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Identification of Student Misconceptions on Dynamic Fluid Material using a Five-tier Diagnostic Test

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Abstract: Misconception is one of the problems that often occurs in physics learning, especially in dynamic fluid materials. Misconceptions can affect physics learning outcomes if allowed to occur continuously. This study aims to identify students' misconceptions about dynamic fluid material using a five-tier diagnostic test. Five-tier diagnostic test is the newest form of diagnostic test that is able to detect deeper misconceptions experienced by students. By using the five-level diagnostic test, you will be able to see dynamic fluid material that still has misconceptions and requires more emphasis. Apart from that, teachers can design remediation learning better. This study employed a one-shot research method with a sample of 68 students from class XI of a high school who had received dynamic fluid material. The result of this study is that students experience misconceptions on dynamic fluid material, with an average percentage of 40.7% in the moderate category. Students' misconceptions on dynamic fluid material occur in the sub-matter of the principle of continuity and Bernoulli's Law. The misconceptions experienced by students in the continuity principle sub-matter regarding the relationship between cross-sectional area (A) and fluid velocity (v) by 37,5%, the relationship between cross-sectional area (A) and fluid debit (Q) by 46,9%, and the relationship between cross-sectional area (A) and volume (V) by 50%, with a moderate category. Meanwhile, in the Bernoulli's Law sub-matter, students experienced misconceptions regarding the relationship between the depth of the leak hole (h) and the distance of the fluid jet (x) by 40,6%, and the relationship between velocity (v) and fluid pressure (P) by 43,8% with moderate categories. Given the misconceptions students still experience with dynamic fluid materials, it is necessary to implement remediation strategies, such as tests, special learning methods, or assignments.

Keywords: Dynamic Fluids; Five-tier Diagnostic Test; Identification; Misconception.

Introduction

Physics is a fundamental science that is the basis for other sciences. If students' understanding of physics concepts is incorrect, it will also affect their knowledge of different sciences. Differences between students' conceptions and scientific concepts or interpretations of concepts that are not based on the knowledge of experts often occur in learning [1]. Students' difficulties in understanding a concept can lead to misconceptions [2]. Research shows there is a positive correlation between misconceptions and learning outcomes [3]. Misconceptions occur due to differences in understanding formed by students with facts described in the literature [4]. The difference in thinking between a person's concept and the scientific theory understood by experts is called a misconception.

Misconception is one of the obstacles that often occur in the physics learning process [5]. Misconceptions that arise in students can have adverse effects, such as a decrease in student learning outcomes, a lack of achievement of learning objectives, and an impact on student understanding of subsequent material. This is due to the inability of students to analyze the concepts of the learning materials [6]. Physics is a complex subject because it is related to theories, concepts, and mathematical formulas used in everyday life. Dynamic fluid is a dynamic fluid material that often gives rise to misconceptions among students, particularly in the context of Bernoulli's law and the continuity equation [7].

Research conducted using a three-tier diagnostic test instrument revealed that 65.34% of students still experienced misconceptions in dynamic fluid material [8]. In addition, another study using a four-level diagnostic test showed that there were 29.21% of students also had misconceptions in dynamic fluid material [9]. Students' misconceptions in dynamic fluid material often occur in the sub-concept material of fluid velocity in horizontal pipes with different cross-sectional areas, fluid discharge with different cross-sectional areas, and fluid pressure in pipes with different cross-sectional areas [10]. The results of research by Nasbey et al show that there are still students who experience misconceptions about fluid dynamic material. The highest percentage of misconceptions in the Bernoulli Equation sub-material was 73% for 11 students, while in the continuity equation sub-material, the highest percentage of misconceptions was 28% for 4 students [7]. Other research using a two-tier diagnostic test also shows that there are 5 forms of student misconceptions identified through a diagnostic test using Google Form, namely students assume the greater the area cross-section, the greater the fluid discharge, as much as 33,95%; students respond the larger the cross-sectional area, the smaller the fluid discharge, as much as 9,72%; learners assumes fluid velocity is directly proportional to cross-sectional area, as much as 13,89%;

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participant students assume that pressure is inversely proportional to the cross-sectional area of the pipe, as much as 27,7%; And students assume that pressure is directly proportional to fluid velocity, as much as 2,77% [11]. These results show that even though misconceptions have been identified using two-tier, three-tier or four-tier diagnostic tests, there are still many students who experience misconceptions in fluid dynamic materials. Therefore, it is necessary to identify misconceptions about fluid dynamic materials more thoroughly.

Misconceptions in dynamic fluid material can be caused by various factors, such as students' preconceptions or understanding of previous concepts, teachers, teaching methods, and textbooks [12]. The teaching method used by teachers is often a lecture-only approach, making students bored and less attentive to learning. Teachers often only discuss formulas without exploring concepts with students. So that students tend to only memorize formulas without understanding the material. Students who tend to only memorize learning material from the teacher will result in a lack of appreciation for the learning process, and not optimal student thinking skills [13]. Dynamic fluid is a physics material related to the concept of fluid movement, requiring adequate visualization or props to help students understand the concept correctly.

Based on the results of pre-research, an initial description of the condition of students at school was obtained. The researcher then interviewed one of the physics teachers at SMAN 13 Surabaya. Based on the results of the interview, it was found that there were still some students who had difficulty understanding physics concepts in the dynamic fluid material. In addition, there has never been a special test to determine students' misconceptions about dynamic fluid material. So there needs to be an effort to reduce misconceptions in dynamic fluid physics material. However, to deal with misconceptions appropriately and effectively, misconception problems must be clearly identified first [14].

Various techniques have been carried out to identify misconceptions experienced by someone on a national and international scale [15]. One way to identify misconceptions is by using diagnostic tests [16].Diagnostic tests are a form of test that serves to identify the strengths and weaknesses of students' understanding, specifically in specific lessons [17]. Diagnostic tests that have been developed and used by researchers to measure students' conceptions include interviews, concept maps, questionnaires, and multiple-choice tests [18]. Each diagnostic test method that has been developed has its advantages and disadvantages, but [19] state that multiple choice tests have the advantages of being versatile, efficient, objective, easy to use, and less affected by each person's tendency to answer multiple choices in a certain way.

Diagnostic tests have had many developments, ranging from two-level, three-level, four-level, and five-level diagnostic tests. The five-tier diagnostic test is a development of the four-tier diagnostic test. The first level contains multiple choice questions with four possible answers, the second level is the level of confidence in the answer to the first level, the third level contains reasons in the form of multiple choice questions and four possible answers, the fourth level is the level of confidence in the reasons, and the fifth level of questions contains essay questions to further confirm the source of misconceptions [20]. The advantages of the five-tier diagnostic test include identifying misconceptions experienced by students, determining their sources, pinpointing areas of the material that require more emphasis during learning, and aiding in the planning of more effective learning implementation.

Based on the problems that have been described, it is necessary to identify students' misconceptions on dynamic fluid material at SMAN 13 Surabaya to find out the students' misconception profile. Identifying students' misconceptions can help teachers design lessons to remediate them and determine which materials require more emphasis. Thus, this research was conducted to identify students' misconceptions about dynamic fluid material using a five-tier diagnostic test. The novelty of this research is the use of a five-tier diagnostic test to identify misconceptions more deeply and accurately. The tests created have been adjusted to potential student misconceptions that have been obtained through pre-research.

Research Methods

Based on the research objectives, the type of research used is one-shot research [21]. The samples of this study were students of class XI-4 and XI-5 at SMAN 13 Surabaya, with a total of 68 students. Sampling in research was chosen based on the provisions and approval of the school and teachers who considered it. This research procedure consists of several stages. The first stage is literature and preliminary studies. The second stage is the preparation of the five-tier diagnostic test instrument. The third stage involves assessing the instrument by experts and developing test questions. Stage four is data collection. Stage five is data processing, data analysis, and conclusion drawing.

The data collection technique in this study is a test. The test used is a five-tier diagnostic test or a five-level diagnostic test, totalling 12 questions that have been declared valid and reliable based on the results of the trial. The advantages of the five-tier diagnostic test include identifying misconceptions experienced by students, determining their sources, pinpointing areas of the material that require more emphasis during learning, and aiding in the planning of more effective learning implementation. To identify students' misconceptions, students' conceptions were classified. Table 1 [22] shows the answer combination for the five-tier diagnostic test.

After grouping the level of students' conceptions, the next step is to classify the students' misconception categories. Table 2 [23] shows the students' misconception categories. After grouping each student's conception level, the next step is to categorize the student's level of misconception. The level of student misconceptions can be calculated using the formula:

$$P = \frac{n_A}{n_s} x 100\%$$

Description:

P : Percentage of students who have misconceptions

n_A : Number of students who have misconceptions

n_s : The total number of students

The results of the percentage level of students' misconceptions can be interpreted according to the criteria in Table 2 [23].

Table 1. Five-tier Diagnostic Test Answer Combination.

One-Tier	Two-Tier	Three-Tier	Four-Tier	Five-Tier	Conception Level
				SD/SC	SC
				PD/PC	ASC
True	Sure	False	Not Sure	MD/MC	LK
				UD/UC	
				ND/NC	UnC
True	Sure	True	Not Sure		
True	Not Sure	True	Sure		
True	Not Sure	True	Not Sure		
True	Sure	False	Not Sure		
True	Sure	False	Sure		
True	Not Sure	False	Sure	(PD/PC) / (MD/MC)/ (UD/UC)/ (ND/NC)	LK
True	Not Sure	False	Not Sure		
True	Sure	True	Sure		
True	Sure	True	Not Sure		
True	Not Sure	True	Sure		
True	Not Sure	True	Not Sure		
True	Sure	False	Not Sure		
True	Not Sure	False	Sure	(PD/PC)/ (MD/MC)/ (UD/UC)/ (ND/NC)	NU
True	Not Sure	False	Not Sure		
True	Sure	False	Sure	(MD/MC)/ (UD/UC)/ (ND/NC)	MSC
Some levels are not answered or answered more than once					UnC

Description:

SD/SC	Scientific Drawing/ Scientific Conclusion
PD/PC	Partial Drawing/ Partial Conclusion
MD/MC	Misconception Drawing/ Misconception Conclusion
UD/UC	Undenified Drawing/ Undenified Conclusion
ND/NC	No Drawing/No Conclusion
SC	Scientific Conception
ASC	Almost Scientific Conclusion
UnC	Un-Code
LK	Lack of Knowledge
NO	No Understand a concept
MSC	Misconception

Table 2. Student Misconception Category.

Percentage	Category
0% < P < 30%	Low
30% < P < 60%	Medium
60% < P < 100%	High

Results and Discussion

After the research was conducted, the average percentage for each level of student conception was obtained. Figure 1 shows the graph of the average rate of students' misconception level.

Based on Figure 1, it can be seen that the highest level of misconception experienced by students is misconception (MSC), with a percentage of 40.7% in the moderate category. Meanwhile, students who understand the concept (SC) are only 16.9%. In addition, many students do not understand the concept (LK), with a percentage of 24.4%. To find out the distribution of misconceptions on each concept, Table 3 shows the distribution of misconceptions on each concept along with the form of misconception.

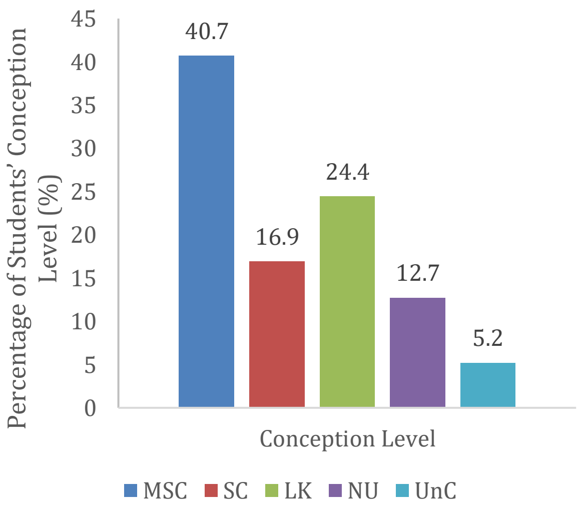

Figure 1. Graph of Average Percentage of Students' Conceptual Level.

Table 3. Misconception Distribution.

Subject	Concept Unit	%	Category
Principle of Continuity	Relationship between cross-sectional area (A) and fluid velocity (v)	37.5	Medium
	Relationship between cross-sectional area (A) and debit (Q)	46.9	Medium
	Relationship between cross-sectional area (A) and volume (V)	50	Medium
Bernoulli's Law	Relationship between hole depth (h) and fluid beam distance (x)	40.6	Medium

	Relationship between fluid velocity (v) and fluid pressure (P)	43.8	Medium
Principle of Continuity and Bernoulli's Law	Relationship of cross-sectional area (A) with fluid velocity (v) and fluid pressure (P)	40.6	Medium

Table 3 shows that students experience misconceptions in the material of the principle of continuity and Bernoulli's Law, with overall misconceptions for each concept having a moderate category. The following is an explanation of students' misconceptions in each sub-material:

Principle of Continuity

In the material of the principle of continuity, students still experience misconceptions about the relationship between cross-sectional area (A) and fluid velocity (v) with a percentage of 37.5% with a moderate category, the relationship between cross-sectional area (A) and discharge (Q) with a percentage of 46.9% with a moderate category, the relationship between cross-sectional area and volume (V) with a percentage of 50% with a moderate category. According to the research, a misconception can be interpreted as a conception that is not in accordance with scientific understanding or understanding accepted by scientists [24]. Students assume that the larger the cross-sectional area (A), the greater the fluid velocity (v). This is in line with previous research, which states that students assume that when the cross-sectional area is large, it has a high fluid velocity [25]. Students also believe that the fluid velocity will be constant even though the cross-sectional area of the pipe is different. This is contrary to the concept of the principle of continuity, where the velocity of incompressible fluid is inversely proportional to the cross-sectional area through which it passes [26].

Students also have misconceptions about the relationship between cross-sectional area (A) and debit *(Q)*. Students assume that the larger the cross-sectional area, the greater the flowing fluid discharge. Figure 2 is the answer to students' misconceptions about the relationship between discharge and cross-sectional area.

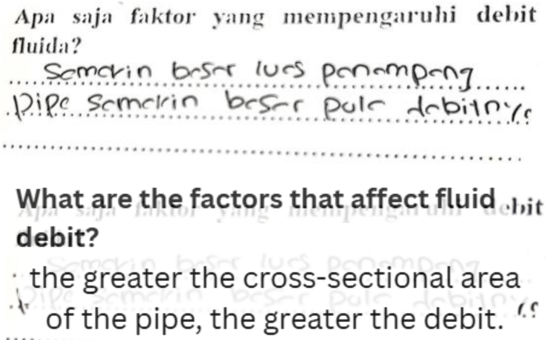

Figure 2. MSC Students' answers regarding the relationship between cross-sectional area (A) and discharge (Q)

Figure 2 shows the answers of students with misconceptions (MSC). The correct concept is that in an incompressible fluid, the fluid discharge at any point will always be constant [25]. In addition, students also assume that the relationship between volume (V) and cross-sectional area (A) is directly proportional. This is not the correct concept that in an incompressible fluid, the volume will always be constant. Students are often mistaken about fluid velocity and discharge. Students assume that speed is the same as discharge. Students also assume that the larger the pipe area, the more fluid will pass and cause greater fluid velocity and fluid discharge.

Bernoulli's Law

In Bernoulli's Law, students still experience misconceptions about the relationship between hole depth (h) and beam distance (x), with a percentage of 40.6% in the moderate category, and the relationship between speed (v) and pressure (P), with a percentage of 43.8% in the moderate category. Students assume that the smaller the distance into the hole, the farther the distance the water will spread. This is contrary to the actual concept, where the depth of the hole is directly proportional to the distance of the resulting beam. Students often mistakenly assume that h is measured from the bottom of the tank, not from the water surface. This is what causes most students to experience misconceptions.

In addition, students also have misconceptions about the relationship between velocity (v) and pressure (P). Students assume that the greater the velocity *(v),* the greater the pressure (P). This is similar to previous research which states that students assume that when the fluid velocity is large, the pressure will also be greater [11, 27]. Students' misconceptions regarding the relationship between fluid velocity and pressure are shown in Figure 3.

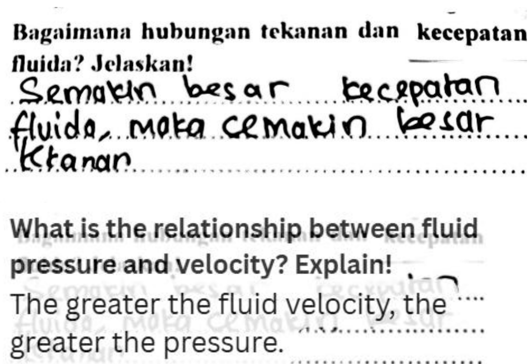

Figure 3. Misconception (MSC) Answers on The Relationship between Velocity and Pressure

The misconception answer in Figure 3 is contrary to the actual concept, where the greater the fluid velocity, the smaller the fluid pressure [28-29]. Students often have difficulty imagining the phenomenon of a leaking water tank, and some of them assume that the position of the leak hole is based on the distance of the hole from the bottom of the tank, not from the water surface. Based on the identification of misconceptions, it is found that there are still many students who experience misconceptions in dynamic fluid material. Thus, it is necessary to conduct further research to remediate students' misconceptions on dynamic fluid material so that students' concept understanding in the following physics material is appropriate, and student learning outcomes can improve. It is necessary to carry out learning strategies to reconstruct or revise incorrect concepts. Learning can be done by applying a certain learning model, which is able to make students aware of the misconceptions they are experiencing and confront wrong concepts, so that dissatisfaction arises in students and a desire to find the correct concept. Teachers can also integrate various supporting media related to dynamic fluid concepts so that students can understand the correct concepts more deeply. Apart from that, practical activities are also needed to prove correct concepts, accompanied by cases and theory. So, students' understanding of new concepts is not only correct but also acceptable and reasonable. Several learning models that have been proven to be successful in remediating misconceptions include the Conceptual Change Model (CCM), Conflict Cognitive-Based Learning (CCBL), Guided Inquiry Learning Model, Learning Cycle 5E/7E Model, and several other models that are integrated using physics media such as PhET.

This research also has several limitations, namely that the research was only conducted at one school, the sample was small, and it only focused on the sub-material of the principle of continuity and Bernoulli's law. The tests are designed according to students' potential misconceptions based on pre-research results.

Conclusion

Based on the results of misconception identification research using the five-tier diagnostic test, it can be concluded that overall, the misconceptions experienced by students in class XI-4 and class XI-5 at SMAN 13 Surabaya on dynamic fluid material have a percentage of 40.7% with a moderate category. The largest percentage of misconceptions is found in the sub-material on the principle of continuity, namely the relationship between cross-sectional area (A) and debit (Q), which is 50%. Meanwhile, the lowest percentage of misconceptions was also found in the continuity principle sub-material regarding the relationship between cross-sectional area (A) and fluid velocity (v) at 37.5%. Therefore, it is necessary to implement treatment to remediate misconceptions, which can be achieved through various means, including tests, special learning methods, or student assignments. Some learning strategies that can be used to remediate misconceptions are by implementing a suitable learning model. This learning model must be able to make students aware of the misconceptions they are experiencing, confront concepts, and make students discover new and correct concepts. Apart from that, learning can also be done by integrating interactive media related to concepts that have misconceptions such as PhET or other demonstration media.

Author's Contribution

Hanifah Rahmania Hazmi: Conceptualisation of the research, data collection, and analysis; Mukhayyarotin Niswati Rodliyatul Jauhariyah: Academic supervision, methodology review, validation of result analysis, and quality check of manuscripts.

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References

[1] R. W. Wadana and Maison, “Description students' conception and knowledge structure on electromagnetic concept,” *J. Phys. Conf. Ser.*, vol. 1185, no. 1, 2019, doi: 10.1088/1742-6596/1185/1/012050.

[2] A. Jayadi, D. H. Putri, and H. Johan, “Identifikasi Pembekalan Keterampilan Abad 21 Pada Aspek Keterampilan Pemecahan Masalah Siswa Sma Kota Bengkulu Dalam Mata Pelajaran Fisika,” *J. Kumparan Fis.*, vol. 3, no. 1, pp. 25–32, 2020, doi: 10.33369/jkf.3.1.25-32.

[3] L. T. Antika and L. Ibana, “JPBIO (Jurnal Pendidikan Biologi) DENGAN HASIL BELAJAR MAHASISWA PENDIDIKAN FISIKA DAN BIOLOGI Islam Madura , Pamekasan,” *JPBIO (Jurnal Pendidik. Biol.*, vol. 3, no. 2, pp. 1–8, 2018.

[4] R. Maryanti *et al.*, “Sustainable Development Goals (Sdgs) in Science Education: Definition, Literature Review, and Bibliometric Analysis,” *J. Eng. Sci. Technol.*, vol. 17, pp. 161–181, 2022.

[5] I. Kaniawati, N. J. Fratiwi, A. Danawan, I. Suyana, A. Samsudin, and E. Suhendi, “Analyzing students' misconceptions about Newton's Laws through Four-Tier Newtonian Test (FTNT),” *J. Turkish Sci. Educ.*, vol. 16, no. 1, pp. 110–122, 2019, doi: 10.12973/tused.10269a.

[6] S. Azura and J. Copriady, “Identification Misconception on Chemical Bonding,” *Ikat. Kim.*, vol. I, no. 2, pp. 3–4, 2017.

[7] R. A. Putri, H. Permana, and H. Nasbey, “Identifikasi Miskonsepsi Materi Fluida Dinamis Dengan Menggunakan Tes Diagnostik Four-Tier Untuk Siswa Sma Kelas Xi,” vol. XI, pp. 181–186, 2023, doi: 10.21009/03.1102.pf25.

[8] F. I. Rahmita and W. Wasis, “Remediasi Miskonsepsi dengan LKPD Model Guided Inquiry Learning Berbantuan PhET Simulation pada Materi Fluida Dinamis,” *J. Ilm. Pendidik. Fis.*, vol. 6, no. 2, p. 302, 2022, doi: 10.20527/jipf.v6i2.5276.

[9] F. D. Aprita, B. Supriadi, and T. Prihandono, “Identifikasi Pemahaman Konsep Fluida Dinamis Menggunakan Four Tier Test pada Siswa SMA 1,” *J. Pembelajaran Fis.*, vol. 7, no. 3, pp. 315–321, 2018.

[10] R. M. Astuti, T. Djudin, and Hamdani, “Penerapan Model Nht Berbantuan Phet Dalam Remediasi Miskonsepsi Fluida Dinamis Sman 1 Sungai Raya,” *Persepsi Masy. Terhadap Perawatan Ortod. Yang Dilakukan Oleh Pihak Non Prof.*, vol. 53, no. 9, pp. 1689–1699, 2017.

[11] Y. Asnita, S. S. Sitompul, and S. B. Arsyid, “Identifikasi Miskonsepsi Peserta Didik Menggunakan Google Form Pada Materi Fluida Dinamis Di Sma Kapuas Pontianak,” *J. Inov.*

Penelit. dan Pembelajaran Fis., vol. 4, no. 1, p. 7, 2023, doi: 10.26418/jippf.v4i1.56570.

[12] A. M. R. Tumanggor, S. Supahar, E. S. Ringo, and M. D. Harliadi, "Detecting students' misconception in simple harmonic motion concepts using four-tier diagnostic test instruments," *J. Ilm. Pendidik. Fis. Al-Biruni*, vol. 9, no. 1, p. 21, 2020, doi: 10.24042/jipfalbiruni.v9i1.4571.

[13] A. goleman, daniel; boyatzis, Richard; Mckee, "Mengatasi Miskonsepsi," *J. Chem. Inf. Model.*, vol. 53, no. 9, pp. 1689–1699, 2019.

[14] S. Arikunto, "Prosedur Penelitian Suatu Pendekatan Praktik Penelitian : Suatu Pendekatan Praktik," 2013.

[15] Kaltakci-Gurel, D., Eryilmaz, A., & McDermott, L. C., "Development and Application of a Fourtier Test to Assess Pre-Service Physics Teachers' Misconceptions About Geometrical Optics," Research in Science and Technological Education, vol. 35, no. 2. 2017, doi : 10.1080/02635143.2017.1310094.

[16] H. Permana and F. Bakri, "Pelatihan Pembuatan Instrumen Tes Diagnostik Fisika Untuk Mengetahui Miskonsepsi Pada Peserta Didik," *Mitra Teras J. Terap. Pengabdi. Masy.*, vol. 1, no. 1, pp. 29–36, 2022, doi: 10.58797/teras.0101.05.

[17] Z. Zaleha, A. Samsudin, and M. G. Nugraha, "Pengembangan Instrumen Tes Diagnostik VCCI Bentuk Four-Tier Test pada Konsep Getaran," *J. Pendidik. Fis. dan Keilmuan*, vol. 3, no. 1, p. 36, 2017, doi: 10.25273/jpfk.v3i1.980.

[18] S. M. Inggit, W. Liliawati, and I. Suryana, "Identifikasi Miskonsepsi dan Penyebabnya Menggunakan Instrumen Five-Tier Fluid Static Test (5TFST) pada Peserta Didik Kelas XI Sekolah Menengah Atas," *J. Teach. Learn. Phys.*, vol. 6, no. 1, pp. 49–68, 2021, doi: 10.15575/jotalp.v6i1.11016.

[19] I. S. Caleon and R. Subramaniam, "Do students know What they know and what they don't know? Using a four-tier diagnostic test to assess the nature of students' alternative conceptions," *Res. Sci. Educ.*, vol. 40, no. 3, pp. 313–337, 2010, doi: 10.1007/s11165-009-9122-4.

[20] A. S. U. Putra, I. Hamidah, and Nahadi, "The development of five-tier diagnostic test to identify misconceptions and causes of students' misconceptions in waves and optics materials," *J. Phys. Conf. Ser.*, vol. 1521, no. 2, 2020, doi: 10.1088/1742-6596/1521/2/022020.

[21] Sugiyono, *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D*. 2020.

[22] A. P. Azahra and Wasis, "Pengembangan , Uji Validitas , Dan Uji Reliabilitas Instrumen Tes," *J. Ris. Rumpun Mat. dan Ilmu Pengetah. Alam*, vol. 2, no. 2, pp. 196–207, 2023.

[23] T. Beniarti, T. Prihandono, and Supeno, "Analisis Miskonsepsi Siswa SMK Pada Pokok Bahasan Rangkaian Listrik," *Semin. Nas. Pendidik. Fis.*, vol. 3, pp. 220–225, 2018.

[24] K. Sari, "Miskonsepsi Pembelajaran Fisika pada Konsep Gerak Lurus di SMA Negeri 1 Baitussalam Aceh Besar," *J. Serambi PTK*, vol. 5, no. 2, pp. 24–29, 2018, [Online]. Available: ojs.serambimekkah.ac.id

[25] F. N. Sholihat, A. Samsudin, and M. G. Nugraha, "Identifikasi Miskonsepsi dan Penyebab Miskonsepsi Siswa Menggunakan Four-Tier Diagnostic Test Pada Sub-Materi Fluida Dinamik: Azas Kontinuitas," *J. Penelit. Pengemb. Pendidik. Fis.*, vol. 3, no. 2, pp. 175–180, 2017, doi: 10.21009/1.03208.

[26] J. Walker, Halliday, and Resnick, "Fundamentals of Physics 9th Extended," vol. 4, no. 1, pp. 1–23, 2016.

[27] U. V. Paramita and M. N. R. Jauhariyah, "Identifying Student Misconceptions on Momentum and Impulse Using Four-Tier Diagnostic Test Instrument with CRI," *Jurnal Pijar Mipa*, vol. 19, no. 1, pp. 75–82, 2024, doi: 10.29303/jpm.v19i1.6086

[28] A. Busyairi and M. Zuhdi, "Analysis of prospective physics teacher misconceptions about friction force with three tier tests and clinical interviews," *Jurnal Pijar MIPA*, vol. 16, no. 5, pp. 650–658, 2021, doi: 10.29303/jpm.v16i5.1448

[29] M. L. Ilhamdi, A. V. Rahmani, and M. Syazali, "Analysis of misconceptions of senior high school students on biodiversity materials, interactions, and their role in nature," *Jurnal Pijar Mipa*, vol. 17, no. 6, pp. 764–769, 2022, doi: 10.29303/jpm.v17i6.3436