Vol 11 No 1 2025 DOI : 10.24036/jppf.v11i1.6 Page : 127-139
JURNAL PENELITIAN PEMBELAJARAN FISIKA (JPPF)
Journal of Physics Learning Research
ISSN 2252-3014 (Print) | ISSN 2746-8445 (Electronic)

Students' Conceptual Understanding of Measurement Topic in Development of Digital Teaching Materials Based on the Cognitive Conflict Learning Model Using Kodular

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ARTICLE INFORMATION

Received : 2025-03-17
Revised : 2025-03-25
Accepted : 2025-03-26

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KEYWORDS:

Conceptual Understanding, Digital Teaching Material, Cognitive Conflict Learning Model, Kodular

ABSTRACT

Physics learning often challenges students due to the abstract nature of the concepts. Effective teaching methods are needed to improve students' understanding, one of which is the cognitive conflict learning model. This model helps address misconceptions and clarify difficult concepts. This study aims to analyze students' conceptual understanding in developing digital teaching materials using the cognitive conflict model with Kodular on the topic of measurement at SMA Negeri 13 Padang. A descriptive qualitative approach was used, consisting of four stages: distributing questionnaires to physics teachers, developing research instruments, collecting data through observation and the Three-Tier Diagnostic Test, and analyzing students' responses. The subjects were 36 tenth-grade students in phase E3. The results show that 73.87% of students have misconceptions, 22.78% lack a solid understanding, and only 3.35% demonstrate correct understanding. These findings highlight the need for more effective learning models to enhance students' conceptual understanding.

INTRODUCTION

Natural Sciences is a field of study that explores the universe and its contents, encompassing objects, events, and various natural phenomena. Through scientific methods such as observation, experimentation, and theory development, IPA helps humans understand natural phenomena while fostering the creation of life-supporting technologies. One essential branch of IPA is physics. Physics education is characterized by its close association with abstract concepts, which often pose challenges for students to grasp

(Musliman & Kasman, 2022). The challenges faced by students need to be addressed by strengthening their understanding of the basic concepts that serve as prerequisite material in physics learning. Therefore, mastery of these prerequisite materials provides an essential foundation for students to tackle more complex physics problems (Nihayah, 2021).

Conceptual understanding goes beyond merely recognizing or knowing; it encompasses the ability to interpret meanings, accurately apply definitions, and creatively and innovatively develop ideas (Firjon & Raicudu, 2023). Students are not only expected to deeply comprehend information but also to connect it, explain it in detail, and generate new ideas based on their understanding. According to Susanto et al. (2021), conceptual understanding is achieved through skills such as interpreting, translating, concluding, discovering, and presenting problems based on learned concepts. This process enables students to apply concepts deeply and effectively, equipping them to face complex challenges and make better decisions.

Students' conceptual understanding plays a crucial role in determining the success of learning, particularly in physics (Rose & Riki, 2023). Fundamental concepts, such as measurements and physical laws, serve as the primary foundation that students must master to effectively apply theories. This is due to the inherently practical nature of physics, which is closely tied to real-life applications. For instance, Shidik (2020) highlights that a strong conceptual understanding enables students to connect physics principles with various real-world phenomena, such as the mechanisms of simple machines or the functions of modern technology. Therefore, a deep understanding of concepts not only facilitates students' comprehension of theories but also serves as a critical first step toward practical application.

Based on observations conducted at SMA Negeri 13 Padang, it was found that students' conceptual understanding is still relatively low. This indicator is evident from the results of the students' tests in the 2023/2024 academic year, where less than 50% of students were able to achieve the Learning Goal Achievement Criteria. Additionally, based on surveys given to several subject teachers, it was found that students tend to struggle with understanding abstract concepts, particularly in subjects that require analytical skills and application, such as physics. This issue is further exacerbated by the limited use of technology and interactive teaching materials that could help students connect theory with real-life applications.

The low conceptual understanding of physics among students can be influenced by various factors, one of which is the application of inappropriate teaching models and the limited knowledge students have about the basic concepts in physics material (Siahaan et al., 2021). Most of the teaching methods used by teachers still rely heavily on the lecture method, making the learning process monotonous and one-way, which is inadequate in building deep understanding (Puspitasari et al., 2022). As a result, students struggle to connect theory with real-world applications. Additionally, the lack of active student involvement in the learning process is also a major contributing factor. Therefore, it is crucial to adopt a more innovative, interactive teaching model that can provide direct and relevant learning experiences for students.

Sutrio et al. (2020), stated that the cognitive conflict learning model is an effective approach to enhance students' conceptual understanding. The learning process encourages students to discover knowledge independently, making them more active in thinking and working, thus making the knowledge acquired more meaningful. Additionally, this model connects new knowledge with the students' prior understanding, helping them build concepts more deeply. This aligns with Mufit et al. (2019), who explained that the model guides students to recognize their prior knowledge, become aware of misconceptions, and correct them. Therefore, cognitive conflict-based teaching materials not only help address misconceptions but also resolve discrepancies between prior knowledge and new concepts, effectively improving students' conceptual understanding (Yuli & Mufit, 2021).

The cognitive conflict learning model is applied in the form of digital teaching materials developed specifically to support the physics learning process. These digital teaching materials encompass all types of content or learning resources that students can access through digital platforms, as explained by Khair et al. (2022). In its development, the digital teaching materials created using Kodular are systematically arranged following the stages of the cognitive conflict learning model. The goal is to assist students in understanding physics concepts more easily, deeply, and practically, so they can actively engage in technology-based learning. Kodular, as a platform for creating apps without the need for coding, enables the development of applications that can be used free of charge, making it easier for both experienced individuals and beginners who want to create Android apps (Sarita et al., 2021). By using Kodular, the creation of these digital teaching materials becomes more efficient and affordable, supporting the implementation of the cognitive conflict model in more interactive and engaging physics learning.

Several previous studies highlight the importance of innovation in physics education to improve students' conceptual understanding. Arifuddin et al. (2022) developed hands-on activity-based teaching materials that proved effective in enhancing students' understanding of physics concepts through direct experience. However, this study did not utilize the potential of digital technology to support a more flexible and interactive learning process. On the other hand, Riani et al. (2021) developed inquiry-based worksheets (LKS) integrated with Edmodo, which successfully increased digital interaction between students and learning materials. However, this approach did not include the use of the cognitive conflict learning model to systematically identify and address students' misconceptions, which is a significant challenge in physics education.

This study offers novelty by integrating the cognitive conflict model with Kodular-based digital teaching materials, designed to address students' misconceptions and provide interactive content that is relevant to the learning needs in the digital era. The aim of this research is to analyze students' conceptual understanding in the context of physics education, specifically in the topic of measurement. The primary focus of this study is to explore the extent to which students can master basic measurement concepts, such as physical quantities, units, dimensions, uncertainty, and the use of measuring instruments. The analysis is conducted from the perspective of students' conceptual understanding in identifying and applying these concepts through technology-based learning, which facilitates active interaction between students and the material. With this approach, it is hoped that solutions will be found to improve students' conceptual understanding and strengthen their ability to apply physics concepts in real-life contexts.

METHODS

The researcher applies the research and development (R&D) method, which focuses on product development. This approach is adapted using the Plomp development model, which has been proven effective in various educational research studies. The Plomp model (2013) consists of three interconnected main phases. The first phase is preliminary research, aimed at identifying existing problems or needs, as well as designing initial solutions. The second phase is the development/prototyping phase, where prototypes or products are developed based on the findings from the preliminary research and then tested. The final phase is the assessment phase, which is carried out to evaluate the effectiveness of the developed product and determine the next steps for improvement or refinement.

This research focuses on the initial phase of the Plomp development model, which is analysis. This analysis is an essential step in the research process, aimed at examining and interpreting data in depth. During the analysis phase, the needs required for product development are identified. The primary focus of this analysis is to assess students' conceptual understanding, particularly on the topic of measurement within the context of physics learning at SMA Negeri 13 Padang. In this process, the instrument used is a set of test questions. The test provided to the students is in the form of a Three Tier Diagnostic Test, consisting of 10 multiple-choice questions with 5 answer options, the rationale for the answers, and a confidence level.

In data processing and analysis, the steps taken are essential to ensure that the obtained data can provide clear and meaningful information. The first step is data reduction, which aims to filter relevant information aligned with the research objectives. This process involves grouping students' responses based on the interpretation table, making it easier to identify existing patterns or trends. Proper data reduction enables the obtained information to be used more effectively for the next analysis step.

Table 1. Criteria for the Three-Tier Diagnostic Test Answers

First Level	Second level	Third Level	Category
True	True	Sure	Understand the concept
True	False	Sure	Misconception (False Positive)
False	True	Sure	Misconception (False Negative)
False	False	Sure	Misconception
True	True	Not Sure	Guess, lack of confidence
True	False	Not Sure	Don't understand the concept
False	True	Not Sure	Don't understand the concept
False	False	Not Sure	Don't understand the concept

After the data reduction stage, the next step in this research is data presentation. In the presentation stage, the data that has been grouped based on the previously defined categories (concept understanding, lack of concept understanding, pure misconception, False Positive, and False Negative) will be presented in more detail. The data presentation is carried out by calculating the percentage of concept understanding experienced by each student for each item in the Three-Tier Diagnostic Test. This process allows the researcher to visualize how the distribution of students' concept understanding is across each question.

In the conclusion drawing stage, this research summarizes the results of the previous analysis to provide an overall conclusion about students' concept understanding. Based on the calculated percentages, the level of success in students' understanding of measurement concepts in physics can be determined, as well as identifying areas that need improvement. Through this data analysis, it is expected that the research will provide a clear picture of the causes of students' low concept understanding in the topic of measurement and offer recommendations for improving teaching and understanding of the material in the classroom.

RESULTS AND DISCUSSION

Results

The subjects in this study are 36 students from class X phase E3. Based on the analysis of their answers to 10 questions designed to measure their understanding of measurement concepts, using the Three-Tier Diagnostic Test format, it was found that not all students were able to answer all the questions with the "Understand the concept (P)" category. Some students were recorded with results categorized as "Misconception (M)" or even "Don't understand the concept (TP)" on almost every question posed. The visualization of the concept understanding distribution percentages based on the existing indicators can be seen in Table 2:

Table 2. Percentage of Students' Physics Concept Understanding

Indicator	Question number	Percentage (%)		
		P	M	TP
Identifying activities that are part of the measurement process.	1	5.6	88.8	5.6
Identifying and correctly ordering quantities, values, units, and types of quantities based on the given information.	2	8.3	91.7	0
Identifying scalar and vector quantities and distinguishing their characteristics.	3	5.6	58.3	36.1
Determining the dimensions of a physical quantity based on formulas and the relationships between quantities.	4	2.8	61.1	36.1
Determining the appropriate measuring instrument for an object based on size and the level of precision required.	5	5.6	58.3	36.1
Identifying significant figures in a measurement or given data.	6	2.8	66.7	30.5
Applying significant figure rules in calculation of measurement results.	7	0	61.1	38.9
Using scientific notation to express the exact value of a quantity.	8	0	94.4	5.6
Determining measurement uncertainty based on the precision of the measuring instrument used.	9	0	63.9	36.1
Identifying measurement accuracy based on the uncertainty displayed.	10	2.8	94.4	2.8
Average		3.35	73.87	22.78

Table 2 shows the variation in students' understanding of the measurement material on each indicator of the questions provided. This data illustrates how students understand the key concepts in measurement. The understanding can be observed through the differences in results on each tested indicator. Based on the analysis of the research data, there are various levels of understanding visible on each question. In more detail, students' understanding of the measurement material can be outlined as follows:

(1) Identifying activities that are part of the measurement process.

Table 2 shows that the percentage of students' concept understanding is much lower compared to the percentage of misconceptions. This indicates that students' understanding of the concept in the first indicator is very low. Based on Table 2, only 5.6% of students demonstrated correct understanding, while 88.8% experienced misconceptions, and the remaining 5.6% did not understand the concept at all. The answers provided by students show that many experienced misconceptions and lack of understanding related to the concept of measurement. Most students had difficulty choosing the correct reason to define an activity as a measurement. For example, they considered activities like counting the number of marbles based on color as a measurement, whereas in the context of physics, measurement involves comparison with a standard and like unit, such as length, mass, or time. This error may be due to an incomplete understanding of what constitutes proper measurement in physics, which should involve measuring an object against a predetermined unit, not just counting quantities or categories.

(2) Identifying and correctly ordering quantities, values, units, and types of quantities based on the given information.

Table 2 shows that the percentage of students' concept understanding is smaller compared to the percentage of misconceptions. This indicates that students' understanding of the concept in the second indicator is very low. Based on Table 2, only 8.3% of students showed understanding, while 91.7% experienced misconceptions, and 0% did not understand the concept at all. The answers provided by students reveal that misconceptions and lack of understanding occurred regarding the concept of measurement. Students struggled to identify the correct order of quantities, values, units, and types of quantities, as reflected in their choice of incorrect answers. Some students selected wrong answers, such as listing "meter" as a type of quantity, whereas in this context, length is the quantity measured in meters, which is a fundamental quantity. This shows that students have not fully understood the difference between quantities, values, units, and types of quantities in measurement. This lack of understanding could be caused by several factors, such as insufficient foundational knowledge of measurement and related concepts, confusion in distinguishing between units and types of quantities, and difficulties in organizing the correct sequence in measurement. Additionally, the lack of relevant practice and inadequate understanding of basic physics concepts may contribute to these misconceptions.

(3) Identifying scalar and vector quantities and distinguishing their characteristics.

Table 2 shows that the percentage of students' concept understanding is much smaller compared to the percentage of misconceptions. This indicates that students' understanding of the concept in the third indicator is very low. Based on Table 2, only 5.6% of students demonstrated correct understanding, while 58.3% experienced misconceptions, and 36.1% did not understand the concept at all. In the first-tier question, only a small number of students answered correctly, choosing speed, time, and mass as scalar quantities, while the majority selected incorrect answers, such as including velocity or acceleration as scalar quantities. This error reflects a misconception in understanding the difference between scalars and vectors.

In the second-tier question, students' response patterns indicate that many students chose incorrect definitions of scalar quantities. Some students believed that scalar quantities have direction, which is actually a characteristic of vector quantities. For example, many students selected answers stating that scalar quantities have value and direction, or even that they have no value but have direction. This demonstrates a fundamental misunderstanding of the definition of scalars as quantities that only have magnitude and no direction. This error may be caused by students' lack of understanding of basic physical quantity concepts and insufficient emphasis on the unique characteristics of scalars and vectors in their learning. Students tend to generalize that all quantities have direction without understanding the unique property of scalars, which only require magnitude.

(4) Determining the dimensions of a physical quantity based on formulas and the relationships between quantities.

Table 2 shows that the percentage of students' concept understanding is much lower compared to the percentage of misconceptions. This indicates that students' understanding of the concept in the fourth indicator is very low. Based on Table 2, only 2.8% of students demonstrated correct understanding, while 61.1% experienced misconceptions, and 36.1% did not understand the concept at all. In the question, only a small number of students selected the correct answer, which is E $[M][L]^2[T]^{-3}$, while the majority chose incorrect answers, such as $[M][L]^3[T]^{-2}$. This pattern of answers shows that many students struggled to understand the relationship between fundamental quantities and derived quantities, particularly in calculating the dimensions of a physical quantity. This error may be caused by a lack of understanding of how to derive the dimensions of a derived quantity from formulas involving fundamental quantities, such as the quantity of power, which is the product of mass, the square of length, and time raised to the negative third power.

Additionally, in the question asking for the reasoning behind the dimensional notation, many students chose incorrect answers, such as B (Dimensional notation represents a way of writing quantities that shows the fundamental and derived quantities that compose it). This indicates confusion in distinguishing between fundamental and derived quantities, as well as the correct way to express dimensions. This error may stem from a lack of understanding of how to derive the dimensions of a derived quantity from formulas involving fundamental quantities, such as in the case of power.

(5) Determining the appropriate measuring instrument for an object based on size and the level of precision required.

Table 2 shows that the percentage of students' concept understanding is much lower compared to the percentage of misconceptions. This indicates that students' understanding of the concept in the fifth indicator is very low. Based on Table 2, only 5.6% of students demonstrated correct understanding, while 58.3% experienced misconceptions, and 36.1% did not understand the concept at all. In the first-tier question, the correct answer is A (1) and 3), which are the thickness of paper and the thickness of an ID card, suitable objects for measurement with a micrometer screw. However, many students selected incorrect answers, such as B (1) and 4), showing a misunderstanding of the types of objects suitable for measurement using this tool. The micrometer screw is a tool used to measure small or thin objects with high precision, such as the thickness of paper or an ID card, with an accuracy of up to 0.01 mm.

In the second-tier question, students were asked to explain why the micrometer screw is used to measure certain objects. The correct answer is B (The micrometer screw is a tool used to measure the length of small/thin objects, which has a main scale and a noni's scale (rotating sleeve), with an accuracy of 0.01 mm). However, many students selected incorrect answers, such as A (The micrometer screw is a tool used to measure the outer diameter, inner diameter, and depth of objects, with a main scale and a noni's scale (sliding jaws), with an accuracy of 0.01 cm). This misconception reflects confusion in understanding the components and function of the micrometer screw, particularly in terms of accuracy and its proper application. The error may be caused by a lack of understanding regarding the micrometer screw's primary use, which is more suited for measuring the thickness or diameter of small objects with very precise measurements.

(6) Identifying significant figures in a measurement or given data.

Table 2 shows that the percentage of students' concept understanding is much lower compared to the percentage of misconceptions. This indicates that students' understanding of the concept in the sixth indicator is very low. Based on Table 2, only 2.8% of students demonstrated correct understanding, while 66.7% experienced misconceptions, and 30.5% did not understand the concept at all. In the first-tier question testing understanding of significant figures, the correct answer for an event involving significant figures is E (Ana's weight increased to 48.2 kg). This is because the number 48.2 kg comes from a measurement that involves an estimated digit, which indicates the precision of the measurement. Significant figures are obtained from measurements that include both certain and estimated digits, and in this case, the number 48.2 reflects the precision in measuring Ana's weight.

Meanwhile, for other answers, such as A (The men's doubles badminton team from village X won 21-17 against their opponent) or B (Class A won the soccer match 1-0 against Class B in the class meeting), these numbers do not involve significant figures because they come from counting activities that do not involve measurements with a specific level of precision. Similarly, in C (There are 20 tables and 40 chairs in class X), the numbers 20 and 40 are exact numbers obtained from counting objects, not from measurements, and thus cannot be considered significant figures. In the second-tier question, the correct reason is B (Significant figures are obtained from measurements that consist of exact numbers and estimated digits). This aligns with the concept that significant figures come from measurements, which include both exact (certain) and estimated (decimal) digits obtained from the precision of the measuring instrument. Errors in choosing answers to this question could be caused by confusion in distinguishing between numbers derived from measurements and those derived from counting or other non-measuring activities.

(7) Applying significant figure rules in calculation of measurement results.

In Table 2, the percentage of students who understood the concept is much lower compared to those with misconceptions. This indicates that students' understanding of the concept in the seventh indicator is very low. Based on Table 2.0% of students demonstrated correct understanding, while 61.1% experienced misconceptions, and 38.9% did not understand the concept at all. In the first-tier question, the correct answer is D (89.2 m^2). This is due to the significant figures rule in multiplication and division. When calculating the area of land by multiplying two numbers, 10.5 m and 8.5 m, we must pay attention to the number of significant figures in each value. 10.5 m has 3 significant figures, and 8.5 m has 2 significant figures. According to the significant figures rule for multiplication, the result should have the least number of significant figures, which in this case is 2 significant figures. Therefore, the product of 10.5 m × 8.5 m = 89.25 m^2 should be rounded to 89.2 m^2, keeping only 2 significant figures.

In the second-tier question, the correct reason is A (In multiplication and division, the result should have the same number of significant figures as the number with the least significant figures in the calculation). This is consistent with the principle that in multiplication or division, the number of significant figures in the result is determined by the number with the least significant figures among the numbers involved in the calculation. The error in selecting the wrong answer might occur because students may not fully understand the rounding rule for significant figures in multiplication or division. This rule requires identifying the number with the least significant figures among the numbers involved in the operation and adjusting the result accordingly.

(8) Using scientific notation to express the exact value of a quantity.

Table 2 shows that the percentage of students' conceptual understanding is much lower compared to the percentage of misconceptions. This indicates that students' understanding of the concept in this eighth indicator is very low. Based on Table 2, only 0% of students demonstrated correct understanding, while 94.4% experienced misconceptions, and 5.6% did not understand the concept at all. Based on the answers provided, the majority of students (a large number of those who chose answer B) incorrectly converted the value 73.7 μC to scientific notation by answering 0.737×10^{-6} C. The correct conversion should be 73.7×10^{-6} C. This error reflects students' difficulties in understanding how to write numbers in scientific notation, particularly in terms of decimal placement and coefficient adjustment. Many students assume that the number must always be shifted to fall between 1 and 10. However, this is not always necessary if the number is already in the correct form, such as 73.7×10^{-6} C. This mistake may be caused by an incomplete understanding of the rules for writing scientific notation, which require the coefficient to be between 1 and 10, as well as how to correctly convert units from micro (μ) to the base unit (Coulomb).

(9) Determining measurement uncertainty based on the precision of the measuring instrument used.

Table 2 shows that the percentage of students' conceptual understanding is much lower compared to the percentage of misconceptions. This indicates that students' understanding of the concept in this ninth indicator is very low. Based on Table 2, only 0% of students demonstrated correct understanding, while 63.9% experienced misconceptions, and 36.1% did not understand the concept at all. The pattern of students' answers indicates that many had misconceptions and difficulties in determining the measurement uncertainty based on the precision of the measuring instrument used. Most students struggled to understand how uncertainty is determined from the smallest scale of the measuring instrument. For example, many chose incorrect answers, such as calculating measurement uncertainty by using an average of the measurement results or irrelevant formulas. In reality, in physical measurements, the uncertainty is determined by half the value of the smallest scale of the measuring instrument, such as with a micrometer screw gauge, which has a precision up to two decimal places. This mistake may be caused by an incomplete understanding of how to determine uncertainty based on the precision of the measuring instrument used, as well as an inability to distinguish between types of measurements requiring higher precision and those with standard precision.

(10) Identifying measurement accuracy based on the uncertainty displayed.

Table 2 shows that the percentage of students' conceptual understanding is much lower compared to the percentage of misconceptions. This indicates that students' understanding of the concept in this tenth indicator is very low. Based on Table 2, only 2.8% of students demonstrated correct understanding, while 94.4% experienced misconceptions, and 2.8% did not understand the concept at all. The pattern of students' answers indicates that they struggled to interpret measurement data accompanied by uncertainty. Most students made errors in linking uncertainty values with the accuracy of the measurement. For example, they did not realize that the smaller the uncertainty, the greater the accuracy of the measurement. Many chose incorrect reasoning, such as believing that accuracy is only influenced by absolute uncertainty, when in this context, accuracy is more related to relative uncertainty, which, when smaller, increases measurement accuracy. This mistake may be caused by a lack of in-depth understanding of the concept of accuracy in measurement, where accuracy is actually related to how close the measurement result is to the true value, reflected in a smaller relative uncertainty.

Discussion

The comparison of the findings from this study with previous research reveals both similarities and significant differences. A study by Fitriani et al. (2021) at MAN 2 Kota Jambi found that students' understanding was still at a "sufficient" level, with many students struggling to understand physics material due to the perception of physics as a difficult subject. This finding aligns with the results of this study, although with a higher level of misconceptions at SMA Negeri 13 Padang. Another study by Unaenah et al. (2020) highlighted students' difficulties with length measurement due to an abstract approach that did not align with students' way of thinking. This supports the findings of this study that a more concrete and applicable approach can reduce students' misconceptions. The differences found underscore the importance of adjusting teaching methods to improve students' understanding.

The factors influencing students' conceptual understanding of measurement material are diverse, and the analysis of this study's results shows that several key factors play a significant role in the learning process. Research by Winingsih et al. (2023) revealed that students often rely on a "plug and chug" memory-based approach to solve physics problems, indicating a lack of deep conceptual understanding. This was also noted in Joy et al. (2023) research, which highlighted that factor such as interest, student potential, motivation, and the surrounding environment greatly influence learning outcomes. Additionally, the study by Alonzo & Mistades (2021) showed that students' varying learning styles, such as dependence on teacher instructions, preference for group work, or independent learning, can impact learning effectiveness if the teacher's teaching style does not align with students' learning styles. All of these findings indicate that the success of learning, particularly in measurement material, is heavily influenced by an approach that takes individual student factors into account and utilizes flexible teaching strategies.

The misconceptions identified during the analysis of students' understanding of measurement material reveal that many students still struggle with fundamental concepts. Research by Sari et al. (2022) at SMA Negeri 1 Grati found that students often misunderstand the concept of fundamental and derived unit quantities, with a misconception rate reaching 35% on related questions, although the overall misconception rate was 16.5%. A similar issue was found in Manalu’s (2020) study, which recorded misconceptions about the concepts of mass and weight, with a misconception rate of 33.25%. Both studies indicate that students' understanding of physics measurement material still requires more attention, particularly in distinguishing between quantities and units. On the other hand, research by Prabowo & Masithoh (2019) in the Physics & Education field found fewer misconceptions in physics textbooks, though conceptual errors still exist and need to be addressed. The impact of these misconceptions is students' difficulty in understanding more advanced concepts, which will hinder their overall comprehension of physics material. Therefore, there is a need for improvements in teaching methods and a strengthening of basic concept understanding through more concrete learning approaches focused on resolving misconceptions.

The findings of this study have important implications for the development of physics learning strategies, particularly in addressing students' misconceptions about measurement concepts. One approach that can be implemented to improve students' conceptual understanding is the Cognitive Conflict-Based Learning (CCBL) model, which has been proven effective in enhancing understanding and reducing misconceptions (Mufit et al., 2023). The CCBL model consists of four main steps: (1) activating preconceptions and misconceptions, (2) presenting cognitive conflict, (3) concept and equation discovery, and (4) reflection (Defrianti et al., 2021). In addition, the use of digital learning materials assisted by technology, such as applications developed with Kodular (Safitri & Aziz, 2022), can provide a more interactive and engaging learning experience for students, supported by videos, animations, and real-world experiments. The digitization of learning materials can also enhance student engagement with content that is more accessible and easier to understand (Rice & Ortiz, 2021) ; (Brokowski C, 2019). By integrating technology and the cognitive conflict-based learning model, it is expected that students will be able to overcome misconceptions and deepen their understanding of measurement concepts in physics.

In conclusion, this study has shown that students' understanding of physics measurement concepts is still hindered by misconceptions, particularly in distinguishing between fundamental and derived quantities as well as using the correct units. These findings contribute to the existing literature on physics education and provide valuable insights for developing more effective teaching methods, such as the cognitive conflict-based learning model and the use of digital technology. For future research, it is recommended to conduct further experiments with a larger and more varied sample and explore the potential for further development in measurement learning strategies, including the implementation of different teaching models that can be tailored to the individual characteristics of students.

CONCLUSION

Based on the results of the research conducted, students' conceptual understanding of physics measurement material at SMA Negeri 13 Padang is still relatively low. The majority of students, around 73.87%, experience misconceptions in understanding the concepts taught, while only 3.35% of students demonstrate correct understanding as expected. An additional 22.78% of students are recorded as not understanding the concepts well. These findings indicate that the low conceptual understanding and high level of misconceptions require more attention in the use of teaching models. As a solution, a digital teaching material based on the cognitive conflict-based learning model designed using Kodular can enhance the learning experience through interactive multimedia applications that are easily accessible. The integration of learning elements such as animations, videos, and interactive quizzes is expected to facilitate the understanding of physics concepts and improve the quality of learning in schools.

REFERENCES

Alonzo, S. M. D., & Mistades, V. M. (2021). Students' Conceptual Understanding and Problem-Solving of the Work-Energy and Impulse-Momentum Theorems in a Flipped Classroom. *Journal of Physics: Conference Series*, *1882*(1).

Arifuddin, A., Sutrio, S., & Taufik, M. (2022). Pengembangan Bahan Ajar Kontekstual Berbasis Hands on Activity dalam Pembelajaran Fisika untuk Meningkatkan Pemahaman Konsep Fisika Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, *7*(2c), 894–900.

Brokowski C, A. M. (2019). HHS Public Access. *Physiology & Behavior*, *176*(5), 139–148.

Defrianti, R., Mufit, F., Gusnedi, -, & Hidayat, Z. (2021). Design of Cognitive Conflict-Based Teaching Materials Integrating Real Experiment Video Analysis on Momentum and Impulse Materials to Improve Students' Concept Understanding. *Pillar of Physics Education*, *14*(2), 97.

Firjon, N. H. A. H., & Raicudu, M. I. R. (2023). Pemahaman Konsep Peserta Didik Kelas VII Pada Materi Segiempat. Prosiding Seminar Nasional Pendidikan Matematika. *Universitas Mulawarman*, *3*, 82–89.

Fitriani, F., Cantika, L., & Lolita, N. (2021). Analisis Analisis Pemahaman Siswa Terhadap Materi Fisika SMA Besaran, Satuan, dan Pengukuran di Man 2 Kota Jambi. *Cermin: Jurnal Penelitian*, *5*(1), 81.

Joy, E., She, T., & McCrory, A. (2023). Identify Students' Conceptual Understanding of Momentum Material. *Journal Evaluation in Education (JEE)*, *4*(4), 151–155.

Khair, B. N., Ermiana, I., Jiwandono, I. S., & Fauzi, A. (2022). Pendampingan Penyusunan Bahan Ajar Digital Untuk Pembelajaran Daring Bagi Guru SD Negeri 17 Ampenan. *Jurnal Interaktif: Warta Pengabdian Pendidikan*, *2*(1), 40–46.

Manalu, E. (2020). Analisis Miskonsepsi Buku Ajar Fisika SMA Kelas X Pada Materi Pengukuran Dan Besaran. *Universitas HKBP Nommensen*.

Mufit, F., Festiyed, F., A. Fauzan, & Lufri, L. (2019). The Application of Real Experiments Video Analysis In The CCBL Model To Remediate The Misconceptions About Motion's Concept'. IOP Conf. Series: *Journal of Physics*, 1317(1), 012156.

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.

Musliman, A., & Kasman, U. (2022). Efektivitas Model Inkuiri Terbimbing untuk Melatih Kemampuan Berpikir Kritis Siswa Pada Konsep Fisika yang Bersifat Abstrak. *Jurnal Jendela Pendidikan*, *2*(01), 48–53.

Nihayah, E. F. K. (2021). the Management Analysis of Pre-Requirements of Algebra in. *Linear: Jurnal Ilmu Pendidikan*, *5*(1), 26–39.

Prabowo, A. G., & Masithoh, D. F (2019). Analisis Miskonsepsi Besaran dan Satuan Pada Buku Ajar Fisika SMA Kelas X. *Jurnal Sains Edukatika Indonesia* (JSEI), 1(2).

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.

Riani, L., Misdalina, M., & Sugiarti, S. (2021). Pengembangan LKS Berbasis Inkuiri Terbimbing Berbantuan Edmodo Untuk Meningkatkan Pemahaman Konsep Fisika Siswa Kelas X IPA. *Jurnal Penelitian Pembelajaran Fisika*, *12*(1), 90–99.

Rice, M. F., & Ortiz, K. R. (2021). Evaluating Digital Instructional Materials for K-12 Online and Blended Learning. *TechTrends*, *65*(6), 977–992.

Rose Amanda Puri, P., & Riki Perdana. (2023). Analisis Kemampuan Pemahaman Konsep Fisika Peserta Didik SMA Di Bantul Pada Materi Fluida Statis dan Upaya Peningkatannya Melalui Model Pembelajaran Visualization Auditory Kinesthetic. *MAGNETON: Jurnal Inovasi Pembelajaran Fisika UNWIRA*, *1*(2), 93–101.

Safitri, M., & Aziz, M. R. (2022). Bahan Ajar Digital Matematika Berbantuan Kodular. *Duconomics Sci-Meet (Education & Economics Science Meet)*, *2*(January), 93–103.

Sari, A. S. D., Ruslimin.A, Safitri, U. N., & Anam, K. (2022). Analisis Miskonsepsi Siswa pada Materi Pengukuran di SMAN 1 Grati Menggunakan CRI (Certainty of Response Index). *Jurnal Ilmiah Wahana Pendidikan*, *8*(24), 337–342.

Sarita, V. R., Jati, S. S. P., & Ayundasari, L. (2021). Pengembangan Bahan Ajar E-Handout Berbasis Kodular Materi Istana Gebang untuk Pembelajaran Sejarah di SMA Negeri 1 Blitar. *Jurnal Integrasi Dan Harmoni Inovatif Ilmu-Ilmu Sosial (JIHI3S)*, *1*(12), 1265–1276.

Shidik, M. A. (2020). Hubungan antara Motivasi Belajar dengan Pemahaman Konsep Fisika Peserta Didik MAN Baraka. *Jurnal Kumparan Fisika*, *3*(2), 91–98.

Siahaan, L., Agus Kurniawan, D., & Deswalman. (2021). Analisis Pemahaman Konsep Siswa pada Mata Pelajaran Fisika Ditinjau dari Perspektif Guru. *E-Proceeding SENRIABDI 2021*, *1*(1), 107–113.

Susanto, A., Kustati, M., & Eli Yusna, N. (2021). Contribution of Learning Model Student Teams Achievement Division in Understanding Mathematical Concepts. In *International Conference Fakultas Tarbiyah Dan Keguruan Universitas Islam Negeri Imam Bonjol Padang*, 6, 209–215.

Sutrio, S., Makhrus, M., & Larasati, A. (2020). Pengaruh Pendekatan Konflik Kognitif Terhadap Pemahaman Konsep Pada Materi Gerak Lurus. *Experiment: Journal of Science Education*, *1*(1), 1–5.

Unaenah, E., Ardelia, E., Anggestin, T., Ulfi, N., Khoiriyah, S., & Awaliah, S. (2020). Analisis Kesulitan Siswa dalam Menyelesaikan Soal Cerita pada Materi Pengukuran Panjang di Kelas IV. *Bintang: Jurnal Pendidikan Dan Sains*, *2*(1), 83–93.

Winingsih, P. H., Kuswanto, H., Saputro, H., Purwanto, J., Erlangga, S. Y., Purnama, A. Y., Sebastian, R., & Silvia, S. (2023). Analysis of Understanding of Physics Concepts Through Problem Solving Units Review in Free Fall Motion Materials. *Revista Mexicana de Fisica E*, *20*(2), 1–6.

Yuli, F., & Mufit, F. (2021). Disain dan Validitas Bahan Ajar Berbasis Konflik Kognitif Mengintegrasikan Virtual Laboratory pada Materi Optik untuk Meningkatkan Pemahaman Konsep Siswa SMA/MA. *Jurnal Penelitian Pembelajaran Fisika*, *7*(1), 101–112.