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Identifying Student Misconceptions on Momentum and Impulse Using Four-Tier Diagnostic Test Instrument with CRI

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Abstract: Identification of students' misconceptions is crucial in Physics learning as an evaluation tool to address and reduce these misconceptions. This study aims to assess the quality of a four-tier diagnostic test using the CRI instrument, assisted by JotForm, and describe the profile of students' misconceptions related to momentum and impulse. The quality of the instrument is evaluated based with validity and reliability. The research follows the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) method. The instrument is developed during the analysis, design, and development stages. The implementation and evaluation stages involve capturing the profile and causes of students' misconceptions. The instrument's quality is assessed based on theoretical validity, which reached 89.29%. Empirical content validity haved percentages of false positives 6.93% and false negatives 6.53%. The empirical validity of the construct, with a significance level of 0.05, resulted in an r_{table} of 0.273. From the 15 questions tested, 12 questions were found to have empirical validity, and a reliability score of 0.475 was obtained. The study revealed that 3 students had low misconceptions, 14 students had medium misconceptions, and 6 students had high misconceptions. The causes of students' misconceptions were primarily false positives and humanistic thinking, accounting for 28.56%. In conclusion, the instrument developed in this study is valid and reliable, and it effectively identifies the profile and causes of students' misconceptions.

Keywords: CRI; Four-Tier Diagnostic Test; Misconceptions; Reliability; Validity.

Introduction

Physics is a subject that often gives rise to misconceptions. This is because students often have difficulty understanding abstract physics concepts. Every concept in physics requires a description and examples of real application. So, in the process of understanding physics concepts, in-depth analytical skills are needed to study the relationship between one Physics concept and another. This allows students with low analytical skills to experience misconceptions when studying physics concepts [1].

Students who experience misunderstanding of concepts in basic Physics material are at great risk of failing to master the concepts in subsequent Physics material. The basic physics material that is often the main foundation in physics concepts is the branch of mechanical physics. Based on research data collected, the branch of mechanical physics often carries out research on misconceptions [2]. Among the many branches of mechanics, momentum and impulse are materials that are not widely used as material for identifying misconceptions compared to other branches of mechanics. In the revised 2013 curriculum, momentum and impulse material must be mastered well in class X of high school. Based on the results of interviews with physics teachers at MAS Muhammadiyah 1 Paciran, it is known that in the material on momentum and impulse, students are likely to experience misconceptions. It was also found that no misconception diagnostic test instrument had been implemented at the school.

Inclusively the causes of misconceptions are summarized in five categories [2], (1) students situations, including preconceptions, associative thinking, humanistic thinking, wrong intuition, incomplete understanding, stage of cognitive development, students' abilities, and interest in learning.(2) the educator's teaching style, which is influenced by the use of media and learning models.(3) textbooks, often the sentences, graphs and images presented are biased and difficult to understand.(4) content (content) of material delivery, and (5) teaching methods applied in the learning process [3].

Diagnostic tests are able to present an accurate portrait of the misconceptions experienced by students based on information about errors in filling out test instruments [4]. Many types of diagnostic tests that can be applied to identify students' misconception profiles, including the interview method, open-ended test, multiple-choice test, and multiple-tier test. These instruments test have their respective strengths and weaknesses.

The interview method is an option that approaches the actual situation regarding students' misconception profiles, but students' answers are difficult to group because they are broad and require a lot of research time. An open-ended test is a test with a non - existent nature so that students can reveal their conceptions in detail, but this test has weaknesses in the identification process caused by the students' use of

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language. Multiple-choice tests are in the form of ordinary multiple choice tests this test can be inefficient because it does not build students' thinking constructs in answering questions. Multiple-tier tests are multilevel tests which have recently been frequently applied to uncover misconceptions that occur within students. This multiple-tier test has several levels starting from two-tier, three tier, and four-tier [5].

The multiple-tier test instrument is a two-tier type. The first tier is in the form of ordinary multiple-test answers, and the second tier is in the form of reasons for the first-tier answers. Answers to questions and reasons can be correct, but this type allows students to choose answers and reasons randomly, so it is still not enough to describe the concept. The two-tier instrument was then developed into a three-tier diagnostic test instrument that included the level of confidence in choosing answers. If the answers and reasons chosen by students are wrong but have a high level of confidence, then it is categorized as a misconception. The misconception diagnostic instrument was also developed into a four-tier diagnostic test. The four-tier instrument consists of multiple-choice questions (tier 1), level of confidence in choosing the answer in the first tier (tier 2), reasons for the answer in the first tier (tier 3), and level of confidence in the reason chosen (tier 4) [5,14]. Four-tier format diagnostic instruments can identify students' conceptions more accurately than two-tier or three-tier ones and can identify the causes of misconceptions in students, including pre-conceptions, humanistic thinking, associative thinking, incomplete understanding, and wrong intuition [2].

Developed an instrument filling method for identifying misconceptions known as the Certainty of Response Index (CRI) [6]. CRI is a method that shows the parameters of students' level of confidence in answering each question given by providing a scale of confidence or certainty that accompanies each answer provided. This method is often used in developing three-tier and four-tier diagnostic test instruments for tiers that express the level of confidence in choosing an answer (second tier) and the level of confidence in choosing a reason (fourth tier). CRI is more effective in determining confidence in choosing answers and reasons, because students are presented with a broader scale than the Guttman scale with two definite options between "yes" and "no" [7].

The development of four-tier diagnostic tests, in some literacies, is generally still paper-based. The paper-based process of identifying misconceptions requires precision and takes a long time to analyze answer sheet data because it combines four answers from each level to obtain a portrait of students' misconceptions. To make it easier to identify misconceptions and process students' misconception data, a four-tier diagnostic test can be developed on the network [4]. Many websites can be used as a basis for four-tier instruments, such as Google Forms, Quizizz, TypeForm, and JotForm.

JotForm, Quizizz, and TypeForm are them as Google Forms and can be used to create questionnaires in the form of online forms. The flexibility of question options presented in Quizizz and TypeForm is not them as JotForm and Google Forms. Because Quizizz and TypeForm have a limited number of questions in one display, it is impossible to model multilevel test instruments. Meanwhile, JotForm and Google Forms can be designed on one page to display more than one type of question. Therefore, Google Forms and JotForm can be used to create graded instrument questions.

Jotform has the advantage of design flexibility. Compared with Google Forms, Jotform can be designed to be as attractive as possible to increase students' interest in filling out diagnostic test instruments. Apart from that, by using the JotForm website, data can be processed quickly and accurately compared with paper-based methods because the existing data can be integrated directly into spreadsheets and Microsoft Excel. Students' input of instruments can be processed directly by entering the required formulas.

Stated that the four-tier diagnostic instrument that has been developed is adequate for identifying portraits of students' misconceptions [8]. This is reinforced by research [7], which aims to develop a web-based instrument to address misconceptions about business and energy. The results of the development carried out received a theoretical validation response from media expert lecturers in the very feasible category. Similar research with the results of the four-tier diagnostic test with CRI instrument, temperature, and heat, which can provide the profile of misconceptions experienced by students [9].

Based on the existing problems, research is needed to develop appropriate instruments to identify misconceptions in momentum and impulse experienced by students. Therefore, this research was carried out with the aim of analyzing the feasibility of the four-tier diagnostic test instrument with CRI momentum and impulse using the JotForm website and describing the profile and causes of misconceptions of class XI ITCP MAS Muhammadiyah 1 Paciran students.

Research Methods

This research uses the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) method. Systematically, the research method steps are presented in Figure 1.

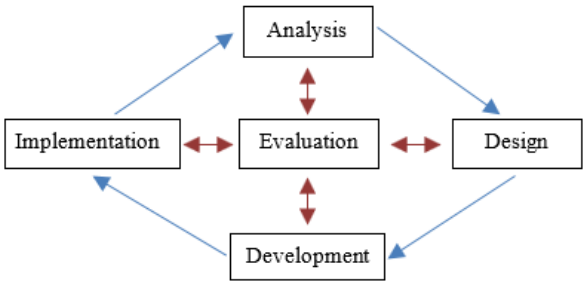

Figure 1. Steps for Implementing the ADDIE Method [10]

The analysis stage was conducted to identify potential misconceptions among students. The potential problems are described and solutions are sought for the existing problems. The first step taken at this stage was a field study using the interview method. Interviews were conducted with physics teachers at MAS Muhammadiyah 1 Paciran on February 22, 2023. This

interview explores the possibility of misconceptions occurring among students. The next step is a literature study to identify potential misconceptions in momentum and impulse material, which is conducted by analyzing books and journals that predict misconceptions. Momentum and impulse material analysis was used to create a four-tier diagnostic test instrument grid.

The analysis of students' conceptions is categorized into five categories: understanding concepts, low knowledge, false negatives, false positives, and misconceptions [4]. In general, students are declared to have misconceptions if they meet the criteria for false positives and true misconceptions. The classification of conceptions found in the students was reviewed on the basis of a combination of students' answers to the four-tier diagnostic test with the CRI instrument. The categories of students' conceptions are presented in Table 1.

Table 1. Decisions Misconception For Four-tier Diagnostic Test with CRI [4].

1 Tier	2 Tier	3 Tier	4 Tier	Category
Correct	≥ 2.5	Correct	≥ 2.5	Scientific Conception
Correct	≥ 2.5	Correct	< 2.5	
Correct	< 2.5	Correct	≥ 2.5	Lack of Knowledge
Correct	< 2.5	Correct	< 2.5	
Correct	≥ 2.5	Wrong	≥ 2.5	False Positives (rarely misconception)
Correct	≥ 2.5	Wrong	< 2.5	
Correct	< 2.5	Wrong	≥ 2.5	Lack of Knowledge
Correct	< 2.5	Wrong	< 2.5	
Wrong	≥ 2.5	Correct	≥ 2.5	False Negatives
Wrong	≥ 2.5	Correct	< 2.5	
Wrong	< 2.5	Correct	≥ 2.5	Lack of Knowledge
Wrong	< 2.5	Correct	< 2.5	
Wrong	≥ 2.5	Wrong	$\geq 2,5$	Misconception (rarely mistake)
Wrong	≥ 2.5	Wrong	< 2.5	
Wrong	< 2.5	Wrong	≥ 2.5	Lack of Knowledge
Wrong	< 2.5	Wrong	< 2.5	

The design stage focuses on creating question indicators, question item grids, and question texts. The instrument grid was adjusted to the basic competencies in the 2013 curriculum. The grid of questions on the diagnostic test for misconceptions about momentum and impulse material is arranged on the basis of potential misconceptions that occur. The instrument consists of 15 questions. The instrument prepared at this stage is a data collection tool as a third-tier option. The instrument is an open three-tier diagnostic test (open ended question) to obtain various answers in the third tier. The combination of reasons in the third-tier functions to identify the causes of misconceptions among students. Data collection was carried out on 15 new students from the class of 2022. It is hoped that these new students will be able to provide answers that are still in line with the level of thinking of high school students. The reasons for the answers given by students at tiers three in one question will vary according to individual understanding. The data obtained were analyzed and developed into four-tier test items.

The development stage was conducted by developing a three-tier open-ended test instrument into a four-tier diagnostic test with CRI. As well testing the quality of the four-tier diagnostic test instrument with CRI. The instrument developed underwent theoretical validation by three expert lecturers who were authorized as instrument validators. The three validator lecturers conducted an analysis of the instrument questions and then provided suggestions and input on the suitability of the question items with the content, construct, and language validity indicators presented in the instrument validation sheet. The instrument, which had been revised according to the suggestions and input of three expert lecturers, was then tested on class XI MIPA students. An instrument is considered feasible if it has an empirical content validity level of <10%, empirical construct validity $r_{11} > r_{table}$, and reliability value $r_{hit} > r_{table}$ [11]. Instruments that are feasible in terms of theoretical validity, empirical validity, and reliability are the four-tier diagnostic test instruments with CRI momentum and impulse.

In the implementation stage, implementation is carried out to identify students' misconception profiles. The misconception profile is based on the level of misconception experienced by students, high, medium, or low. The application of this instrument was carried out by students in class XI ITCP MIPA program.

At the evaluation stage, students' answers to each question are processed to identify the causes of misconceptions regarding momentum and impulse material. The identification results are presented in percentage form. As supporting data for identifying the causes of misconceptions in the momentum and impulse material experienced by students using a four-level diagnostic instrument, interview sessions were also conducted with students to dig deeper into the causes of misconceptions.

Results and Discussion

Research conducted at MAS Muhammadiyah 1 Paciran on June 17–19, 2023, presents research results including the quality of the four-tier diagnostic test instrument with CRI momentum and impulse as well as the profile and causes of student misconceptions.

The quality of the instrument is based on theoretical validity, and the result is that the instrument is declared valid. Calculation of theoretical validity using Equation 1.

$$\text{Theoretical Validity} = \frac{\text{total skors validity}}{\text{amount lecturers}} \times 100\% \quad (1)$$

Figure 2 shows the percentage of construct validity for each domain.

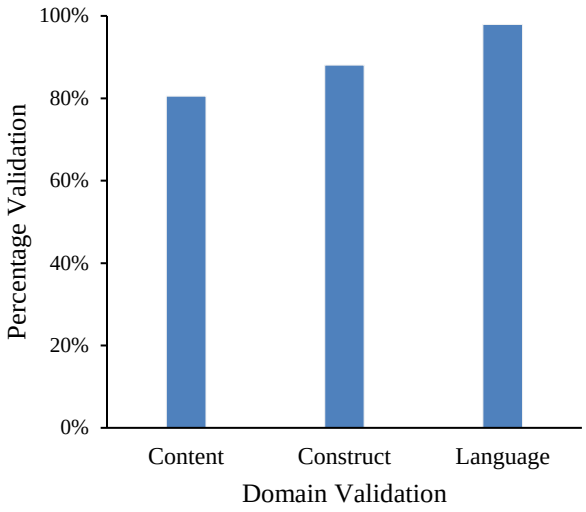

Figure 2. Theoretical Validity Percentage Diagram for Each Domain

The percentage of theoretical validity in the content domain reached 81% with the Very Valid category, indicating that the question material presented is very suitable to the General Competencies (KI) and Primary Competencies (KD), the question items are in accordance with the question indicators presented, and the boundaries of the questions, answers, and reasons are clear. The percentage of theoretical validity in the construct domain reaches 88%, showing clear instructions for filling out the test, the question items are in accordance with Bloom's taxonomy and KD indicators, each test item can diagnose portraits of students' misconceptions, the choice of a combination of the four-tier diagnostic test with CRI momentum and impulse can reveal misconceptions experienced by students, in the choice of reasons distractors were given that were rational and homogeneous to the first tier, the images presented were in accordance with the problem in the questions, and the presentation of the instruments was interesting. The percentage of theoretical validity in the language domain reached 98%, indicating that the sentences used were in accordance with PUEBI rules, did not give rise to multiple interpretations, were presented in communicative language, and accordance with the students' level of thinking [13].

The percentage of empirical content validity was calculated using Equation 2. The instrument is declared valid if it meets false positive (FP) and false negative (FN) values <10%.

$$\text{Percentage of False} = \frac{\text{Total False}}{\sum \text{Student} \times \sum \text{equestion}} \times 100\% \quad (2)$$

The calculation of the empirical content validity results is presented in Table 2.

Table 2 presents the empirical content validity values with FP = 6.97% and FN = 6.53%. On the basis of these data, it can be concluded the percentage of both false is <10%. Therefore, it can be stated that the four-tier diagnostic test instrument with CRI momentum and impulse meets the empirical content validity criteria of the instrument, so it can be stated that the instrument is empirically content valid [12].

Table 2. Empirical Content Validity

Question Number	False Positives	False Negatives
1	2	1
2	3	2
3	5	0
4	2	3
5	4	4
6	2	3
7	2	12
8	9	4
9	7	4
10	2	4
11	1	0
12	5	3
13	3	3
14	3	5
15	2	1
$\sum f$	52	49
Percentage	6.93%	6.53%

Questions that have been tested and declared theoretically and empirically valid in content are then tested for empirical construct validity. The empirical validity of the construct is determined on the basis of the product moment correlation equation. Empirical construct validity tests must be performed to analyze the feasibility of each item on the instrument [15]. The results of the empirical validity test of the construct are presented in Table 3.

Table 3. Empirical Construct Validity

Question	r_{xy}	r_{table}	Criteria
1.	0.488		Accepted
2.	0.282		Accepted
3.	0.309		Accepted
4.	0.491		Accepted
5.	0.363		Accepted
6.	0.234		Rejected
7.	0.189		Rejected
8.	0.311	0.273	Accepted
9.	0.284		Accepted
10.	0.418		Accepted
11.	0.515		Accepted
12.	0.304		Accepted
13.	0.126		Rejected
14.	0.376		Accepted
15.	0.316		Accepted

Question items are considered empirical constructs validity if the value $r_{xy} > r_{table}$ Theoretically, the product moment r_{tabel} value with 50 respondents is at the 0.05 significance level, namely 0.273. Thus, questions with an $r_{xy} < 0.273$ are declared invalid. Based on the empirical construct validity data in Table 3, it was found that of the fifteen questions tested, twelve questions were declared valid and three questions were invalid.

Questions that pass the empirical construct validity test are then subjected to reliability test analysis. The reliability test aims to measure the consistency of students' answers to the four-tier diagnostic test with CRI momentum and impulse misconception instrument. Calculating the reliability of the instrument using Alpha Cronbach equation, it was found $r_{11} = 0.475$ and it was known that $r_{table} = 0.273$, so the instrument reliability test had a value of $r_{11} > r_{table}$, so instrument has reliable [15].

The four-tier diagnostic test instrument with CRI momentum and impulse, which was declared valid and reliable, was then tested on students to obtain the profile and causes of misconceptions experienced by students. The application of this instrument was conducted directly on 23 students in class XI MIPA ITCP (International Class Program) MAS Muhammadiyah 1 Paciran. This research was conducted on June 18, 2023. The students' misconception profiles were divided into three categories: low, medium, and high. Determining the classification of students' misconception levels can be done by determining the upper and lower limits of the total percentage of misconceptions.

High Misconception Category,

$$percentage\ of\ misconception \geq (Mi + \delta) \quad (3)$$

Medium Misconception Category,

$$(Mi - \delta) \leq percentage\ of\ misconception < (Mi + \delta) \quad (4)$$

Low Misconception Category,

$$percentage\ of\ misconception < (Mi - \delta) \quad (5)$$

Using equations 3, equations 4, and equations 5, get classification students misconception, systematically presented in Table 4.

Table 4. Profile of student misconceptions

Sd	%Msc	Category	Sd	%Msc	Category
1.	41.67%	Medium	13.	50.00%	High
2.	41.67%	Medium	14.	25.00%	Medium
3.	41.67%	Medium	15.	41.67%	Medium
4.	50.00%	High	16.	33.33%	Medium
5.	16.67%	Low	17.	16.67%	Low
6.	66.67%	High	18.	33.33%	Medium
7.	33.33%	Medium	19.	50.00%	High
8.	33.33%	Medium	20.	25.00%	Medium
9.	50.00%	High	21.	16.67%	Low
10.	33.33%	Medium	22.	33.33%	Medium
11.	33.33%	Medium	23.	50.00%	High
12.	41.67%	Medium			

[a] Student. [b] misconception.

Based on data from Table 4, students are considered to have misconceptions if they meet the criteria for false positives and truly have misconceptions following the rules for the conception categories in Table 1 [4]. Based on Table 4, of the 23 students, three were 3 in the low misconception category, 14 in the medium misconception category, and 6 in the high misconception category. This shows that, in general, the understanding of the concepts of momentum and impulse in Class XI MIPA ITCP is quite good, because only 13% of students have a high level of misconception.

Table 5. Causes of Misconception in Students for Each Indicator

Causes of Misconception for Each Indicator (%)					
Indicator	1[c]	2[d]	3[e]	4[f]	5[g]
Linear Momentum	20.81	18.97	23.57	39.41	33.49
Law of Conservation of Momentum	36.42	16.56	25.81	0.00	6.77
Law of Conservation of Momentum and energy in collisions	10.40	20.53	0.00	24.43	21.06
Comparison of Momentum and Kinetic Energy	13.87	9.66	34.91	22.72	10.53
Impulse	18.50	35.25	15.71	17.53	31.31

[c] preconceptions. [d] humanistic thinking. [e] associative thinking. [f] incomplete understanding. [g] wrong intuition.

The classification of the causes of misconceptions among students is based on the reasons for the answers chosen by the students [16-18]. The causes of misconceptions in students that can be measured using the four-tier diagnostic test instrument are divided into five categories: preconceptions, humanistic thinking, associative thinking, incomplete understanding, and wrong intuition. The categorization of portraits of the causes of students' misconceptions based on each test indicator is presented in Table 5.

In the linear momentum sub-material, students who fall into the category that causes misconceptions and incomplete understanding assume that density is directly proportional to the object's momentum. In the sub-material the law of conservation of momentum, students who experience misconceptions caused by preconceptions assume that the momentum of an object is only influenced by mass and speed without paying attention to the direction of the momentum. In the sub-material of the law of conservation of momentum and energy in collisions, students whose misconceptions are caused by incomplete understanding assume that every collision that has a coefficient of restitution value must be a perfectly elastic collision. In the sub-material on the comparison of momentum and kinetic energy, students who have misconceptions about associative thinking experience errors in understanding the equation where students assume that the equation for the law of conservation of momentum is $m_1 \times v_2 = m_2 \times v_1$. In the impulse sub-material, students' misconceptions caused by humanistic thinking assume that the longer the contact time at impact, the greater the impulse value. A more detailed of the misconceptions experienced by students is presented in the Table 6.

Table 6. Misconception Experienced by Students

Subject Matter	Misconception	Scientific Conception
Linear Momentum	Students assume that momentum is affacted by object volume.	Momentum is a difficulty of stopping an object; in this case, momentum is the product of mass and speed.
	Students assume that momentum is affacted by density.	
	Students assume, when mass and velocity changes that are must produce the same momentum value.	To produce the same momentum in two different condition, it is necessary that the product of the mass and velocity be the same.
	Students assume, momentum is inversely proportional to mass and speed.	
	Students assume that momentum only in colliding objects.	Momentum occurs in all moving objects and particles.
Conservation Momentum's Law	Students assume that gravity has a full effect on momentum.	Momentum is tied to the mass value of an object that has speed.
	Students assume, amount of momentum not affacted by differences speed.	
	Students assume, amount of momentum not affacted by differences mass.	
	Students assume, momentum has the same direction.	The direction of momentum corresponds to the direction of speed.
Conservation Momentum's Law and Collision Energy	Students assume, in a elastic collision there is kinetic energy transferred.	In a perfectly elastic collision isn't kinetic energy changed.
	Students assume, a elastic collision makes two objects move in the same direction at the same time.	Elastic collision between a moving object and a stationary object will cause the moving object to occupy the initial potition of the stationary object, and the total momentum of the moving object will be transferred to the stationary object.
	Students assume that an object was hits the floor will bounce further after the collision.	The collision of an object on the floor is a partially elastic collision, object was hits the floor will bounce lower than initial position.
Comparison of Momentum and Kinetic Energy	Students assume, kinetic energy and momentum will be of greater value if the mass of the object is heavier.	Kinetic energy and momentum are affacted by speed and mass but with different functions.
	Students assume, momentum and kinetic energy have the same value.	
	Students assume, momentum is only affected by the mass of the object, while kinetic energy is not affected by mass	
	Students assume, that kinetic energy isn't measured using mass nor endeavors in the system.	Kinetic energy in a system is measured half the product of mass and the speed square, or attention to the endeavors in the system.
	Students assume, conservation momentum's law is the product of the mass a by the speed b which is equal to the mass b multiplied by the speed a.	conservation momentum's law is the product of the mass a by the speed a which is equal to the mass b multiplied by the speed b.
Impulse	Students assume, impulse isn't affected by mass.	Impulse is the product of mass and instantaneous acceleration and time interval.
	Students assume, impulse is only affected by mass.	
	Students assume, the longer contact time, has the greater impulse.	To increase the impulse value, it can be shortening the contact time.
	Students assume, with controlling the speed to remain constant, it can produce a strong collision.	
	Students assume, impulse is a condition where differences in momentum.	Impulse is the force of an object hitting another object. In other words, impulse is alteration in momentum.

In general, the causes of misconceptions among students are presented in Table 7.

Table 7. Causes of Misconceptions in Students

Causes of Misconception in Students

1	2	3	4	5
19.69%	28.56%	13.04%	20.86%	17.84%

Based on the data revealed in Table 6, it can be seen that the causes of misconceptions experienced by students are dominated by humanistic thinking at 28.56%. Based on the categorization of students' conceptions in Table 1, 19.93% of students experienced false positives and 17.39% experienced misconceptions. Therefore, it can be stated that the cause of misconceptions is also dominated by false positives [19-22].

Conclusion

The quality four-tier diagnostic test instrument with CRI momentum and impulse based on theoretical validity reached 89.29% in the very valid category. It was found that the percentages of FP and FN were 6.93% and 6.53%, respectively, of which both False had a percentage of <10% so that the instrument could be declared valid in terms of empirical content validity. Using a significance level of 0.05 was found r_{table} = 0.273, so that from the 15 questions presented, 12 questions were empirically valid constructs. Based on reliability, the r_{11} value is equal to 0.475, and it can be stated that $r_{11} > r_{table}$ so that the instrument is declared reliable. The profile of the causes of misconceptions of MAS Muhammadiyah 1 Paciran students was measured using a four-tier diagnostic test instrument with CRI momentum and impulse assisted by JotForm, which had passed the quality test. The results showed that there were 3 students who were in the low misconception category, 14 students were in the medium misconception category, and 6 students fall into the high misconception category. In addition, it was found that the causes of students' misconceptions were dominated by false positives and humanistic thinking at 28.56%.

References

[1] Didik, Lalu A., & F. Aulia. (2019). Analisa Tingkat Pemahaman dan Miskonsepsi pada Materi Listrik Statis Mahasiswa Tadris Fisika Menggunakan Metode 3-Tier Multiple Choices Diagnostic. *Phenomenon*, *9*(1), 99–112.

[2] Suparno, Paul. (2013). *Miskonsepsi dan Perubahan Konsep Pendidikan Fisika*. Jakarta: PT. Grasindo.

[3] Mulyastuti, H., W. Setyarsih., & M. N. R. Jauhariyah. (2016). Profil Reduksi Miskonsepsi Siswa Materi Dinamika Rotasi Sebagai Pengaruh Penerapan Model Pembelajaran ECIRR Berbantuan Media Audiovisual. *Jurnal Inovasi Pendidikan Fisika (JIPF)*. *5*(2), 82-84.

[4] Saputri, L., Maison, & W. Kurniawan. (2021). Pengembangan *Four-Tier Diagnostic Test* Berbasis *Website* untuk Mengidentifikasi Miskonsepsi pada Materi Suhu dan Kalor. *Jurnal Ilmiah Teknologi Informasi Asia*, *15*(1), 61-68.

[5] Gurel D. K., A. Eryilmaz, & L. C. McDermott. (2015). A Review and Comparison of Diagnostic Instruments to Identify Student's Misconceptions in science. *Erusia Journal of Mathematics, Science & Technology Education*, *11*(5), 989-1008.

[6] Hanum, A., Maison, & W. Kurniawan. (2021). Pengembangan Instrumen Miskonsepsi Materi Usaha dan Energi pada SMA menggunakan Aplikasi Dreamweaver Berbasis Web. *Edumaspul – Jurnal Pendidikan*, *5*(1), 222-229.

[7] Zayyinah., Fatimatul, M., & Irsad R. (2018). Identifikasi Miskonsepsi Siswa SMP dengan *Certainty of Response Index* (CRI) pada Konsep Suhu dan Kalor. *Prosiding Senco: Pendidikan IPA*, 78-89.

[8] Jannah, Emita M., & Frida U. Ermawati. (2019). Validitas dan Reliabilitas Instrumen Tes Diagnostik Berformat *Four-Tier* untuk Materi Dinamika Rotasi dan Kesetimbangan Benda Tegar. *Inovasi Pendidikan Fisika*, *08*(02), 560-564.

[9] Fenditasari, K., Jumadi, E. Istiyono, & Hendra. (2020). Identification of misconceptions on heat and temperature among physics education students using four-tier diagnostic test. *Journal of Physics: Conference series*, 1407 012055.

[10] Cheung, L. (2016). Using the ADDIE Model of Instructional Design to Teach Chest Radiograph Interpretation. *Journal of Biomedical Education.* 1–6.

[11] Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif, & RnD*. Bandung: Alfabeta.

[12] Hestenes, D., & Halloun, I. (1995). Interpreting the Force Concept Inventory: A Response to March 1995 Critique by Huffman and Heller. *The Physics Teacher*, 33, 502-506.

[13] Riduwan, & Akdon. (2013). *Rumus dan Data dalam Analisis Statistika*. Bandung: Alfabeta.

[14] Rokhim, D. A., S. Rahayu., & I. W. Dasna. (2023). Analisis Miskonsepsi Kimia dan Instrumen Diagnosisnya: Literatur Review. *Jurnal Inovasi Pendidikan Kimia*, *17*(1), 23-34.

[15] Putri, R. E., & H. Subekti. (2021). Analisis Miskonsepsi Menggunakan Metode *Four- Tier Certainty Of Response Index:* Studi Eksplorasi Di SMP Negeri 60 Surabaya. *Pensa E-Jurnal: Pendidikan Sains*, *9*(2), 220-226.

[16] Ulfah, Siti & H. Fitriyani. (2017). Certainty of Response Index (CRI): Miskonsepsi Siswa SMP pada Materi Pecahan. *Seminar Nasional Pendidikan, Sains dan Teknologi*. ISBN: 978-602-61599-6-0.

[17] Ilhamdi, M. L., Rahmani, A. V., & Syazali, M. (2022). Analysis of misconceptions of senior high school students on biodiversity materials, interactions, and their role in nature. *Jurnal Pijar Mipa*, *17*(6), 764-769.

[18] Rahmi, S., & Azra, F. (2023). Description of student learning difficulties in the thermochemistry. *Jurnal Pijar Mipa*, *18*(5), 736-742.

[19] Zia, R., Dewi D., & Zainuddin Z. (2022). Identifikasi Miskonsepsi Peserta Didik Menggunakan *Four-tier Diagnostic Test* pada Materi Impuls Momentum di MAN Kabupaten Banjar. *Seminar Nasional Pendidikan Fisika VII*, E-ISSN, 2830-4535.

[20] Prayitno, T. A., & Hidayati, N. (2022). Analysis of Students' Misconception on General Biology Concepts Using Four-Tier Diagnostic Test (FTDT). *IJORER: International Journal of Recent Educational Research*, *3*(1), 1-10.
[21] Thompson, W. B. (2019). Alpha is not the false alarm rate: An activity to dispel a common statistical misconception. *Teaching of Psychology*, *46*(1), 72-79.
[22] Treff, N. R., & Marin, D. (2021). The "mosaic" embryo: misconceptions and misinterpretations in preimplantation genetic testing for aneuploidy. *Fertility and Sterility*, *116*(5), 1205-1211.