connect scientific principles with maritime phenomena. Context-based learning has been shown to promote conceptual change and reduce misconceptions (AYDIN et al., 2021; Duit & Treagust, 2003). In this regard, integrating maritime contexts - such as floating ships, submarine operations, or diving pressure - can bridge students' experiential knowledge with scientific reasoning. Learning models such as Contextual Teaching and Learning (CTL) and Problem-Based Learning (PBL) can serve as effective approaches for contextual General Physics instruction to enhance students' conceptual understanding.

## CONCLUSIONS

This study revealed that first-year students still face substantial difficulties in understanding the basic concepts of static fluids - density, hydrostatic pressure, and buoyant force - even though these concepts are strongly related to the maritime context of their everyday lives. Students' misconceptions included difficulties in distinguishing between mass and density, misunderstanding the factors affecting hydrostatic pressure, and failing to explain how the buoyant force acts on submerged objects. These findings highlight the novelty of this study: living in a maritime environment does not automatically promote scientific understanding, suggesting that contextual familiarity must be supported by explicit conceptual instruction. The study contributes to physics education research by emphasizing that initial understanding and conceptual change should be examined within students' sociocultural and environmental contexts, particularly in maritime regions. Pedagogically, the results call for context-based General Physics instruction that explicitly integrates maritime phenomena - such as floating ships, diving, and submarine operation - into classroom learning. Such approaches are expected to bridge students' experiential knowledge and scientific reasoning, thereby strengthening their conceptual understanding of static fluids.

Future research could further explore the effectiveness of maritime-context learning interventions in promoting conceptual change and long-term understanding among university students.

## REFERENCES

- Adeel, S., Daniel, A. D., & Botelho, A. (2023). The effect of entrepreneurship education on the determinants of entrepreneurial behaviour among higher education students: A multi-group analysis. *Journal of Innovation and Knowledge*, 8(1), 100324. <https://doi.org/10.1016/j.jik.2023.100324>
- Afni, N., & Hartono. (2020). Contextual teaching and learning (CTL) as a strategy to improve students mathematical literacy. *Journal of Physics: Conference Series*, 1581(1). <https://doi.org/10.1088/1742-6596/1581/1/012043>
- Astra, I. M., Raihanati, R., & Mujayanah, N. (2020). Development of Electronic Module Using Creative Problem-Solving Model Equipped with HOTS Problems on The Kinetic Theory of Gases Material. In *Jurnal Penelitian & Pengembangan Pendidikan Fisika* (Vol. 6, Issue 2, pp. 181-194). <https://doi.org/10.21009/1.06205>
- AYDIN, S., ÖZTAY, E. S., & EKİZ, B. (2021). Examination of pre-service chemistry teachers' STEM conceptions through an integrated STEM course. *Turkish Journal of Education*, 10(4), 251-273. <https://doi.org/10.19128/turje.894588>
- Bada, & Olusegun, S. (2015). Constructivism Learning: A Paradigm for Teaching and Learning. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, 5(6), 66-70. <https://doi.org/10.9790/7388-05616670>
- Basham, J. D., Hall, T. E., Carter, R. A., & Stahl, W. M. (2016). An Operationalized Understanding of Personalized Learning. *Journal of Special Education Technology*, 31(3), 126-136. <https://doi.org/10.1177/0162643416660835>
- Bellaera, L., Weinstein-Jones, Y., Ilie, S., & Baker, S. T. (2021). Critical thinking in practice: The priorities and practices of instructors teaching in higher education. *Thinking Skills and Creativity*, 41(May), 100856. <https://doi.org/10.1016/j.tsc.2021.100856>
- Berek, F. X., Sutopo, S., & Munzil, M. (2016). Enhancement of junior high school STUDENTS' CONCEPT comprehension in hydrostatic pressure and archimedes law concepts by predict-observe-explain strategy. *Jurnal Pendidikan IPA Indonesia*, 5(2), 230-238. <https://doi.org/DOI:10.15294/jpii.v5i2.6038>
- Buteler, L., & Coleoni, E. (2016). Solving problems to learn concepts, how does it happen? A case for buoyancy. *Physical Review Physics Education Research*, 12(2), 020144. <https://doi.org/http://dx.doi.org/10.1103/PhysRevPhysEducRes.12.020144>
- Cáceres, M., Nussbaum, M., & Ortiz, J. (2020). Integrating critical thinking into the classroom: A teacher's perspective. *Thinking Skills and Creativity*, 37(June), 100674. <https://doi.org/10.1016/j.tsc.2020.100674>
- Cari, C., Pratiwi, S. N., Affandy, H., & Nugraha, D. A. (2020a). Investigation of undergraduate student concept understanding on Hydrostatic Pressure using two-tier test. *Journal of Physics: Conference Series*, 1511(1), 012085. <https://doi.org/10.1088/1742-6596/1511/1/012085>
- Cari, C., Pratiwi, S. N., Affandy, H., & Nugraha, D. A. (2020b). Investigation of undergraduate student concept understanding on Hydrostatic Pressure using two-tier test. *Journal of Physics: Conference Series*, 1511(1). <https://doi.org/10.1088/1742-6596/1511/1/012085>
- Consales, M., Principe, S., Iele, A., Leone, M., Zaraket, H., Jomaa, I., Cutolo, A., & Cusano, A. (2018). A Fiber Bragg Grating Liquid Level Sensor Based on the Archimedes' Law of Buoyancy. *Journal of Lightwave Technology*, 36(20), 4936-4941. <https://doi.org/10.1109/JLT.2018.2866130>
- Cucinotta, D., & Vanelli, M. (2020). WHO declares COVID-19 a pandemic. *Acta Bio Medica: Atenei Parmensis*, 91(1), 157. <https://doi.org/10.23750/abm.v91i1.9397>

- Dhanil, M., & Mufit, F. (2021). Design and Validity of Interactive Multimedia Based on Cognitive Conflict on Static Fluid Using Adobe Animate CC 2019. In *Jurnal Penelitian & Pengembangan Pendidikan Fisika* (Vol. 7, Issue 2, pp. 177-190). <https://doi.org/10.21009/1.07210>
- Duit, R., & Treagust, D. F. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education*, 25(6), 671-688. <https://doi.org/10.1080/09500690305016>
- Fardiah, D., Yulianita, N., Yuniati, Y., Yuliani, M., & Seppriadi, I. (2023). The Patterns of Distance Learning Communication in The Covid-19 Pandemic Era. *Jurnal Komunikasi Pendidikan*, 7(1), 2549-4163. <https://doi.org/10.32585/jurnalkomdik.v7i1.2209>
- Farhodovna, A. M., Olimboevich, A. J., & Badriddinovich, K. B. (2020). Innovative Pedogogical Technologies For Training The Course Of Physics. *The American Journal of Interdisciplinary Innovations and Research*, 02(12), 82-91. <https://doi.org/10.37547/tajir/volume02issue12-12>
- Gregorcic, B., & Bodin, M. (2017). Algodoo: A Tool for Encouraging Creativity in Physics Teaching and Learning. *The Physics Teacher*, 55(1), 25-28. <https://doi.org/http://dx.doi.org/10.1119/1.4972493>
- HACIOĞLU, Y., & GÜLHAN, F. (2021). The Effects of STEM Education on the 7th Grade Students' Critical Thinking Skills and STEM Perceptions. *Journal of Education in Science, Environment and Health*. <https://doi.org/10.21891/jeseh.771331>
- Heard, J., Scoular, C., Duckworth, D., Ramalingam, D., & Teo, I. (2020). Critical Thinking : Skill Development Framework. *Australian Council for Educational Research*, September 2021, 1-23. <https://doi.org/10.37517/978-1-74286-752-6>
- Ho, Y. R., Chen, B. Y., & Li, C. M. (2023). Thinking more wisely: using the Socratic method to develop critical thinking skills amongst healthcare students. *BMC Medical Education*, 23(1), 1-16. <https://doi.org/10.1186/s12909-023-04134-2>
- Irhasyuarna, Y., Kusasi, M., Fahmi, F., Fajeriadi, H., Aulia, W. R., Nikmah, S., & Rahili, Z. (2022). Integrated science teaching materials with local wisdom insights to improve students' critical thinking ability. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, 4(3), 328. <https://doi.org/10.20527/bino.v4i3.14148>
- Iskandar, I., Mardiansyah, W., Lestari, D. O., & Masumoto, Y. (2020). What did determine the warming trend in the Indonesian sea? *Progress in Earth and Planetary Science*, 7(1). <https://doi.org/10.1186/s40645-020-00334-2>
- Jamaludin, J., & Batlolona, J. R. (2021). Analysis of Students' Conceptual Understanding of Physics on the Topic of Static Fluids. *Jurnal Penelitian Pendidikan IPA*, 7(SpecialIssue), 6-13. <https://doi.org/10.29303/jppipa.v7ispecialissue.845>
- Jufriadi, A., Kusairi, S., & Sutopo, S. (2021). Exploration of student's understanding of distance and displacement concept. *Journal of Physics: Conference Series*, 1869(1), 0-6. <https://doi.org/10.1088/1742-6596/1869/1/012195>
- Juniwati, Yusrizal, & Khaldun, I. (2020). Influence of the contextual teaching and learning model against student learning outcome. *Journal of Physics: Conference Series*, 1460(1). <https://doi.org/10.1088/1742-6596/1460/1/012128>
- Kim, S., & Paik, S.-H. (2021). Archimedes' Balance Approach Applied to Buoyant Force. *The Physics Teacher*, 59(2), 125-127. <https://doi.org/10.1119/10.0003469>
- Koes-H, S., Muhardjito, M., & Wijaya, C. P. (2018). Scaffolding for solving problem in static fluid: A case study. *AIP Conference Proceedings*, 1923. <https://doi.org/10.1063/1.5019519>
- Kulgemeyer, C., & Wittwer, J. (2023). Misconceptions in Physics Explainer Videos and the Illusion of Understanding: an Experimental Study. *International Journal of Science and Mathematics Education*, 21(2),

- 417-437. <https://doi.org/10.1007/s10763-022-10265-7>
- Lestari, F. P., Ahmadi, F., & Rochmad, R. (2021). The implementation of mathematics comic through contextual teaching and learning to improve critical thinking ability and character. *European Journal of Educational Research*, 10(1), 497-508. <https://doi.org/10.12973/EU-JER.10.1.497>
- Liandi, A., & Andryawan. (2022). Wilayah Laut Indonesia Guna Menjaga Keberlanjutan. *Jurnal Serina IV*, 2(2), 229-238. <https://doi.org/10.24912/pserina.v2i1.18534>
- Liu, R., Liu, L., & Wang, F. (2022). The role of hydrostatic pressure on the metal corrosion in simulated deep-sea environments – a review. *Journal of Materials Science & Technology*, 112(2022), 230-238. <https://doi.org/https://doi.org/10.1016/j.jmst.2021.10.014>
- Madsen, A., McKagan, S. B., & Sayre, E. C. (2017). Resource Letter RBAI-1: Research-Based Assessment Instruments in Physics and Astronomy. *American Journal of Physics*, 85(4), 245-264. <https://doi.org/10.1119/1.4977416>
- Martawijaya, M. A., Rahmadhanningsih, S., Swandi, A., Hasyim, M., & Sujiono, E. H. (2023). the Effect of Applying the Ethno-Stem-Project-Based Learning Model on Students' Higher-Order Thinking Skill and Misconception of Physics Topics Related To Lake Tempe, Indonesia. In *Jurnal Pendidikan IPA Indonesia* (Vol. 12, Issue 1, pp. 1-13). <https://doi.org/10.15294/jpii.v12i1.38703>
- Massolt, J., & Borowski, A. (2020). Perceived relevance of university physics problems by pre-service physics teachers: personal constructs. *International Journal of Science Education*, 42(2), 167-189. <https://doi.org/10.1080/09500693.2019.1705424>
- Maynastiti, D., Serevina, V., & Sugihartono, I. (2020). The development of flip book contextual teaching and learning-based to enhance students' physics problem solving skill. *Journal of Physics: Conference Series*, 1481(1). <https://doi.org/10.1088/1742-6596/1481/1/012076>
- Menz, C., Spinath, B., & Seifried, E. (2021). Where do pre-service teachers' educational psychological misconceptions come from? *Zeitschrift Für Pädagogische Psychologie*. <https://doi.org/10.1024/1010-0652/a000299>
- Neidorf, T., Arora, A., Erberber, E., Tsokodayi, Y., & Mai, T. (2020). *Student misconceptions and errors in physics and mathematics: Exploring data from TIMSS and TIMSS Advanced*. Springer Nature. [https://doi.org/10.1007/978-3-030-30188-0\\_5](https://doi.org/10.1007/978-3-030-30188-0_5)
- Niss, M. (2017). Obstacles Related to Structuring for Mathematization Encountered by Students when Solving Physics Problems. *International Journal of Science and Mathematics Education*, 15(8), 1441-1462. <https://doi.org/10.1007/s10763-016-9754-6>
- Oladejo, A. I., Okebukola, P. A., Akinola, V. O., Amusa, J. O., Akintoye, H., Owolabi, T., Shabani, J., & Olateju, T. T. (2023). Changing the Narratives of Physics-Learning in Secondary Schools: The Role of Culture, Technology, and Locational Context. *Education Sciences*, 13(2). <https://doi.org/10.3390/educsci13020146>
- Oladejo, A. I., Okebukola, P. A., Olateju, T. T., Akinola, V. O., Ebisin, A., & Dansu, T. V. (2022). In Search of Culturally Responsive Tools for Meaningful Learning of Chemistry in Africa: We Stumbled on the Culturo-Techno-Contextual Approach. *Journal of Chemical Education*, 99(8), 2919-2931. <https://doi.org/https://doi.org/10.1021/acs.jchemed.2c00126>
- Ozkan, G., & Selcuk, G. S. (2015). Effect of Technology Enhanced Conceptual Change Texts on Students' Understanding of Buoyant Force. *Universal Journal of Educational Research*, 3(12), 981-988. <https://doi.org/10.13189/ujer.2015.031205>
- Ozkan, G., & Selcuk, G. S. (2016). Facilitating conceptual change in students' understanding of concepts related to pressure. *European Journal of Physics*, 37(5), 1-20. <https://doi.org/10.1088/0143-0807/37/5/055702>
- Phan, T. (2020). Novel coronavirus: From discovery to clinical diagnostics. *Infection, Genetics and Evolution*, 79(January), 104211.

- <https://doi.org/10.1016/j.meegid.2020.104211>
- Pieschl, S., Budd, J., Thomm, E., & Archer, J. (2021). Effects of Raising Student Teachers' Metacognitive Awareness of Their Educational Psychological Misconceptions. *Psychology Learning and Teaching, 20*(2), 214–235. <https://doi.org/10.1177/1475725721996223>
- Pisano, A. (2021). Physics for anesthesiologists and intensivists: From daily life to clinical practice. In *Physics for Anesthesiologists and Intensivists: From Daily Life to Clinical Practice*. <https://doi.org/10.1007/978-3-030-72047-6>
- Pramana, A., Syafa'at, A. M., Khotimah, K., & Susarno, L. H. (2024). The Influence of Teaching Talent on Student Learning Outcomes. *Jurnal Komunikasi Pendidikan, 8*(1), 1–11. <https://doi.org/10.32585/jurnalkomdik.v8i1.4585>
- Puji, R. P. N., Wathon, S., Zulianto, M., Surya, R. A., & Kurnianto, F. A. (2020). The Students' Prior Knowledge at the Department of History Education within Tertiary Education. *IOP Conference Series: Earth and Environmental Science, 485*(1). <https://doi.org/10.1088/1755-1315/485/1/012041>
- Puspitasari, R., & Mufit, F. (2021). Conditions of learning physics and students' understanding of the concept of motion during the covid-19 pandemic. *Journal of Physics: Conference Series, 1876*(1), 012045. <https://doi.org/10.1088/1742-6596/1876/1/012045>
- Rios, J. A., Ling, G., Pugh, R., Becker, D., & Bacall, A. (2020). Identifying Critical 21st-Century Skills for Workplace Success: A Content Analysis of Job Advertisements. *Educational Researcher, 49*(2), 80–89. <https://doi.org/10.3102/0013189X19890600>
- Rusoke-Dierich, O. (2018). Archimedes' Principle. In *Diving Medicine* (pp. 85–86). Springer International Publishing. [https://doi.org/10.1007/978-3-319-73836-9\\_11](https://doi.org/10.1007/978-3-319-73836-9_11)
- Saputra, O., Setiawan, A., & Rusdiana, D. (2019). Identification of student misconception about static fluid. *Journal of Physics: Conference Series, 1157*(3), 032069. <https://doi.org/10.1088/1742-6596/1157/3/032069>
- Sari, S. Y., Rahim, F. R., Sundari, P. D., & Aulia, F. (2022). The importance of e-books in improving students' skills in physics learning in the 21st century: A literature review. *Journal of Physics: Conference Series, 2309*(1). <https://doi.org/10.1088/1742-6596/2309/1/012061>
- Sarkity, D., Azhar, A., & Sundari, P. (2022). Students' Ability to Identify The Types of Motion of Objects Through Kinematics Graphs. *International Conference on Maritime Education (ICOME ) 2021, 134–141*. <https://doi.org/10.4108/eai.3-11-2021.2314799>
- Sarkity, D., & Fernando, A. (2021). *Pengalaman Praktik Mengajar Calon Guru Biologi di Masa Pandemi COVID-19. 6*(2), 133–151. <https://doi.org/https://doi.org/10.37058/bioed.v6i2.2772>
- Sarkity, D., & Fernando, A. (2023). Maritime-Related Topics on Natural Science Learning in Independent Curriculum. *BIO Web of Conferences, 79*. <https://doi.org/10.1051/bioconf/20237902003>
- Sarkity, D., & Sundari, P. D. (2020). Pemahaman Konsep Fisika Calon Guru Biologi Pada Topik Kinematika. *Pdagogi Hayati: Jurnal Ilmiah Pendidikan Biologi, 4*(2), 106–116.
- Satriawan, M., Rosmiati, R., Widia, W., Sarnita, F., Suswati, L., Subhan, M., & Fatimah, F. (2020). Physics learning based contextual problems to enhance students' creative thinking skills in fluid topic. *Journal of Physics: Conference Series, 1521*(2). <https://doi.org/10.1088/1742-6596/1521/2/022036>
- Seah, L. H., Clarke, D., & Hart, C. (2015). Understanding Middle School Students' Difficulties in Explaining Density Differences from a Language Perspective. *International Journal of Science Education, 37*(14), 2386–2409. <https://doi.org/10.1080/09500693.2015.1080879>

- Setiani, L., & Dewi, S. P. (2023). Gambaran Prior Knowledge Siswa Pada Konsep Respirasi Seluler Dalam Kajian Studi Literatur. *INKUIRI: Jurnal Pendidikan IPA*, 12(2), 146–152.  
<https://doi.org/10.20961/inkuiri.v12i2.73691>
- Shangguan, C., Gong, S., Guo, Y., Wang, X., & Lu, J. (2020). The effects of emotional design on middle school students' multimedia learning: the role of learners' prior knowledge. *Educational Psychology*, 40(9), 1076–1093.  
<https://doi.org/10.1080/01443410.2020.1714548>
- Shaw, A., Liu, O. L., Gu, L., Kardonova, E., Chirikov, I., Li, G., Hu, S., Yu, N., Ma, L., Guo, F., Su, Q., Shi, J., Shi, H., & Loyalka, P. (2020). Thinking critically about critical thinking: validating the Russian HEIghten® critical thinking assessment. *Studies in Higher Education*, 45(9), 1933–1948.  
<https://doi.org/10.1080/03075079.2019.1672640>
- Sidel, J. L., Bleibaum, R. N., & Tao, K. W. C. (2018). Quantitative Descriptive Analysis. In S. E. Kemp, J. Hort, & T. Hollowood (Eds.), *Descriptive Analysis in Sensory Evaluation* (pp. 287–318). John Wiley & Sons Ltd.  
<https://doi.org/10.1002/9781118991657.ch8>
- Siedlecki, S. L. (2020). Understanding Descriptive Research Designs and Methods. *Clinical Nurse Specialist*, 34(1), 8–12.  
<https://doi.org/10.1097/NUR.00000000000000493>
- Silitonga, H. T. M., Panjaitan, M., & Supriyati, Y. (2020). Problem solving based physics learning strategy to enhance students' higher order thinking skills. *Journal of Physics: Conference Series*, 1567(4).  
<https://doi.org/10.1088/1742-6596/1567/4/042104>
- Sugiyono. (2019). *Metode Penelitian Kuantitatif Kualitatif dan RND* (Ke 2). Alfa Beta.
- Sundari, P. D., & Dewi, W. S. (2021). Interactive recitation methods as a solution to the students' deepening physics material during the Covid-19 pandemic. *Journal of Physics: Conference Series*, 1876(1), 012071.  
<https://doi.org/10.1088/1742-6596/1876/1/012071>
- Supena, I., Darmuki, A., & Hariyadi, A. (2021). The Influence of Learning Model on Students' Learning Outcomes. *International Journal of Instruction*, 14(3), 873–892.
- Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence*, 11(3).  
<https://doi.org/10.3390/jintelligence11030054>
- Toheri, Winarso, W., & Haqq, A. A. (2020). Where exactly for enhance critical and creative thinking: The use of problem posing or contextual learning. *European Journal of Educational Research*, 9(2), 877–887.  
<https://doi.org/10.12973/eu-jer.9.2.877>
- Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing & Health Sciences*, 2013(15), 398–405.  
<https://doi.org/10.1111/nhs.12048>
- Wale, B. D., & Bishaw, K. S. (2020). Effects of using inquiry-based learning on EFL students' critical thinking skills. *Asian-Pacific Journal of Second and Foreign Language Education*, 5(1).  
<https://doi.org/10.1186/s40862-020-00090-2>
- Wang, H., Wang, Z., Dong, Y., Chang, R., Xu, C., Yu, X., Zhang, S., Tsamlag, L., Shang, M., Huang, J., Wang, Y., Xu, G., Shen, T., Zhang, X., & Cai, Y. (2020). Phase-adjusted estimation of the number of Coronavirus Disease 2019 cases in Wuhan, China. *Cell Discovery*, 6(1), 4–11.  
<https://doi.org/10.1038/s41421-020-0148-0>
- Widyastuti, I., & Sahal, M. (2023). The Effectiveness of Maritim-Based Physics Teaching in Increasing The Science Process Skills of SMA Negeri 2 Dumai Students. *Journal of Indonesian Science Teacher*, 1(1), 26–35.

Zouhor, Z., Bogdanovic, I., & Segedinac, M. (2016). Effects of the Know-Want-Learn Strategy on Primary School Students' Metacognition and Physics Achievement. *Journal of Subject Didactics*, 1(1), 39-49. <https://doi.org/10.5281/zenodo.55473>