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Analysis of Misconceptions of Class X High School Students in Padang City About Newton's Law Material Using Four-Tier Multiple Choice Diagnostic Test

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ABSTRACT

The importance of students' understanding of concepts is crucial for enhancing the learning process and achieving good learning outcomes. However, what often occurs is that students face difficulties in comprehending the material, errors in applying concepts, and even frustration or loss of interest in certain subjects. This research aims to describe students' misconceptions through a four-tier multiple choice diagnostic test on the topic of Newton's laws. This study is a qualitative descriptive research using a four-tier multiple choice test instrument. The research sample includes three public high schools in the city of Padang in the academic year 2023/2024. Sampling was done using simple random sampling, amounting to 25% of the total number of students in each school, resulting in 80 students in this research. Based on the analysis, the highest level of concept understanding experienced by students is in the sub-topic of Newton's Third Law, with an average percentage of 57.3%. Meanwhile, the highest misconceptions experienced by students are in the sub-topics of applications of Newton's Laws I, II, III, with average percentages of 84.6%, 76.3%, and 85% respectively. Furthermore, the highest level of misunderstanding of concepts is in the sub-topic of forces on inclined planes, with a percentage of 40%. Thus, it can be concluded that in the Newton's laws material, there are more students experiencing misconceptions.

Keywords: Misconception analysis, Newton's laws, four-tier multiple choice diagnostic test.

I. INTRODUCTION

One of the sciences that significantly contributes to the advancement of Natural Sciences and Technology (IPTEK) is physics. To engage in physics learning, students need to have critical thinking skills and the ability to assess issues related to natural phenomena, both qualitatively and quantitatively, using physics methodology [1]

Conceptual knowledge refers to the understanding, definition, specific characteristics, components, or parts of an object studied [2]. Students should prioritize conceptual understanding [3] because students form concepts in their heads based on their experiences or the educational process at school [4]. Each student has a unique experience, so they may have accurate or inaccurate ideas about what scientific concepts are [5]. When students misunderstand a concept, it occurs because they experience misconceptions [6].

Misconceptions occur when students interpret a concept differently from physicists [7]. Misconceptions are a learning problem, one of which is associated with the existence of misconceptions. Much current research focuses on misconceptions. According to previous research findings, mechanics is a commonly occurring misconception in physics learning [8]. The Newton's Laws material given to high school students is one of the physics topics that often lead to misconceptions in mechanics. As a result, many students have misconceptions about mechanics

[9]. Misconceptions include incorrect concept understanding, incorrect concept application, misclassification of examples of concept application, different concept meanings, concept confusion, and incorrect concept hierarchies [10].

Misconceptions that arise should not be ignored because they will disadvantage students [11]. Additionally, there is a strong possibility that students who have misconceptions may continue to experience misconceptions about more difficult concepts if left alone [12]. Consequently, it is essential to recognize misconceptions to reduce the likelihood of misconceptions occurring [13]. Research on misconceptions about mechanics is at the forefront of all physics fields, indicating that many people have misconceptions about mechanics, according to an article on Research on Alternative Conceptions in Science [14].

Newton's Laws material is highly relevant to everyday life. Furthermore, Newton's Laws material is fundamental to understanding subsequent materials, including mechanics. However, it is found that many students have misconceptions about Newton's Laws material [15,16]. The Education Assessment (PUSPENDIK) in 2019 shows that the mechanics material is classified as low in X High School Padang with a percentage of 37.33% of students answering correctly [17].

The Three-Tier Test diagnostic test is a diagnostic test consisting of three levels of questions, where the first level (one tier) consists of regular multiple-choice questions or regular questions, the second level (two-tier) consists of reasoning for choosing answers at the first level, and the last level is the third tier (three-tier), which consists of students' confidence based on answers at the first and second levels [18].

The diagnostic test known as the Four-Tier Diagnostic Test is one of the assessments that can be used to detect student misconceptions. This diagnostic test has four levels: at the first level, the answer selection scale is considered correct, at the second level, the confidence scale for the selected answers, at the third level, the scale of reasons for choosing answers from questions, and at the fourth level, the scale of confidence for the reasons selected [19]. Based on the reasons provided by students, this method can identify students who have misconceptions [20].

The implications of this research are expected to serve as information that there are still misconceptions experienced by students regarding Newton's laws and their application. One of the tools that teachers can use to identify these misconceptions is diagnostic tests [21]. The misconceptions data obtained can be used as a reference for teachers to help correct students' misconceptions and explain Newton's laws and their application correctly to students, so that the misconceptions experienced do not continue in students. Through the use of this Four-Tier Multiple Choice diagnostic test, teachers can measure students who truly understand, students who have misconceptions, and students who lack knowledge of Newton's laws and their application.

II. METHOD

This type of research is qualitative descriptive research, aimed at describing students' misconceptions through a four-tier multiple choice diagnostic test on Newton's laws in high schools in the city of Padang. The research sample consists of three schools, namely SMAN X Padang, SMAN Y Padang, SMAN Z Padang. The selection of these schools is based on the ranking of the results of the 2019 UNBK scores with the average scores in the mechanics field ranked 11th, 13th, and 16th, respectively. With each school having accreditation of A. The sample was taken using simple random sampling technique, namely 25% of the total number of students in each school in this study, reaching 80 students.

Table 1. Research Sample

Educational Institutions	Number of Students in Class X Science Stream	Sample Selection (25%)
SMAN X Padang	108	27
SMAN Y Padang	108	27

Educational Institutions	Number of Students in Class X Science Stream	Sample Selection (25%)
SMAN Z Padang	105	26
Amount	321	80

The independent variable in this study is "class X Padang city" which indicates the classes of students who are the subjects of the research. The data collection technique in this study uses diagnostic tests to identify students' misconceptions on Newton's laws material, as well as observations to obtain a deeper understanding of how students approach and comprehend the material. The combination of categories of concept understanding, misconceptions, and lack of concept understanding are presented in Table 2.

Table 2. Combination of Answer Categories on Student Understanding Levels

Answer	Reason	Description	Code
Correct	Correct	Understand the concept well	UC
Correct	Correct	Understand the concept but are not sure	UCAS
Correct	Incorrect	Misconceptions	M
Correct	Incorrect	Don’t know the concept	DKC
Incorrect	Correct	Misconceptions	M
Incorrect	Correct	Don’t know the concept	DKC
Incorrect	Incorrect	Misconceptions	M
Incorrect	Incorrect	Don’t know the concept	DKC

Explanation:

UC = Understand the concept well

UCAS = Understand the concept but are not sure

M = Misconceptions

DKC = Don’t know the concept

Using the following formula to determine the percentage of understanding concepts, misconceptions, and lack of understanding of concepts:

$$Test\ percentage = \frac{Number\ of\ correct\ concepts}{number\ of\ test\ concepts"}$$

III. RESULTS AND DISCUSSION

1. Level of Students' Understanding of Concepts at SMAN X Padang

The graph showing the percentage of diagnostic test results at SMAN X Padang for each level of students' understanding of concepts in each learning indicator can be seen in Figure 3.1.

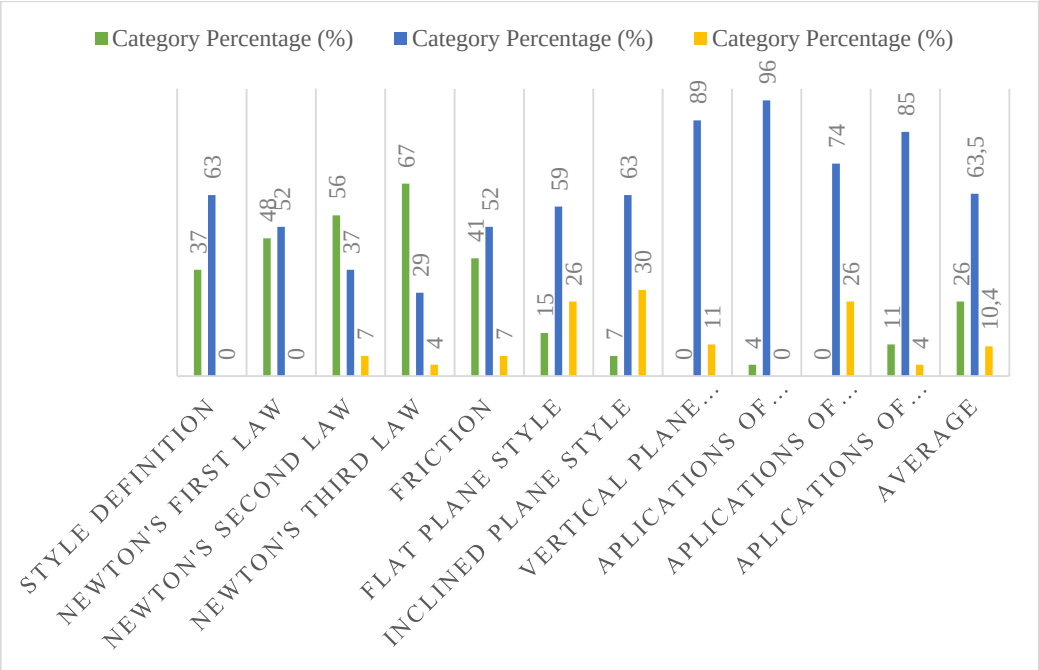

Figure 3.1 Percentage Graph of Student Conceptual Understanding Variation at SMAN X Padang

Based on the graph in Figure 3.1 above, the level of students' understanding of the concepts at SMAN X Padang through the diagnostic four-tier test on Newton's laws shows the highest misconception (M) at 96% in the sub-topic of the application of Newton's first law in everyday life, which is found in question number 9. The highest category of not understanding the concept (DKC) is 30% in the sub-topic of forces on inclined planes in question number 7. The highest category of understanding the concept (UC) is 67% in the sub-topic of Newton's third law, specifically in question number 4.

The written test results regarding Newton's third law show that more students understand the concept compared to those who do not. So, from this school, there are none who do not understand, meaning they are more understanding of the concept, and some experience a high level of misconception.

2. Level of Students' Understanding of Concepts at SMAN Y Padang

The percentage graph of diagnostic test results at SMAN Y Padang for each level of students' understanding of concepts in each learning indicator can be seen in Figure 3.2.

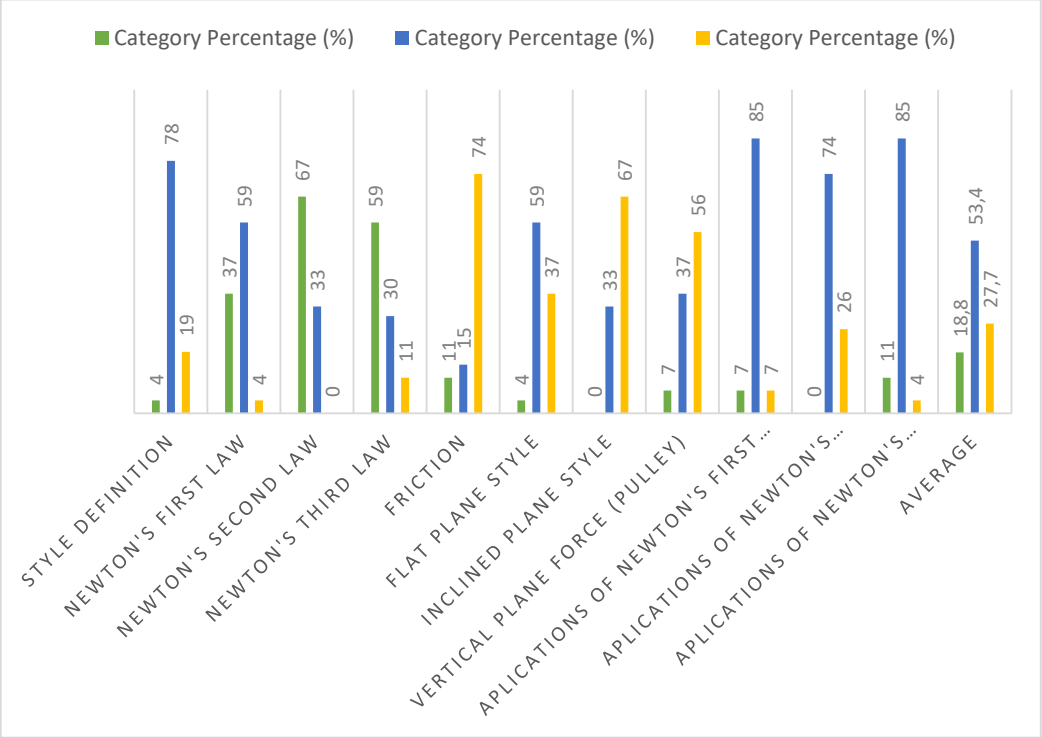

Figure 3.2 Percentage Graph of Student Conceptual Understanding Variation at SMAN Y Padang

Based on the graph in Figure 3.2 above, the results of the diagnostic four-tier test on Newton's laws at SMAN Y Padang reveal the highest misconception at 85% in the sub-topics of the application of Newton's first and third laws in everyday life, which are found in questions number 9 and 11. Meanwhile, the highest category of not understanding the concept (TPK) is 74% in the sub-topic of frictional forces found in question number 5. On the other hand, the category of understanding the concept (PK) shows the highest average at 67% in the sub-topic of Newton's second law, particularly in question number 3.

The written test results regarding the concept of frictional forces show that more students do not understand the concept compared to those who do. So, from this school, many do not understand, meaning few understand the concept, and some experience misconception.

3. Level of Students' Understanding of Concepts at SMAN Z Padang

The percentage graph of diagnostic test results at SMAN Z Padang for each level of students' understanding of concepts in each learning indicator can be seen in Figure 3.3.

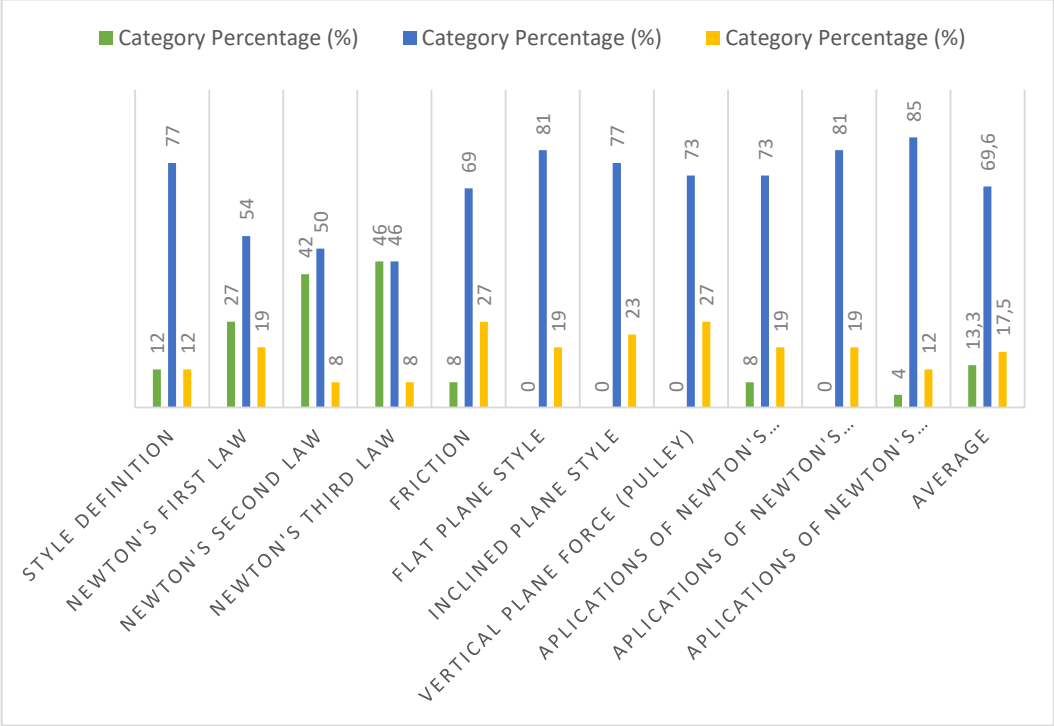

Figure 3.3 Percentage Graph of Student Conceptual Understanding Variation at SMAN Z Padang

Based on Graph 3.3, the results of the Four-Tier Multiple Choice Test diagnostic on Newton's Laws at SMAN Z Padang reveal the highest misconception percentage at 85% in the sub-topic of the application of Newton's third law in everyday life, found in question number 11. The category of not understanding the concept (DKC) has the highest percentage at 27% in the sub-topics of frictional forces and forces acting on vertical surfaces (pulleys), found in questions number 5 and 8. The category of understanding the concept (UC) has the highest percentage at 46% in the sub-topic of Newton's third law, specifically in question number 4.

The written test results regarding Newton's third law show that more students understand the concept compared to those who do not. So, from this school, many understand, meaning few do not understand the concept, and some experience misconception.

IV. CONCLUSION

Based on the analysis conducted, it is concluded that there are many misconceptions regarding the topic of Newton's laws. The misconceptions found include concepts related to the definition of force, Newton's first law, Newton's second law, Newton's third law, frictional forces, forces on flat surfaces, forces on inclined planes, forces on vertical surfaces (pulleys), applications of Newton's first law, applications of Newton's second law, and applications of Newton's third law. It can be concluded that students' understanding of concepts is more dominantly categorized as misconceptions in the topic of Newton's laws.

Based on the research findings obtained, the researcher suggests that further efforts should be made to address students' misconceptions regarding the application of Newton's laws in everyday life, such as in the development of teaching materials and learning media, as well as the determination of teaching methods to reduce students' misconceptions as a tool for physics teachers in conducting the learning process.

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REFERENCES

[1] Sulastiani, S., Nurhayati, N., & Kauseng, A. "Analisis Keterampilan Proses melalui Metode Eksperimen dalam Pembelajaran Fisika pada Siswa Kelas VIII SMP Negeri I Makassar". Jurnal Sains dan Pendidikan Fisika, vol. 8,no. 3, 2012.

[2] Kamaluddin, H., & Fihrin, H. "Analisis Pemahaman Konsep Gerak Lurus pada Siswa SMA Negeri di Kota Palu". JPFT (Jurnal Pendidikan Fisika Tadulako Online), vol. 4, no 3, pp. 1–3, 2016.

[3] Cepni, S., Ulger, B. B., & Ormanci, U. PreService Science Teachers' Views Towards the Process of Associating Science Concepts with Everyday Life. Journal of Turkish Science Education, vol. 14, no. 4, pp. 1–15, 2017.

[4] Gurel, D. K., Eryilmaz, A., & McDermott, L. C. A Review and Comparison of Diagnostic Instruments to Identify Students' Misconceptions in Science. Eurasia Journal of Mathematics, Science and Technology Education, vol. 11, no. 5, pp. 989– 1008, 2015.

[5] Samsudin, A., Fratiwi, N., Amin, N., Wiendartun, Supriyatman, Wibowo, F., Faizin, M., & Costu, B. Improving Students' Conceptions on Fluid Dynamics Through Peer Teaching Model with PDEODE (PTM-PDEODE). Journal of Physics: Conference Series, vol. 1013, no. 1, pp. 1–7, 2018.

[6] Annisa, R., Astuti, B., & Mindyarto, B. N. Tes Diagnostik Four Tier untuk Identifikasi Pemahaman dan Miskonsepsi Siswa pada Materi Gerak Melingkar Beraturan. Jurnal Pendidikan Fisika Dan Keilmuan (JPFK), vol. 5, no. 1, pp. 25–32, 2019.

[7] Fariyani Q, et al. Pengembangan Four-Tier Diagnostic Test Untuk Mengungkap Miskonsepsi Fisika Siswa SMA Kelas X. Jurnal Universitas Negeri semarang, vol. 4. no. 2, 2015.

[8] Haris, V. Identifikasi Miskonsepsi Materi Mekanika Dengan Menggunakan CRI (*Certainty of Response Index)*. Ta'dib, vol. 16, no. 1, 2016.

[9] Safriana. S, & Fatmi, N. Analisis Miskonsepsi Materi Mekanika pada Mahasiswa Calon Guru Melalui *Force Concept Inventory dan Certainty of*5 *Response Index*. Jurnal Pendidikan Sains Indonesia, vol. 6, no. 2, pp. 90–94, 2018.

[10] Suparno Paul. 2013. Miskonsepsi dan Perubahan Konsep dalam Fisika. Jakarta: Grasindo.

[11] Lestari, D., Handayani, D., & Darussyamsu, R. Identification Students 'Misconceptions of Class VIII SMPN 21 Padang in the Skeletal Systems of Organism by Using CRI Technique. Atrium Pendidikan Biologi, vol. 4, no. 1, pp 135–142, 2019.

[12] Qurrota, A., & Nuswowati, M. Analisis Miskonsepsi Siswa Menggunakan Tes Diagnostic Multiple Choice Berbantuan CRI (Certainty of Response Index). Jurnal Inovasi Pendidikan Kimia, 2018.

[13] Sheftyawan, W. B., Prihandono, T., & Lesmono, A. D. Identifikasi Miskonsepsi Siswa Menggunakan Four-tier Diagnostic Test pada Materi Optik Geometri. Jurnal Pembelajaran Fisika, vol. 7, no. 2, pp. 147–153, 2018.

[14] Docktor, J. L., & Mestre, J. P. Synthesis of Discipline-Based Education Research In Physics. Physical Review Special Topics-Physics Education Research, vol. 10, no. 2, pp 1554-9178, 2014.

[15] Imre, Kuczmann. Students' Misconceptions in Mechanics and their Manifestation in a Survey. Physics Competitions , vol. 15, pp. 1-2, 2013.

[16] Puspendik. Daftar Nilai Wilayah dan Satuan Pendidikan, 2019.

[17] Syahrul, D. A., & Setyarsih, W. JIPF, vol. 04, no. 03, pp. 67–70, 2015.

[18] *Sugianto, Fariyani, R. A."Pengembangan Four-Tier Dagnostik Test Untuk Mengungkapkan Miskonsepsi Fisika Siswa SMA Kelas X". Journal of Innovative Science Education, vol. 4, no. 2,2015.*

[19] Suryono, Hariyanto. Belajar dan Pembelajaran. Bandung: PT Remaja Rosdakarya Offset, 2011.

[20] Hakim, A. Student Concept Understanding of Natural Products Chemistry in Primary and Secondary Metabolies Using the Data Collecting Technique of Modified CRI. International Online Journal of Educational Sciences, vol. 4, no. 3, pp. 544-553, 2012.

[21] Juita, Z., Sundari, P. D., Sari, S. Y., & Rahim, F. R. Identification of physics misconceptions using five-tier diagnostic test: newton's law of gravitation context. *Jurnal Penelitian Pendidikan IPA*, vol. *9, no.* 8, pp. 5954-5963, 2023.