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Misconception Analysis of Static Fluid Material Using a Four-Tier Diagnostic Test on High School Students

Nenden Farida Alia[1], Irma Fitria Amalia[1*], Rizal Adimayuda[1]

[1]Physics Education Study Program, Faculty of Applied Science and Sciences
Institut Pendidikan Indonesia, Garut, Indonesia

e-mail: irmafitriaa@institutpendidikan.ac.id

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ABSTRACT

This study aims to analyze students' misconceptions on the static fluid concept using a Four-Tier Diagnostic Test instrument. Static fluid material was chosen because of its complex characteristics and potential to cause misconceptions, particularly in the sub-concepts of hydrostatic pressure, Pascal's law, and Archimedes' principle. This study used a descriptive method with a quantitative approach. The subjects were 68 eleventh-grade students from a public senior high school in Garut Regency, selected through purposive sampling because they had completed instruction on static fluid material. The research instrument consisted of a four-tier diagnostic test comprising 15 multiple-choice items, developed and content-validated by two expert validators. The data obtained were analyzed based on the combination of students' answers at each tier to identify categories of conceptual understanding, misconception, lack of understanding, and partial understanding. The results showed that overall, 37.74% of students experienced misconceptions, 37.65% understood the concept, 14.31% did not understand the concept, and 10.30% partially understood the concept. At the sub-concept level, the highest misconception was found in Pascal's law (52.20%), followed by Archimedes' principle (41.47%) and hydrostatic pressure (25%). The highest item-level misconception occurred in item number 7 concerning the lifting force on a piston, with a percentage of 73.53%. These results indicate the need for more serious efforts in identifying and remediating student misconceptions, as well as the importance of applying in-depth diagnostic instruments such as the Four-Tier Diagnostic Test in physics learning.

Keywords: Misconception; static fluid; four-tier diagnostic test; physics; high school students.

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Analisis Miskonsepsi Materi Fluida Statis Menggunakan *Four Tier Diagnostic Test* pada Siswa SMA

ABSTRAK

Penelitian ini bertujuan untuk menganalisis miskonsepsi siswa pada materi fluida statis menggunakan instrumen Four Tier Diagnostic Test. Materi fluida statis dipilih karena memiliki karakteristik yang kompleks dan berpotensi menimbulkan miskonsepsi, terutama pada subkonsep tekanan hidrostatis, hukum Pascal, dan hukum Archimedes. Penelitian ini menggunakan metode deskriptif dengan pendekatan kuantitatif. Subjek dalam penelitian ini adalah siswa kelas XI SMA di salah satu sekolah negeri di Kabupaten Garut yang berjumlah 68 orang, dipilih melalui teknik purposive sampling karena telah mempelajari materi fluida statis. Instrumen penelitian berupa tes diagnostik empat tingkat yang terdiri dari 15 butir soal, yang dikembangkan dan divalidasi isi oleh dua validator ahli. Data yang diperoleh dianalisis berdasarkan kombinasi jawaban peserta didik pada setiap tingkat untuk mengidentifikasi kategori pemahaman konsep, miskonsepsi, tidak paham konsep, dan paham sebagian. Hasil penelitian menunjukkan bahwa secara keseluruhan, sebanyak 37,74% siswa mengalami miskonsepsi, 37,65% siswa paham konsep, 14,31% siswa tidak paham konsep, dan 10,30% siswa paham sebagian. Pada tingkat subkonsep, miskonsepsi tertinggi ditemukan pada hukum Pascal sebesar 52,20%, diikuti oleh hukum Archimedes sebesar 41,47% dan tekanan hidrostatis sebesar 25%. Miskonsepsi tertinggi pada tingkat soal terdapat pada soal nomor 7 tentang gaya angkat pada piston dengan persentase 73,53%. Hasil ini menunjukkan perlunya upaya yang lebih serius dalam mengidentifikasi dan meremediasi miskonsepsi siswa, serta pentingnya penerapan instrumen diagnostik yang mendalam seperti Four Tier Diagnostic Test dalam proses pembelajaran fisika.

Kata kunci: *Miskonsepsi; fluida statis; four tier diagnostic test; fisika; siswa SMA.*

INTRODUCTION

Science education, particularly physics, plays an important role in shaping students' understanding of the basic concepts needed to explain natural phenomena, given that physics is both abstract and concrete and closely related to everyday life. In line with the content standards for physics learning at the senior high school level, the objective of physics instruction is to develop students' capacity for analytical thinking by using physical concepts and principles to explain various events in daily life; accurate conceptual knowledge indicates that students have genuinely understood the concept being taught (Sheftyawan, Prihandono, & Lesmono, 2018). Sound conceptual understanding is therefore essential if the objectives of physics learning are to be achieved.

Each student has a different capacity for learning and understanding physics concepts. Their conceptual understanding often originates from everyday experience in explaining natural phenomena rather than from systematic scientific reasoning, producing a fragile understanding that is prone to error when connected with the understanding held by experts. This pattern recurs across different physics topics: a study on dynamic electricity among pre-service physics teachers found that fragile, experience-based understanding often diverges from expert conceptions (Didik, Wahyudi, & Kafrawi, 2020), while research on physics learning strategies more broadly found that students frequently memorize formulas and definitions without genuine conceptual understanding or attention to the relationships between concepts (Khairunnisa, Ishafit, & Fayanto, 2020). Taken together, these findings indicate that superficial, rote-based learning is a crosscutting source of misconception rather than one confined to a single physics topic, and that misconceptions frequently arise from an incorrect understanding of how physics concepts relate to one another.

According to Suparno (2013), there are five main causes of misconceptions, namely the students themselves, textbooks, the context of the sentences used, teachers, and the teaching methods applied. Left unaddressed, these misconceptions tend to persist and compound over time: they make it difficult for students to accept the correct concept (Hermita, Suhandi, & Syaodih, 2017), create long-term learning problems (Gradini, 2016), and interfere with the acquisition of subsequent, related concepts (Yuliati, 2017), together forming a cycle in which early, unresolved misconceptions accumulate across a student's learning trajectory.

One physics topic that is particularly prone to causing student misconceptions is static fluid material. Using a four-tier diagnostic test, two recent studies conducted among eleventh-grade students in Kendari converge on Pascal's law as the most persistent source of misconception: Jannah, Erniwati, Mongkito, and Yuris (2022) reported an overall misconception percentage of 56% (moderate category) among students at SMKN 2 Kendari, with the highest misconceptions found in explaining the factors affecting hydrostatic pressure and buoyant force (62.5%) and in relating Pascal's law to the magnitude of pressure and lifting force (59.4%); similarly, Sukariasih and Yuris (2024), using a 20-item four-tier instrument accompanied by confirmatory interviews among 52 eleventh-grade students at SMA Negeri 2 Kendari, found that 46.25% of students experienced moderate misconceptions on static fluid material overall, and 55.29% specifically on Pascal's law. However, both studies were conducted within the same regional and institutional context, using instruments and samples specific to that setting; whether comparable misconception patterns occur among students in other regions, such as Garut Regency, and how these misconceptions are distributed at a more detailed sub-concept and item level, remains unexamined.

These misconceptions need to be analyzed in order to identify the difficulties experienced by students in learning. In identifying misconceptions, it is important to distinguish between students who genuinely hold a misconception and those who simply do not understand the concept (Jannah et al., 2022); a diagnostic test is an appropriate solution for identifying the weaknesses experienced by students so that appropriate follow-up action can be taken (Perwitasari, 2015). Multiple-choice diagnostic tests exist in several forms, including one-tier, two-tier, three-tier, and four-tier tests. This study employed the four-tier diagnostic test to measure higher-order misconceptions, which was developed from the three-tier diagnostic test by adding a confidence-rating tier for the answer (Zaleha & Nugraha, 2017). The advantages of the four-tier diagnostic test include enabling teachers to categorize students' confidence levels for both their answers and their reasons, thereby providing deeper insight into students' conceptual understanding; enabling more precise identification of student misconceptions; allowing greater emphasis to be placed on specific parts of the material; and helping teachers determine appropriate follow-up steps to reduce the misconceptions experienced by students (Fariyani et al., 2015).

Building on this gap, the present study aims to analyze eleventh-grade students' misconceptions on static fluid material — encompassing the sub-concepts of hydrostatic pressure, Pascal's law, and Archimedes' principle — using a four-tier diagnostic test administered to students in Garut Regency. By mapping misconceptions at the overall, sub-concept, and item levels, this study is intended to extend the recent literature on static fluid misconceptions to a previously unexamined regional context and to provide teachers with a more detailed diagnostic basis for designing targeted remediation strategies.

METHOD

This study used a descriptive research method with a quantitative approach, representing a non-experimental, sampling-survey design, which is the simplest research design. Descriptive research does not require control and experimental groups and does not involve complex statistical calculations; its purpose is to systematically, factually, and accurately describe the facts and characteristics of a particular population as they actually are, in this case to determine students' conceptual understanding of static fluid material based on the percentage of student misconceptions obtained (Sugiyono, 2018). Figure 1 summarizes the overall procedure followed in this study, from instrument development through the interpretation of results.

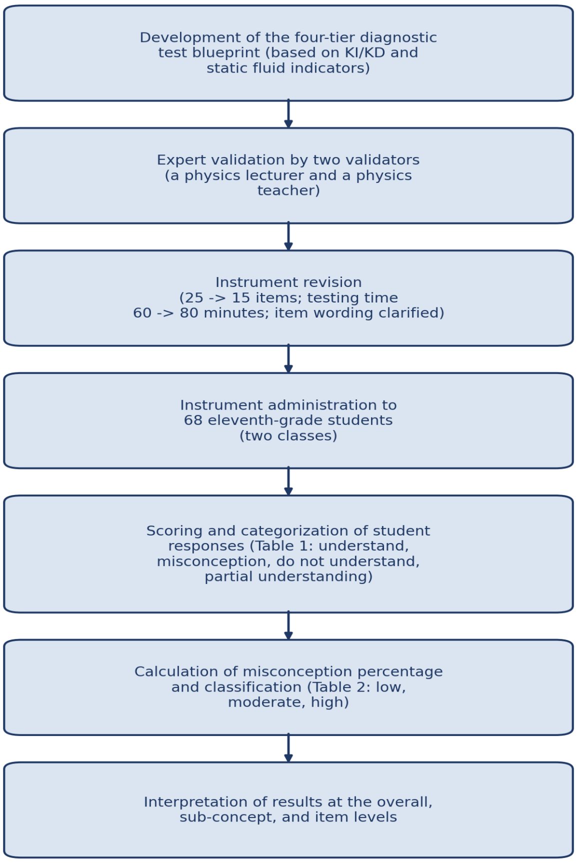

Figure 1. Flowchart of the research procedure.

Population and Sample

The population of this study consisted of all eleventh-grade students at a public senior high school in Garut Regency. The sample was selected using a purposive sampling technique because the study required respondents who met a specific criterion, namely having completed classroom instruction on static fluid material, rather than a sample representative of every stratum or region; students who had not yet studied the topic would not be able to provide meaningful diagnostic data on their conceptual understanding. Based on this criterion, two intact eleventh-grade science classes that had completed the static fluid unit within the current academic term were identified and made accessible for the study, yielding a total of 68 students; this sample size is consistent with the scale used in comparable four-tier diagnostic studies on static fluid material (e.g., 52 students in Sukariasih & Yuris, 2024) and was considered sufficient for a descriptive, class-level analysis. The study was conducted in two stages: expert judgment by two validators (one lecturer and one teacher), followed by data collection using the four-tier instrument administered to the 68 students across the two classes.

Data Collection Technique

The data collection technique used in this study was a four-tier diagnostic test presented in the form of a question sheet and an answer sheet. The trial administration of the test was conducted once on eleventh-grade students at a senior high school in Garut Regency who had already studied static fluid material, with the items having been validated by two physics lecturers and one physics subject teacher.

Research Instrument

The instrument used was a multiple-choice test with four tiers. The first tier consisted of a multiple-choice question with one correct answer and four distractors. The second tier asked students to indicate their confidence level in their answer to the first tier. The third tier consisted of a set of reasons, again with one correct reason and four distractors. The fourth tier asked students to indicate their confidence level in the reason selected. The items were developed based on a test blueprint referring to the Core Competencies (KI) and Basic Competencies (KD), learning indicators, and material related to fluid concepts drawn from several reference books.

Instrument validity was established through content validation by two expert validators: a physics education lecturer with expertise in assessment and instrument development, and a senior physics teacher experienced in teaching static fluid material at the senior high school level. The validators independently reviewed each item using a structured validation sheet covering three criteria: (1) content relevance to the Core Competencies (KI) and Basic Competencies (KD) and to the static fluid learning indicators; (2) clarity and appropriateness of the language for eleventh-grade students; and (3) conceptual accuracy of the distractors used to detect specific misconceptions. Their scores and written comments were then discussed with the researcher, and items receiving substantial disagreement or critical comments were revised or removed. Based on this feedback, the number of items was reduced from 25 to 15 to focus on the three targeted sub-concepts, the testing time was extended from 60 to 80 minutes to accommodate the four-tier response format, and the wording of several items was clarified before the instrument was administered.

Data Analysis Technique

The data analysis technique in this study was based on students' answers across all four tiers. The first step was to collect and categorize students' test results according to the combination of answers presented in Table 1, which classifies responses into the categories of understanding the concept, misconception, not understanding the concept, and partial understanding, following the reference framework of Jannah (2022).

Table 1. Simplified combination of four-tier diagnostic test answers

Category	Answer	Confidence (answer)	Reason	Confidence (reason)
Understand	Correct	Confident	Correct	Confident
Misconception	Correct / Incorrect	Confident / Not confident	Incorrect	Confident
Do not understand	Correct / Incorrect	Confident / Not confident	Correct / Incorrect	Not confident
Partial understanding	Incorrect	Confident / Not confident	Correct	Confident

(adapted from Jannah, 2022)

After the responses were categorized, the percentage for each category was calculated using the formula p = (f / n) × 100%, where p is the percentage, f is the frequency being sought, and n is the total number of respondents. The percentages were then used to determine each student's level of misconception, which was classified according to the criteria in Table 2.

Table 2. Misconception level criteria

Percentage	Category
0–30%	Low
31–60%	Moderate
61–100%	High

(Istighfarin, 2015)

Misconceptions were analyzed at three levels: the overall percentage of students' misconception on static fluid material, the percentage of misconception per sub-concept (hydrostatic pressure, Pascal's law, and Archimedes' principle), and the percentage of misconception per test item.

RESULT AND DISCUSSION

Results

As described in the Method section, the test items were content-validated by two expert validators and revised accordingly, before being administered to 68 eleventh-grade students across two classes. The overall results showed that, out of the 68 students tested, 37.65% understood the concept, 37.74% experienced misconceptions, 14.31% did not understand the concept, and 10.30% partially understood the concept of static fluid, as presented in Table 3.

Table 3. Overall percentage of students' conceptual understanding of static fluid material

Category	Percentage
Understand the concept	37.65%
Misconception	37.74%
Do not understand the concept	14.31%
Partial understanding	10.30%

These findings indicate that students' overall level of misconception on static fluid material can be classified as moderate. The percentage of students experiencing misconceptions was nearly equal to the percentage who understood the concept, suggesting that student understanding of static fluid material remains far from complete.

At the sub-concept level, the results showed that 25% of students experienced misconceptions on hydrostatic pressure, 52.20% on Pascal's law, and 41.47% on Archimedes' principle, as shown in Table 4.

Table 4. Misconception category per sub-concept of static fluid material

Sub-concept	Misconception (%)	Category
Hydrostatic pressure	25.00	Low
Pascal's law	52.20	Moderate
Archimedes' principle	41.47	Moderate

At the item level, out of the 15 items tested, the highest misconception was found in item 7 (73.53%, high category), concerning the determination of lifting force on a piston, followed by item 13 (61.76%, high category), concerning the formula for Archimedes' principle. Items with moderate-category misconceptions were items 3, 5, 6, 9, 11, and 15, while items with low-category misconceptions were items 1, 2, 4, 8, 10, 12, and 14.

Discussion

The four-tier diagnostic test used in this study, whose diagnostic value for physics misconceptions has been documented across a broad range of topics and settings (Çelikkanlı & Kızılcık, 2022; Istiyono, Dwandaru, Fenditasari, Ayub, & Saepuzaman, 2023), makes it possible to distinguish genuine misconceptions from mere lack of understanding. The following discussion therefore interprets each sub-concept in relation to prior findings and to conceptual-change theory, rather than restating the percentages alone.

On the sub-concept of hydrostatic pressure, 53.92% of students understood the concept, 25% experienced misconceptions, 8.58% did not understand, and 12.50% partially understood. The lowest item-level misconception in this sub-concept was found in item 14 (1.47%), concerning the application of hydrostatic pressure in an intravenous (IV) infusion setup, while the highest was found in item 5 (38.23%), concerning the relationship between hydrostatic pressure, atmospheric pressure, and absolute pressure. Many students assumed that hydrostatic pressure was the only pressure acting within a liquid, without accounting for the atmospheric pressure acting on the liquid's surface, whereas absolute pressure is in fact the sum of hydrostatic and atmospheric pressure ($P_m = P_h + P_a$). Viewed through the lens of conceptual change, this pattern reflects an intuitive, everyday conception — that pressure is a single, directly observable quantity, being applied to a formal physics context without being restructured to accommodate the additive nature of pressure components, consistent with students' understanding of hydrostatic pressure relying largely on everyday observation and intuitive logic rather than on the underlying scientific principles. Notably, the 25% misconception rate found here is markedly lower than the 62.5% reported for a comparable hydrostatic-pressure item by Jannah et al. (2022) and the 71% reported by Putranta and Afifah (2025) for the same sub-concept using a differently structured instrument, suggesting that the specific wording and distractor design of a four-tier item, and not only students' underlying conceptual grasp, can meaningfully influence the misconception rate detected.

On the sub-concept of Pascal's law, the misconception rate was the highest among the three sub-concepts, at 52.20%, with only 21.32% of students understanding the concept. The lowest item-level misconception in this sub-concept was found in the item asking students to state Pascal's law (23.53%), while the highest was found in the item asking students to determine the lifting force on a piston (73.53%). Most students had not fully grasped that pressure applied to an enclosed fluid is transmitted equally in all directions, and that the resulting force depends on the cross-sectional area rather than on the magnitude of the pressure alone; many students incorrectly assumed that if the pressure on both sides of a hydraulic system were equal, a heavy load such as a car could not be lifted, whereas Pascal's principle demonstrates that equal pressure transmitted through pistons of different areas is precisely what enables the lifting of heavy loads with a comparatively small force. This finding is consistent with, and indeed more pronounced than, the misconception rates on Pascal's law reported by Jannah et al. (2022) (59.4%) and Sukariasih and Yuris (2024) (55.29%) among students in Kendari, indicating that difficulty in reasoning about force–area relationships in enclosed fluids is not specific to a single regional context but appears to be a persistent, cross-context misconception. Rather than a straightforward lack of exposure to the formula, the gap between students being able to state Pascal's law (23.53% misconception) and being able to apply it to determine lifting force (73.53% misconception) points to a procedural–conceptual divide: students can reproduce the statement of the law without having restructured their intuitive, proportional reasoning about force and pressure, a distinction that rote-formula instruction alone is unlikely to resolve.

On the sub-concept of Archimedes' principle, 31.17% of students understood the concept while 41.47% experienced misconceptions. The lowest item-level misconception was found in the item on the SI unit of buoyant force (10.29%), while the highest was found in the item asking students to write the formula for Archimedes' principle (61.76%), where many students confused the formula for buoyant force with that of hydrostatic pressure (incorrectly writing $F_A = \rho, g, h$ instead of the correct $F_A = \rho_f, V_{bf}, g$). Misconceptions in this sub-concept were dominated by errors in relating buoyant force to the density and the volume of fluid displaced, as well as by a tendency among students to conflate this concept with hydrostatic pressure and force equilibrium. This confusion likely stems from the structural similarity between the two formulas, both of which involve density and the gravitational constant, indicating that students had memorized the symbolic form of each equation without connecting it to the distinct physical mechanism it represents — fluid weight displaced versus vertical pressure difference — a pattern that echoes the broader observation that four-tier instruments are particularly effective at revealing this kind of surface-level, formula-based recall rather than genuine conceptual mastery (Çelikkanlı & Kızılcık, 2022).

Taken together, although the percentage of students experiencing misconceptions (37.74%) was nearly equal to the percentage who understood the concept (37.65%), these findings show that students' understanding of static fluid material remains incomplete. Students frequently confuse different physics concepts, rely on everyday logic without a scientific basis, and lack understanding of the relationships between physical quantities. This is consistent with the view that a lack of conceptual understanding is itself a key contributor to misconceptions (Nuraina & Rohantizani, 2023). Compared with prior four-tier diagnostic studies on static fluid material — both those conducted in Kendari (Jannah et al., 2022; Sukariasih & Yuris, 2024) and, more recently, in Bantul (Putranta & Afifah, 2025) — Pascal's law and the hydrostatic-pressure/buoyant-force distinction recur as the most persistent sources of misconception regardless of regional context or the specific instrument used, suggesting that the difficulty lies less in any particular test or population and more in the abstract, multi-variable reasoning these sub-concepts demand. These findings underscore the importance of a learning approach that places greater emphasis on conceptual understanding through experimentation, simulation, and explicit clarification of common misconceptions, rather than one that relies primarily on formula memorization.

CONCLUSION

Based on the analysis of students' misconceptions on static fluid material using the four-tier diagnostic test, it can be concluded that the overall misconception experienced by students falls into the moderate category, with a misconception percentage of 37.74%. At the sub-concept level, the highest misconception percentage was found in Pascal's law (52.20%), followed by Archimedes' principle (41.47%) and hydrostatic pressure (25%). At the item level, the highest misconception was found in item 7 (73.53%), which required students to determine the lifting force on a piston, while the lowest was found in item 14 (1.47%), concerning the application of hydrostatic pressure in an intravenous infusion setup. These findings indicate that although a similar proportion of students understand the concept of static fluid, a substantial number continue to hold persistent misconceptions, particularly regarding the transmission of pressure in enclosed fluids and the relationship between buoyant force, density, and displaced fluid volume, highlighting the need for more diagnostic and remediation-oriented approaches in physics instruction.

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REFERENCES

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Longman.

Arikunto, S. (2009). Dasar-dasar evaluasi pendidikan (Rev. ed.). Bumi Aksara.

Çelikkanlı, N. Ö., & Kızılcık, H. Ş. (2022). A review of studies about four-tier diagnostic tests in physics education. Journal of Turkish Science Education, 19(4), 1291–1311. https://doi.org/10.36681/tused.2022.175

Didik, L. A., Wahyudi, M., & Kafrawi, M. (2020). Identifikasi miskonsepsi dan tingkat pemahaman mahasiswa Tadris Fisika pada materi listrik dinamis menggunakan 3-tier diagnostic test. Journal of Natural Science and Integration, 3(2). https://doi.org/10.24014/jnsi.v3i2.9911

Fariyani, Q., Rusilowati, A., & Sugianto. (2015). Pengembangan four-tier diagnostic test untuk mengungkap miskonsepsi fisika siswa SMA kelas X. Journal of Innovative Science Education, 4(2), 41-49.

Gradini, E. (2016). Miskonsepsi dalam pembelajaran matematika sekolah dasar di dataran tinggi Gayo. Numeracy, 3(2), 52-60.

Hermita, N., Suhandi, A., & Syaodih, E. (2017). Identifikasi miskonsepsi pada materi listrik statis pada mahasiswa calon guru sekolah dasar. Jurnal Pendidikan, 1, 336-340.

Istighfarin, L., Ambarwati, R., & Rahayu, D. A. (2015). Profil miskonsepsi siswa pada materi struktur dan fungsi jaringan tumbuhan. Berkala Ilmiah Pendidikan Biologi, 4(3), 991-995.

Istiyono, E., Dwandaru, W. S. B., Fenditasari, K., Ayub, M. R. S. S. N., & Saepuzaman, D. (2023). The development of a four-tier diagnostic test based on modern test theory in physics education. European Journal of Educational Research, 12(1), 371–385. https://doi.org/10.12973/eu-jer.12.1.371

Jannah, M., Erniwati, E., Mongkito, V. H. R., & Yuris, M. (2022). Analisis miskonsepsi siswa menggunakan four tier diagnostic test pada pokok bahasan fluida statis siswa SMKN 2 Kendari. Jurnal Penelitian Pendidikan Fisika, 7(1), 19-25. https://doi.org/10.36709/jipfi.v7i1.23084

Khairunnisa, K., Ishafit, I., & Fayanto, S. (2020). Physics teaching: Development of Lectora Inspire with multiple-representation approach to reduce of misconception. Jurnal Dedikasi Pendidikan, 4(2), 159-170.

Mayasari, R. (2021). Identifikasi miskonsepsi siswa menggunakan tes diagnostic four-tier berbantuan Google Formulir pada konsep termodinamika di SMA Negeri 11 Tangerang Selatan [Undergraduate thesis, Universitas Islam Negeri Syarif Hidayatullah Jakarta].

Nuraina, & Rohantizani. (2023). Analisis miskonsepsi siswa menggunakan Certainty of Response Index (CRI) pada materi turunan di SMA Negeri 1 Muara Batu. Jurnal Penelitian Pembelajaran Matematika Sekolah, 7(1), 95-105.

Perwitasari, A. D. (2015). Pengembangan tes diagnostik berbasis web pada materi termodinamika untuk mengidentifikasi tingkat pemahaman konsep siswa [Undergraduate thesis, Universitas Negeri Semarang].

Putranta, H., & Afifah, F. (2025). Development of the four-tier diagnostic test to identify student misconceptions in the static fluids chapter. Journal on Efficiency and Responsibility in Education and Science, 18(4), 268–281. https://doi.org/10.7160/eriesj.2025.180403

Rawh, P., Samsudin, A., & Nugraha, M. G. (2020). Pengembangan four-tier diagnostic test untuk mengidentifikasi profil konsepsi siswa pada materi alat-alat optik. WaPFI (Wahana Pendidikan Fisika), 5(1), 84-89.

Sheftyawan, W. B., Prihandono, T., & Lesmono, A. D. (2018). Identifikasi miskonsepsi siswa menggunakan four-tier diagnostic test pada materi optik geometri. Jurnal Pembelajaran Fisika, 7(2), 147-153.

Sufiani, Y., Erniwati, & Eso, R. (2019). Analisis pemahaman konsep fisika peserta didik dengan instrumen four-tier diagnostic test. Jurnal Penelitian Pendidikan Fisika, 4(1), 35-43.

Sugiyono. (2018). Metode penelitian pendidikan: Kuantitatif, kualitatif, dan R&D. Alfabeta.

Sukariasih, L., & Yuris, M. (2024). Identifikasi miskonsepsi siswa kelas XI pada konsep fluida statis dengan menggunakan four-tier diagnostic test di SMA Negeri 2 Kendari. Jurnal Penelitian Pendidikan Fisika, 9(3), 139-151.

Suparno, P. (2013). Miskonsepsi dan perubahan konsep dalam pendidikan fisika. PT Grasindo.

Yuliati, Y. (2017). Miskonsepsi siswa pada pembelajaran IPA serta remediasinya. Bio Educatio, 2(2), 50-58.

Zaleha, A. S., & Nugraha, M. G. (2017). Pengembangan instrumen tes diagnostik VCCI bentuk four-tier test pada konsep getaran. Jurnal Pendidikan Fisika dan Keilmuan (JPFK), 3(1), 32-38.