JIPF (JURNAL ILMU PENDIDIKAN FISIKA)
p-ISSN: 2477-5959 | e-ISSN: 2477-8451 *Vol. 9 No. 3, September 2024, Page 464-473*

Concept Understanding and Causes of Student Misconceptions on Simple Harmonic Motion

Fatni Mufit [1*)], Khofifah Karzah [2]
Universitas Negeri Padang, Indonesia[1,2]
[*)]Corresponding E-mail: fatni_mufit@fmipa.unp.ac.id

Received: April 24th, 2024. Revised: August 13th, 2024. Accepted: August 14th, 2024

Keywords :
Diagnostic Test; Causes of Misconception; Simple Harmonic Motion

ABSTRACT
This study aims to evaluate the profile of students' misconceptions and their causes when learning simple harmonic motion. Five tier multiple choice diagnostic test with 20 questions has been for determination of the misconceptions and their causes. The descriptive method with quantitative approach was used in this exploration. There were 177 high school pupils in the sample data collection for this study. This study used the following sample was a purposive sample, that is high level and low level schools based on the average physics exam scores obtained from physics teachers at the high school level. Overall, students' concept getting to know simple harmonic motion material falls into the low category. The greatest concept understanding is found in high-level schools. Students' misconceptions in physics lessons based on simple material on harmonic motion overall fall into the medium category. The largest misunderstanding occur in high-level schools. Students' misconceptions in learning physics on simple harmonic motion material as a whole fall into the medium category. The biggest misconceptions occur in high-level schools. Where the highest misconceptions are highest in the concept of deviation, velocity and acceleration of simple harmonic motion. The more dominant cause of misunderstanding at both school levels is students' personal thoughts, followed by teachers, the internet, books, and friends.

INTRODUCTION

Physics is one of the scientific fields that play an important role in developing science and technology [1] [2]. Physics is the study of natural phenomenology and cannot be separated from observation and experimentation [2] [3]. Physics basically aims to study and analyse quantifiable understanding of natural phenomena or processes and the nature of substances and their applications. Therefore, physics is closely related to nature so that in studying it, facts, concepts, principles, laws, theories and models that have been formulated by scientists based on their research results from nature are needed [4].

Physics learning at school according to Sari & Mufit [5] is an effort to offer knowledge and abilities to add to the insights that students already know. Purpose of the study of physics at school is that students are be able to cope with the concepts, policies and have the skills to be a leader in the development of knowledge [1] [6]. In this context, according to Setiawati & Jatmiko [7] the goal of physics learning is to develop students' ability to reason in analytical thinking, using physical concepts and principles to explain events in everyday life and to solve problems both qualitatively and quantitatively. Achieving this goal requires a good understanding and correct application of the student's concepts.. Understanding the concept is the main goal in physics learning [8]. Concept understanding is the capacity for understanding facts that exist around and compare with scientific concepts. Koniceck-Moran and Keeley asserted that when learners are able to apply a concept in different situations, use your own words to describe or define it, create a concept model or identify an effective analogy for the concept [9]. Good concept understanding can support physics problem solving [10].

Students' concept understanding is the result of various factors, including is preconceptions or students' first thoughts obtained from the event in the daily environment and the natural events or symptoms that learners witness [11]. In addition, students also gain an understanding of the concept through classroom learning. Learners will be able to build a concept after the learning through the expression of fundamentals you receive learning with the help their initial hypotheses. Students will then synthesise these concepts to understand [5]. For development purposes a mindset to learn physics requires physics concepts that have been embedded in the minds of students. Therefore, the concepts embedded in the minds of learners must be scientifically correct or in other word not misconceptions.

Misconceptions according to Foisy et al [12], is a person's spontaneous scheme of a thought or an idea that is inconsistent with scientific knowledge. When the initial concept that pupils have does not correspond to the concepts of the experts who have guaranteed validity, then in this case students experience misconceptions [8] [13] [14] [15] [16] [17]. Students' misconceptions about physics learning affect their subsequent physics learning [18].

Misconceptions according to Sands [10] and Fajari & Chumdari [19], is due to students' low understandings of the concept. The weak understandings of the concepts are the result of the learning process carried out by the teachers, like teacher centred learning, and the pupils are not involved in finding the contents [19] [20] [21]. Misconceptions that are common in the students, must be detected in order to provide remedial action so that they do not continue and interfere with students' understanding in the next stage of learning [16] [18] [22]. In addition, the causes of misconceptions must also be determined in order to find workable solutions for continued physics education. The use of diagnostic tests can help to identify misconceptions and their causes [15] [23].

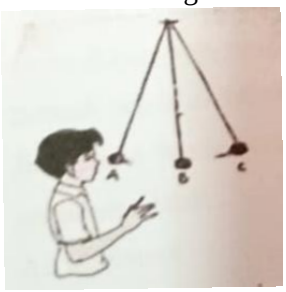
A diagnostic test is a tool that can be used to determine the following and identify pupils' understanding of concepts in a particular lesson [16] [24] [25]. Using concept maps, concepts interviews and other diagnostic tests, you can also find out about learners' misconceptions [26]. Among the three ways, diagnostic testing is a more efficient way to identify misconceptions better than interviewing [16] [27] [28]. Nevertheless, multiple-choice still has weaknesses for example, the answers to questions can be assumed by the student who has no need to understand the topic of the question.

Overcoming of these difficulties, multiple choice tests were developed as a multi-level system tests ranging from one tiered, two tiered, three tiered, four tiered, and more recent developments five tiered tests [29]. The five levels diagnostic the test is an evolution of the four leve diagnostic test in which the fifth level adds a level in the form information sources answers questions and concerns [15]. The development of instruments to determine Student misconceptions about simple harmonic motion material use of a four-step diagnostics tool has been carried out by previous researchers, namely Guswina & Mufit [30]. Based on the problems that were found, this research the goal of the plane analysis of understanding concepts and that causes of student misconceptions in Simple Harmonic Motion.

METHOD

Descriptive exploration with a quantitative approach is research carrsting symptoms, planning the approach, and collecting data in the form of numbers as material for making reports. The methodology used in this study is survey based, where information from respondents is collected using questionnaires. The sample used was 118 students from high level school and 59 students from low level school. Where determination of high level and low level schools was carried out using a purposive sampling technique by looking at the semester exam scores of class X students on harmonious vibration material in each school. So that we get a school with a high level, namely SMA Negeri 1 Lubuk Sikaping and a school with a low level, namely SMA Negeri 1 Dua Koto. The sample used was class XI students from the science department. Where previously they had studied harmonious vibration material in class X. The total sample used from both schools was 177 students. The instrument used in this research is a five tier multiple choice instrument which refers to indicators of competency achievement in the material. The instrument used is also equipped with question-taking instructions which provide things that can and cannot be done while working on the questions. The number of questions used was 20 questions where all the questions had been tested for validity, reliability, level of difficulty and differential power. After the trials were carried out, a validity value of 0.82 was obtained, a reliability value of 0.84, so it can be concluded that this five tier multiple choice instrument can be used. The following is an example of a question used in the five tier multiple choice instrument.

Table 1. Five-tier multiple choice instrument

Tier	Question
1	Look at the image below.  A stone is tied to a string of mass m. If the stone is in position B, the speed of the stone is.…. A. Minimum B. Maximum C. Same at every point D. Same as point A E. Same as point C
2	Confidence in your answer: 1) Certain 2) Uncertain
3	Reason for your answer: A. The speed of an object is minimum at the equilibrium position B. The object's speed is maximum at the farthest point C. The maximum speed of an object at the equilibrium position D. The speed of an object is the same at all points E. The speed of an object does not depend on the position of the object
4	Confidence reasons for your answer: 1) Sure 2) Not Sure

Tier	Question
5	Sources used to answer your questions and reasons: A. Teacher B. Book C. Personal thought D. Friend E. Internet F. Other:……

A five level multiple-choice diagnostic test instrument can be in use to see students' misconceptions regarding simple harmonic motion. Validity, reliability, discrimination and difficulty index of this instrument have been tested. Construct validity results study show that all the following questions are valid. The instrument can be said to be reliable and usable because the instrument reliability test results are in the high category. Results of test the validity of instrument are in the range of 0.43 to 0.71 in the moderate to high category. The reliability test results for tier-I and tier-III are in the very high category, namely 0.90 and 0.84, so they are suitable to be used to evaluate students' understanding the concepts and the causes of the misunderstandings. After using a diagnostic test instrument with five multiple choice levels, student response data was collected. The data was then processed and analyzed with the help of the table.

Tier *I*	Tier *II*	Tier *III*	Tier *IV*	Tier *V*	Conceptual level
				Book	MC-B
				Teacher	MC-T
0	Y	0	Y	Personal thoughts	MC-PT
				Other people's explanation	MC-OPE
				Internet	MC-I
				Book	SU-B
				Teacher	SU-T
1	Y	1	Y	Personal thoughts	SU-PT
				Other people's explanation	SU-OPE
				Internet	SU-I
1	Y	1	TY		
1	TY	1	Y		
1	TY	1	TY		
1	Y	0	Y	Book	PU-B
1	Y	0	TY	Teacher	PU-T
1	TY	0	Y	Personal thoughts	PU-PT
1	TY	0	TY	Other people's explanation	PU-OPE
0	Y	1	Y	Internet	PU-I
0	Y	1	TY		
0	TY	1	Y		
0	TY	1	TY		
				Book	NU-B
0	Y	0	TY	Teacher	NU-T
0	TY	0	Y	Personal thoughts	NU-PT
0	TY	0	TY	Other people's explanation	NU-OPE
				Internet	NU-I
There are levels that are not answered or answer more than one option available					UC

Fig 1. *Categories of conceptual understanding of students on the five tier diagnostic test instrument* [31]

Information:
Misconception (MC), Understand The Concept (UTC), Partial Understanding (PU), No Understanding (NU), Un Coded (UC*)*. from the Book (B*)*, Teacher (T), Personal Thoughts (PT), Other People's Explanation (OPE), Internet (I); 1= Right answer; 0= Answer is wrong; Y=Certain; TY=Uncertain.

Students' answers that are correct on all question tiers and are confident in their answers are categorized as understanding the concept. Students' answers that are incorrect on all question tiers and are confident in their answers are categorized as misconceptions. Students' answers that are incorrect on tiers 1 and 3 and students who are confident and/or unsure on tiers 2 and 4 are categorized as not understanding the concept. Students' answers that are correct on one of the tiers, either tier 1 or tier 3

or on both tiers and students who are confident and/or unsure on tiers 2 and 4 are categorized as partially understanding. While tier 5 is used to analyze the sources of misconceptions experienced by students.

At this point in time, data analysis is performed in percentage form determination of the percentage of students who have concept understand, partially understand it, don't understanding concept, misconceptions, and cannot be coded. It can be processed using the formula:

$$P = \frac{f}{N} \times 100\% \quad (1)$$

P = Respondents' percentages (concept understanding and not understanding the concept, misunderstanding, partial understand, and cannot be coded)
f = Frequency of respondents' responses (number of respondents who understand the concept, do not understand the concept, have misconceptions, partial understanding, and cannot be coded)
N = Number of participants

RESULTS AND DISCUSSIONS

The information obtained using the results of the five tier multiple-choice diagnostic test was analyzed in accordance with the researcher's objectives, namely analyzing about of conceptual understanding and the causes of the misconceptions of the students in learning physics on simple harmonic material at Senior High School. The misconception profile was maintained after grouping pupils' understanding of the concept based on the categories in table 2, namely tier-1 to tier-4. Meanwhile, the causes of misconceptions are analyzed based on tier-5.

Student Misconceptions Profile in Learning Physics Material on Simple Harmonic Motion
Student misconception profiles are displayed in the categories of Understand The Concepts (UTC), partially understand (PU), not understand the concept (NU), misconception (MC), and un coded (UC) for every item. The frequency and percentage of student understanding of each validated indicator in 2 high and low level senior high schools shown in Table 2 below.

Table 2. Mean Percentage of Pupils' Level of Understanding

No	Question Indicator	UTC (%)	PU (%)	NU(%)	MC (%)	UN (%)
1	Understanding concept of simple harmonic motion	22,6	26	13	33,6	4,8
2	Analyze the simple harmonic motion of the pendulum	7,78	36,72	19,9	31,42	4,16
3	Analyzing simple harmonic motion in springs	5,37	29,35	23,57	35,47	6,17
4	Analyze potential energy, kinetic energy and mechanical energy	3,65	24,3	21,85	43,8	6,32
5	Analyzing deviation, speed and acceleration of simple harmonic motion	12,05	16,7	26	45,75	4,5
6	Analyze the relationship between deviation, potential energy, kinetic energy and mechanical energy	3,4	39,53	23,7	29	4,3

The concept of harmonic vibrations in springs is presented by 4 questions, namely questions number 4, 8, 9 and 16. The indicator for question number 4 is comparing the increase in length of two springs. The level of thinking ability in question number 4 is C5. The indicator for question number 8 is

analyzing the direction of the force acting on the spring with a level of thinking ability at C4. The indicator for question number 9 is analyzing discourse regarding events that experience harmonic motion events to determine the total constant value. The indicator for question number 16 is analyzing the relationship between deviation and angular frequency, vibration frequency, and spring period with a thinking ability level of C4.

Students experience misconceptions on all the questions proven. In simple harmonic motion, the most common misconceptions among students were 101 out of 177 samples related to the concepts of potential energy, kinetic energy, and mechanical energy. Based on Table 2 above, we see that the average percentage of students who experience the most misunderstandings is in the concepts of deviation, speed and acceleration in simple harmonic motion, namely 45.75%. Meanwhile, average percentage of Student experience least misunderstanding was in the concept of the relationship among deviation and potential energy, kinetic energy and mechanical energy, namely 29%.

Simple Harmonic Motion

The concept of a simple harmonic motion in this five tier multiple-choice test diagnostic instrument is composed of 2 questions, namely item 1 and item 2. The following are the percentage results of students' concept understanding in SHS H and SHS L on the concept of simple harmonic motion.

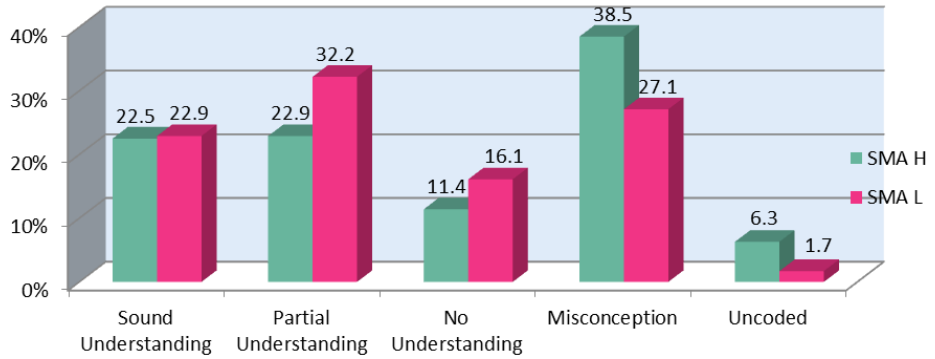


Fig 2. *Percentage results of students' concept understanding in SHS H and SHS L on the concept of simple harmonic motion*

Based on Figure 2 above, students' conceptual understanding at SHS L is higher than at SHS H, where SHS H has a concept understanding percent of 22.5% while SHS L is 22.9%. The percentage of students' misconceptions at SHS H is higher, namely 36.8% compared to SHS L with a percentage of misconceptions of 27.1%. Apart from understanding concepts and misconceptions, students also have understand partially of concepts, do not understand concepts, and cannot be coded. Examples of student responses to the concept of simple harmonic motion can be on view in Figures 3 to 7 below.

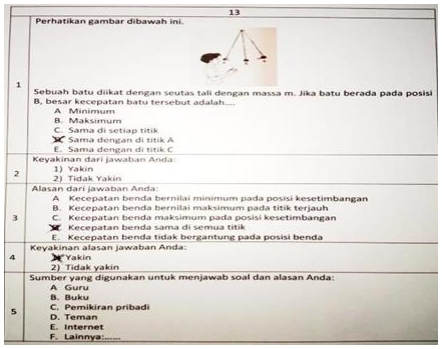


Fig 3. *Student responses that un coded*

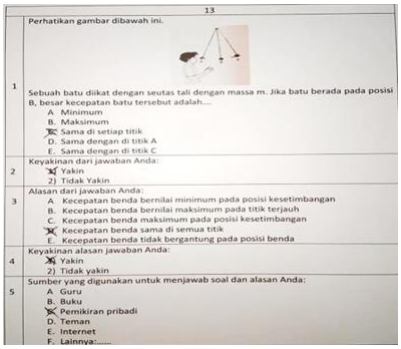
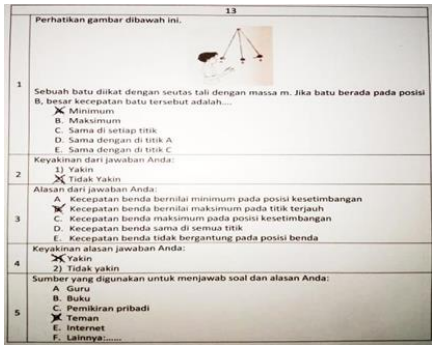


Fig 4. *Responses from students who are experiencing misconceptions*


13

1 Perhatikan gambar dibawah ini.

Sebuah batu diikat dengan seutas tali dengan massa m. Jika batu berada pada posisi B, besar kecepatan batu tersebut adalah....
- ✗ Minimum
- B. Maksimum
- C. Sama di setiap titik
- D. Sama dengan di titik A
- E. Sama dengan di titik C

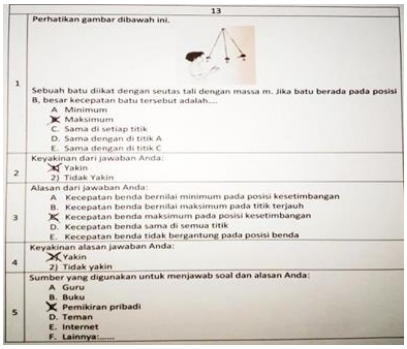
2 Keyakinan dari jawaban Anda:
- 1) Yakin
- ✗ Tidak Yakin

3 Alasan dari jawaban Anda:
- A. Kecepatan benda bernilai minimum pada posisi kesetimbangan
- ✗ Kecepatan benda bernilai maksimum pada titik terjauh
- C. Kecepatan benda maksimum pada posisi kesetimbangan
- D. Kecepatan benda sama di semua titik
- E. Kecepatan benda tidak bergantung pada posisi benda

4 Keyakinan alasan jawaban Anda:
- ✗ Yakin
- 2) Tidak yakin

5 Sumber yang digunakan untuk menjawab soal dan alasan Anda:
- A. Guru
- B. Buku
- C. Pemikiran pribadi
- ✗ Teman
- E. Internet
- F. Lainnya:.....

Fig 5. *Responses from students who not understand the concept*


13

1 Perhatikan gambar dibawah ini.

Sebuah batu diikat dengan seutas tali dengan massa m. Jika batu berada pada posisi B, besar kecepatan batu tersebut adalah....
- A. Minimum
- ✗ Maksimum
- C. Sama di setiap titik
- D. Sama dengan di titik A
- E. Sama dengan di titik C

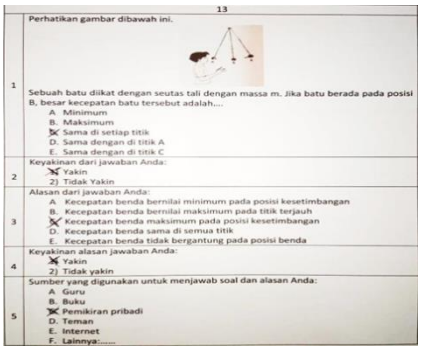
2 Keyakinan dari jawaban Anda:
- ✗ Yakin
- 2) Tidak Yakin

3 Alasan dari jawaban Anda:
- A. Kecepatan benda bernilai minimum pada posisi kesetimbangan
- B. Kecepatan benda bernilai maksimum pada titik terjauh
- ✗ Kecepatan benda maksimum pada posisi kesetimbangan
- D. Kecepatan benda sama di semua titik
- E. Kecepatan benda tidak bergantung pada posisi benda

4 Keyakinan alasan jawaban Anda:
- ✗ Yakin
- 2) Tidak yakin

5 Sumber yang digunakan untuk menjawab soal dan alasan Anda:
- A. Guru
- B. Buku
- ✗ Pemikiran pribadi
- D. Teman
- E. Internet
- F. Lainnya:.....

Fig 6. *Student answers who sound understand the concept*


13

1 Perhatikan gambar dibawah ini.

Sebuah batu diikat dengan seutas tali dengan massa m. Jika batu berada pada posisi B, besar kecepatan batu tersebut adalah....
- A. Minimum
- B. Maksimum
- ✗ Sama di setiap titik
- D. Sama dengan di titik A
- E. Sama dengan di titik C

2 Keyakinan dari jawaban Anda:
- ✗ Yakin
- 2) Tidak Yakin

3 Alasan dari jawaban Anda:
- A. Kecepatan benda bernilai minimum pada posisi kesetimbangan
- B. Kecepatan benda bernilai maksimum pada titik terjauh
- ✗ Kecepatan benda maksimum pada posisi kesetimbangan
- D. Kecepatan benda sama di semua titik
- E. Kecepatan benda tidak bergantung pada posisi benda

4 Keyakinan alasan jawaban Anda:
- ✗ Yakin
- 2) Tidak yakin

5 Sumber yang digunakan untuk menjawab soal dan alasan Anda:
- A. Guru
- B. Buku
- ✗ Pemikiran pribadi
- D. Teman
- E. Internet
- F. Lainnya:.....

Fig 7. *Responses from students who partially understand the concept*

From Figure 3 shows that the student has an respons that cannot be coded. This is caused by incomplete answers from students, these students leave blank answers in Level 2 and Level 5. Figure 4 shows the answers of students who experience misconceptions which can be seen from the students' wrong answers and feeling confident about the wrong answers. Figure 5 shows examples of answers by students who do not understand the concept of the lesson. This can be seen from students' incorrect answers in tiers 1 and 3. Figure 6 shows examples of answers from students who understand the concept. This can be seen from students' correct answers in tiers 1 and 3 and students feel confident in these answers. Next, Figure 7 shows examples of answers from students who partially understand the concept. The students' incorrect answers in Tier 1 prove this and correct in tier 3.

Reasons for misunderstanding in learning physics in Simple Harmonic Motion

Identify the reasons of student misunderstand from Tier 5, where the highest causes of misunderstanding are in the pupils' personal thoughts. Average causes of pupils' misconceptions are shown in the following Figure 8 below.

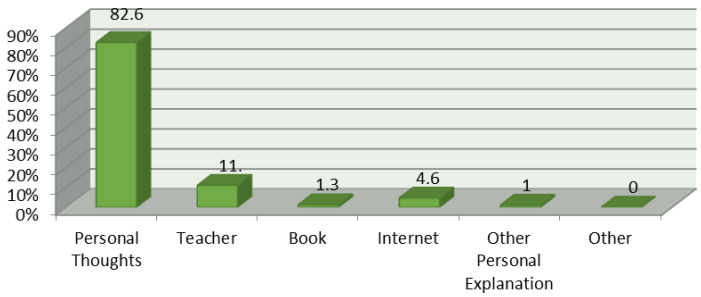


Fig 8. *Causes of Misconceptions in Simple Harmonic Motion*

It can be concluded from Figure 8 above that the highest reasons of misconceptions is personal reflections, namely 82.6%. The second reasons of misunderstanding is teachers, namely 11%.

The biggest cause of misconceptions is the personal thoughts of the pupilts themselves [5] [32]. When learning students assume that one concept is always the same as another concept, this is the source of misconceptions that arise from personal thinking. Students consider terms in everyday life to be the same as terms found in learning [19].

The next cause of misconceptions is teachers. According to research by Fajari & Chumdari [19] and Mufit et al [33], learning methods that focus on teachers are the cause of the misunderstandings and students experience difficulties in the understanding of physics learning. Students receive only concepts and information by the teacher's explanations, and pupils become passive in the process, unable to create physics ideas based on their own experience. Teacher-centered learning also focuses students on memorizing formulas and failing to understand basic concepts Apart from that, students' misconceptions can also be caused by teachers who do not master the concepts correctly. Teachers experience misconceptions about many concepts in science learning [19]. Inappropriate learning models and learning methods used by teachers can give rise to misconceptions in students.

CONCLUSION AND SUGGESTION

The findings of this research suggest that students' overall conceptual understandings are low. Meanwhile, students' misconceptions about learning physics regarding simple harmonic motion are overall categorized as moderate. Where the biggest misconception is in schools with a high level, namely 36.5%. The highest misconception of high school students at higher level is in the concept of deviation, speed and acceleration of simple harmonic motion, namely 48.3%. The highest misconception at low level SHS is about simple harmonic motion in springs, namely 41.95%.

Students' misconceptions come from personal thoughts, teachers, friends, books, and the Internet. The most dominant cause of misconceptions at both school levels is students' personal thoughts, followed by teachers, the internet, books and friends. The research shows that misconceptions occur among students at all levels of schooling, and that most are caused by students' personal thoughts.

Students' personal thoughts are the cause of more dominant misconceptions at both school levels. Therefore, teachers are advised to re-examine students' initial perceptions by designing appropriate learning to overcome low conceptual understanding and correct misconceptions. One model that can overcome misconceptions and low concepts understanding is a conflict cognitive based learning model.

ACKNOWLEDGMENTS

The author is grateful for the support of the school for allowing the author to conduct research at school and the students who were willing to participate in this research.

REFERENCES

[1] Lusiana, & Yohandri. (2020). Validity of student worksheet based on project based learning models assisted by tracker application for simple harmonic motion experiment. In *Journal of Physics: Conference Series* (Vol. 1481, No. 1, p. 012126). IOP Publishing.

[2] Yulkifli, Afandi, Z., & Yohandri. (2018, April). Development of gravity acceleration measurement using simple harmonic motion pendulum method based on digital technology and

photogate sensor. In *IOP Conference Series: Materials Science and Engineering* (Vol. 335, No. 1, p. 012064). IOP Publishing.
[3] Mufit, F., Festiyed, Fauzan, A., & Lufri. (2023). The Effect of Cognitive Conflict-Based Learning (CCBL) Model on Remediation of Misconceptions. *Journal of Turkish Science Education*, *20*(1), 26-49.
[4] Ashar, H., & Hufaini, A. M. F. (2021). Identification of students' concept understanding ability on gas kinetic theory by using certainty of response index (CRI) in class xi SMA negeri 12 makassar. *Al-Khazini Journal: Journal of Physics Education*, *1*(2), 113-119.
[5] Sari, D. R., & Mufit, F. (2023). Students' Misconceptions and the Causes on Straight Motion Materials Using Six-Tier Multiple Choice. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1987-1995.
[6] Sari, A. L. R., Parno, P., & Taufiq, A. Pemahaman Konsep dan Kesulitan Siswa SMA pada Materi Hukum Newton. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *3*(10), 1323-1330.
[7] Setiawati, W. E., & Jatmiko, B. (2018). Penerapan model pembelajaran inkuiri terbimbing untuk meningkatkan pemahaman konsep fisika siswa SMA. *Inovasi Pendidikan Fisika*, *7*(2), 287-291.
[8] Wijaya, T. P., & Mufit, F. (2023, September). The Five-Tier Multiple Choice Instruments in Parabolic Motion for Assessing Concept Understanding of High School Students. In *Journal of Physics: Conference Series* (Vol. 2582, No. 1, p. 012041). IOP Publishing.
[9] Tan, R. M., Yangco, R. T., & Que, E. N. (2020). Students' Conceptual Understanding and Science Process Skills in an Inquiry-Based Flipped Classroom Environment. *Malaysian Journal of Learning and Instruction*, *17*(1), 159-184.
[10] Sands, D. (2014). Concepts and conceptual understanding: what are we talking about?. *New Directions in the Teaching of Natural Sciences*, *10*(1), 7-11.
[11] Rahayu, P., & Hariyono, E. (2019). Profil Penguasaan Konsep Siswa pada Sub Materi Gerak Jatuh Bebas dengan Menggunakan Four Tier Diagnostic Test. *Inovasi Pendidikan Fisika*, *8*(2), 618-622.
[12] Foisy, L. M. B., Potvin, P., Riopel, M., & Masson, S. (2015). Is inhibition involved in overcoming a common physics misconception in mechanics?. *Trends in Neuroscience and Education*, *4*(1-2), 26-36.
[13] Wahyuningsih, A., Astuti, E. S., & Musadieq, M. A. (2013). The Effect of Organizational Learning on Knowledge Management, Capability and Performance of Organization. *Journal of Basic and Applied Scientific Research*, *3*(5), 159-169.
[14] Bayuni, T. C., Sopandi, W., & Sujana, A. (2018, May). Identification misconception of primary school teacher education students in changes of matters using a five-tier diagnostic test. In *Journal of Physics: conference series* (Vol. 1013, No. 1, p. 012086). IOP Publishing.
[15] Isra, R. A, & Mufit, F. (2023). Students' conceptual understanding and causes of misconceptions on Newton's Law. *International Journal of Evaluation and Research in Education (IJERE)*, *12*(4), 1914-1924.
[16] Kirbulut, Z. D., & Geban, O. (2014). Using three-tier diagnostic test to assess students' misconceptions of states of matter. *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(5), 509-521.
[17] Soeharto, S., & Csapó, B. (2021). Evaluating item difficulty patterns for assessing student misconceptions in science across physics, chemistry, and biology concepts. *Heliyon*, *7*(11).
[18] Mufit, F. (2018). *Model Pembelajaran Berbasis Konflik Kognitif (PbKK)*. Universitas Negeri Padang.
[19] Sarwanto, S., Fajari, L. E. W., & Chumdari, C. (2021). Critical thinking skills and their impacts on elementary school students. *Malaysian Journal of Learning and Instruction*, *18*(2), 161.
[20] Puspitasari, R., Mufit, F., & Asrizal, A. (2022). Kepraktisan E-Book Berbasis Konflik Kognitif Menginterasikan Real Experiment Vidio Analysis Untuk Meningkatkan Pemahaman Konsep Siswa. *Jurnal Penelitian Pembelajaran Fisika*, *8*(1), 27-36.
[21] Mufit, F., Hanum, S. A., & Fadhilah, A. (2020, March). Preliminary research in the development of physics teaching materials that integrate new literacy and disaster literacy. In *Journal of Physics: Conference Series* (Vol. 1481, No. 1, p. 012041). IOP Publishing.
[22] Çelikler, D., & Aksan, Z. (2014). Determination of knowledge and misconceptions of pre-service elementary science teachers about the greenhouse effect by drawing. *Procedia-Social and*

Behavioral Sciences, *136*, 452-456.
[23] Özdemir, H., Toraman, Ç., & Korkmaz, G. (2022). Are Academics Satisfied with the Measurement and Evaluation Practices Applied During Emergency Remote Teaching due to COVID-19?. *Educational Process: International Journal*, *11*(4).
[24] Kantahan, S., Junpeng, P., Punturat, S., Tang, K. N., Gochyyev, P., & Wilson, M. (2020). Designing and Verifying a Tool for Diagnosing Scientific Misconceptions in Genetics Topic. *International Journal of Evaluation and Research in Education*, *9*(3), 564-571.
[25] Putra, A. S. U., & Hamidah, I. (2020, April). The development of five-tier diagnostic test to identify misconceptions and causes of students' misconceptions in waves and optics materials. In *Journal of Physics: Conference Series* (Vol. 1521, No. 2, p. 022020). IOP Publishing.
[26] Ali, M. (2019). Analisis miskonsepsi siswa berdasarkan gender dalam pembelajaran fisika dengan menggunakan tes diagnostik two-tier di kotabaru. *Cendekia: Jurnal Ilmiah Pendidikan*, *7*(1), 59-66.
[27] Salsabila, F. N., & Ermawati, F. U. (2020). Validity and reliability of conception diagnostic test using five-tier format for elasticity concepts. *Inovasi Pendidikan Fisika*, *9*(03), 439-446.
[28] Butler, A. C. (2018). Multiple-choice testing in education: Are the best practices for assessment also good for learning?. *Journal of Applied Research in Memory and Cognition*, *7*(3), 323-331.
[29] Anam, R. A. S., Widodo, A., Sopandi, W., & Wu, H. K. (2019). Developing a Five-Tier Diagnostic Test to Identify Students' Misconceptions in Science: An Example of the Heat Transfer Concepts. *Ilkogretim Online*, *18*(3).
[30] Guswina, S., & Mufit, F. (2020). Desain Four-Tier Multiple Choice Test pada Materi Getaran Harmonis untuk Mengidentifikasi Pemahaman Konsep Siswa Kelas X SMA/MA. *Jurnal Penelitian Pembelajaran Fisika*, *6*(2).
[31] Rosita, I., Liliawati, W., & Samsudin, A. (2020). Pengembangan Instrumen Five-Tier Newton's Laws Test (5TNLT) Untuk Mengidentifikasi Miskonsepsi dan Penyebab Miskonsepsi Siswa. *Jurnal Pendidikan Fisika Dan Teknologi*, *6*(2), 297-306.
[32] Fakhruddin, F., Azizahwati, A., & Rahmi, Y. (2012). Analisis penyebab miskonsepsi siswa pada pelajaran fisika di kelas XII SMA/MA Kota Duri. *Jurnal pendidikan matematika*, *3*(1), 87-98.
[33] Mufit, F., Festiyed, Fauzan, A., & Lufri. (2019, October). The application of real experiments video analysis in the CCBL model to remediate the misconceptions about motion's concept. In *Journal of Physics: Conference Series* (Vol. 1317, No. 1, p. 012156). IOP Publishing.