Tadris: Jurnal Keguruan dan Ilmu Tarbiyah 10 (2): 623-635 (2025)
DOI: 10.24042/tadris.v10i1.27447

TADRIS: JURNAL KEGURUAN DAN ILMU TARBIYAH
(Tadris: Journal of Education and Teacher Training)
P-ISSN: 2301-7562 | E-ISSN: 2579-7964
ejournal.radenintan.ac.id/index.php/tadris/index

Diagnostic Test Development for Uncovering Student Misconceptions in Mechanical Wave Characteristics Topic

Aneu Siti Nurohmah[1]*, Achmad Samsudin[1], Heni Rusnayati[1], Mustafa Sozbilir[2]
[1]Department of Physics Education, Universitas Pendidikan Indonesia, Indonesia
[2]Department of Chemistry Education, Atatürk University, Turkiye

Article History:
Submitted: May 19th, 2025
Revised: September 3rd, 2025
Accepted: November 12th, 2025
Published: December 29th, 2025

Keywords:
Construct validity,
Diagnostic test,
Mechanical wave characteristics,
Rasch model,
Reliability

***Correspondence Address:**
aneusnr@upi.edu

Abstract: High school students have studied the characteristics of mechanical waves, including definitions, types, physical quantities, and properties of waves. However, many students still hold misconceptions about these concepts. This study aims to describe the validity and reliability of the Four-Tier Mechanical Wave Characteristics (FTMWC) diagnostic test instrument, developed to identify misconceptions among high school students regarding mechanical wave characteristics. The FTMWC was created through development research using the 4D model (Define, Design, Develop, Disseminate). The study involved 112 grade XI high school students who had already studied mechanical waves and were selected using purposive sampling. The instrument was analyzed using the Rasch Model with Winsteps software version 3.73. The validity of the FTMWC instrument was confirmed based on item dimensionality. The construct validity yielded a Cronbach's Alpha value of 0.61, indicating that the instrument sufficiently explains the interaction between participants and items. The item reliability was found to be 0.95, categorized as "very high." Conceptual analysis using Wright maps and Guttman scalograms revealed that the most common misconception was related to constructive interference in the sub-concept of wave properties. In conclusion, the FTMWC instrument is valid and reliable for assessing students' conceptions and identifying misconceptions about mechanical wave characteristics.

INTRODUCTION

Understanding concepts in physics education is key to applying physics in everyday life (Sulman et al., 2021). When students can apply their knowledge in new situations, they are considered to have a good understanding of the concept. Previous research reveals that students' mastery of physics material is not yet optimal (Adriana Sari et al., 2021), and misconceptions often arise that can influence students' reasoning patterns in the future (Samsudin, Afif, et al., 2021; Suhandi et al., 2020). In practice, students still have difficulty understanding physics concepts, resulting in differences between the concepts held by students and those accepted by physicists or scientific communities (Gressianita et al., 2024).

Misconceptions can lead to difficulties for students when faced with learning materials containing basic scientific concepts (Erna et al., 2020). This is because the basic concepts contradict scientific concepts (Samsudin et al., 2025). Student misconceptions can be caused by several factors, such as teaching methods, school facilities and infrastructure, and the use of media and learning models that are overly teacher-

© 2025 URPI Faculty of Education and Teacher Training
Universitas Islam Negeri Raden Intan Lampung

centered (Samsudin et al., 2024). Mechanical waves are studied in school as an introduction to sound and light waves. The concepts studied in mechanical waves include the definition of waves, types of waves, physical quantities of waves, and properties of waves.

Many students find physics concepts difficult to understand, such as the concept of waves. Previous studies have shown that students have many misconceptions about wave material (Mufida et al., 2024; Mufida et al., 2022; Kurniawan et al., 2023). However, specifically for the material on the characteristics of mechanical waves, which includes the sub-concepts of wave definition, types of waves, physical quantities of waves, and properties of waves, there has been relatively little attention paid to it. Previous research has shown that misconceptions still exist in this material. For example, in the sub-concept of wave definition, students often assume that waves move the particles of the medium through which they pass.

Misconceptions among students can be identified through diagnostic testing as the first step toward addressing them. Misconceptions can be effectively addressed once they have been clearly identified (Herliana et al., 2024). According to Soeharto et al. (2021), several diagnostic test approaches can be used to identify students' misconceptions, such as interviews, concept maps, open-ended questions, and multiple-choice questions. Multiple-choice questions were chosen in this study because they are effective in exploring students' conceptions in depth (Mislawati et al., 2025).

The development of multiple-choice tests has led to various forms, such as two-tier, three-tier, four-tier, five-tier, and even multi-tier diagnostic tests. In this study, the diagnostic test used was the Four-Tier Diagnostic Test (FT-DT). FT-DT consists of four levels: Tier 1 includes multiple-choice questions, Tier 2 adds an additional level of confidence for students in choosing answers from Tier 1, Tier 3 provides an expression of the reasons students gave for choosing their answers in Tier 1, and Tier 4 adds a level of confidence that learners express when explaining their reasons in Tier 3 (Herliana et al., 2024). The diagnostic test developed in this study is called the Four-Tier Mechanical Wave Characteristics (FTMWC).

Although previous studies have identified students' misconceptions in wave material, most of these studies focus on general concepts, such as transverse waves (Mufida et al., 2022; Mufida et al., 2024), stationary waves, or vibrations, without specifically examining the characteristics of mechanical waves, which include the sub-concepts of wave definition, types of waves, physical quantities of waves, and wave properties. Furthermore, the diagnostic instruments used in previous studies were generally two-tier or three-tier tests, which have limitations in revealing students' conceptual reasoning and confidence levels comprehensively. The more diagnostic and in-depth four-tier format is still rarely applied systematically to this topic. On the other hand, although Rasch analysis has been widely used in the validation of educational instruments, its application to assess the quality of four-tier diagnostic instruments for mechanical wave characteristics is still very limited. Therefore, this study aims to fill this gap by developing and validating the FTMWC instrument using the Rasch Model approach, thereby providing empirical contributions to more accurately and deeply identifying students' misconceptions. These findings are expected to serve as a basis for developing more targeted learning strategies to improve students' understanding of physics concepts.

Thus, the purpose of this study is to describe the validity and reliability of the FTMWC diagnostic test instrument used

to identify high school students' misconceptions about mechanical wave characteristics through Rasch model analysis. The research questions that guide this study are as follows: (1) What is the validity and reliability of the FTMWC instrument?; and (2) How are students' conceptions and misconceptions assessed based on the results of the FTMWC instrument trial?

METHOD

Four-Tier Mechanical Wave Characteristics (FTMWC) was developed through the 4D model research and development stages (Define, Design, Develop, Disseminate), first introduced by Thiagarajan et al. in 1974, and has been widely used in previous studies (Samsudin, Rusdiana, et al., 2021; Astuti et al., 2023). In the define stage, a literature review was conducted on types of diagnostic tests that can be used to identify misconceptions, as well as a review on student conceptions, particularly in the subject of mechanical wave characteristics. The design stage involved designing the diagnostic test, including question construction, indicators, and question grids, and creating a four-tier open-ended diagnostic test on mechanical wave characteristics based on the results of the literature review. The development stage involved modifying the diagnostic test from an open-ended format to a closed-ended format, based on the students' reasoning in tier 3 of the first trial, and conducting expert validation. In the final stage, the dissemination stage, trials were conducted with students, and the results were analyzed using the Rasch Model through Winsteps 3.73 software to obtain information about the validity and reliability of the instrument. The Rasch model was chosen to analyze the results of this study because it provides more accurate statistical analysis and can test both student responses and test items simultaneously (Sumintono & Widhiarso, 2014). The Rasch model can also identify items that are unsuitable, which can then be marked and revised, thereby increasing construct validity, enabling assessment scale analysis, and detecting item bias (Aryadoust et al., 2021).

The stages of the 4D development research for the FTMWC instrument are shown in Figure 1.

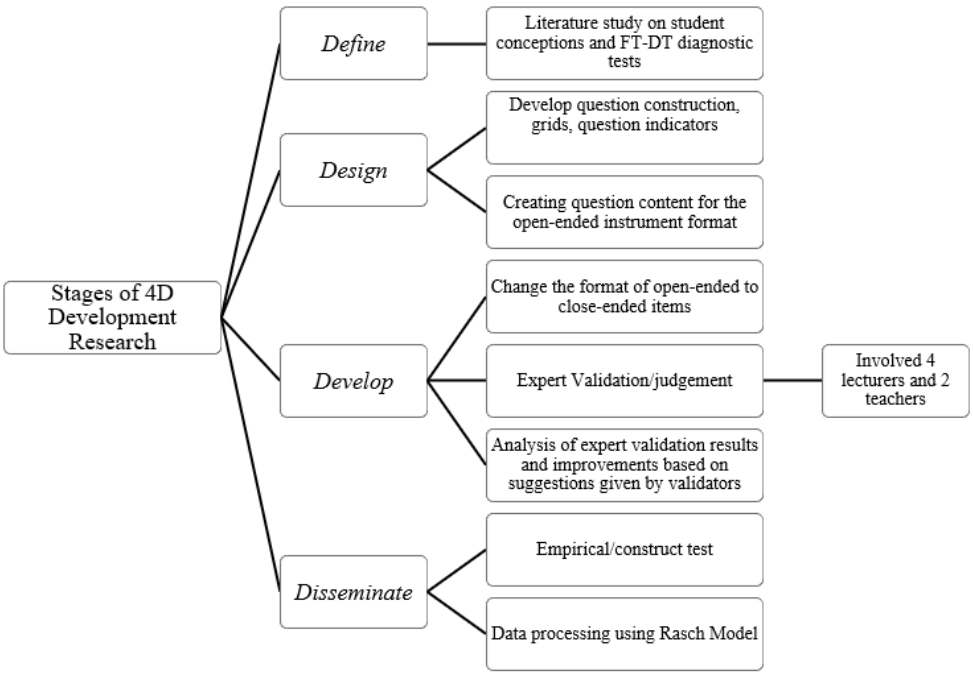

Figure 1. Stages of Research on the Development of the 4D FTMWC Model

Participants

This study involved six experts as validators in the fields of physics, physics education assessment, and misconceptions. Each validator was provided with a validation sheet containing questions and assessment indicators to evaluate the FTMWC instrument. The indicators for each question covered aspects of construction, material, and language. In addition, this study involved 112 grade XI high school students who had already studied mechanical wave material. The students came from a private school in the city of Bandung and were selected using purposive sampling. Purposive sampling is the process of selecting samples according to the researcher's objectives. This technique relies on the researcher's judgment regarding who is eligible to be a sample for the study. Samples are chosen because they are considered to have the information needed for the study (Etikan, 2016).

Instrument

The FTMWC diagnostic test instrument developed consists of seven questions. The questions are presented in various representations, including images, statements, mathematical symbols, tables, and graphs. The FTMWC covers material on the characteristics of mechanical waves, consisting of the sub-concepts of wave definition, types of waves, physical quantities of waves, and properties of mechanical waves.

Data Analysis

The instrument was analyzed using the Rasch Model (Irwandani et al., 2024) with Winsteps software version 3.73, focusing on the Wright map output table, the validity of the instrument from output table 23 (item dimensionality), and the reliability of the instrument from output table 3.1 Summary Statistics. The analysis considered the Cronbach alpha (KR-20) and item reliability values. To interpret a reliable instrument, the following criteria were used.

Table 1. Criteria for Item Reliability, Person Reliability, dan Cronbach Alpha (KR-20)

Criteria Value	Index Value	Interpretation
Item Reliability	$r > 0.94$	Excellent
	$0.91 < r \leq 0.94$	Very Good
	$0.81 < r \leq 0.91$	Good
	$0.67 < r \leq 0.81$	Enough
	$r \leq 0.67$	Weak
Cronbach Alpha (KR-20)	$KR\ 20 > 0.8$	Very Good
	$0.7 < KR\ 20 \leq 0.8$	Good
	$0.6 < KR\ 20 \leq 0.7$	Enough
	$0.5 < KR\ 20 \leq 0.6$	Bad
	$KR\ 20 \leq 0.8$	Poor

The data to be analyzed will first be grouped based on concept categories and scored according to concepts and misconceptions. Student concept categories and concept and misconception scoring based on research (Mufida et al., 2024); (Fratiwi et al., 2024), shown in Tables 2 and 3.

Table 2. Student Conception Categories

Tier	Student Conception Categories																
	SU		PU+						PU-				NU		MC		SU
1	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	
2	S	S	US	US	S	S	US	US	S	S	US	US	S	US	US	S	Incomplete
3	O	O	O	O	X	X	X	X	O	O	O	O	X	X	X	X	answer
4	S	US	S	US	S	US	S	US	S	US	S	US	US	S	US	S	

Description:
SU: Sound Understanding, PU+: Partial Understanding Positive, PU-: Partial Understanding Negative, MC: Misconception, NU: No Understanding, NC: No Coding, O: Correct answer, X: Incorrect Answer, S: Sure US: Unsure.
Tier: 1 (option); 2 (Confidence Level); 3 (Reason); 4 (Confidence Level)

Table 3. Conception and Misconception Scores

Categories	Conception Score	Misconception Score
SU	4	0
PU+	3	0
PU-	1	1
NU	0	3
MC	0	4
NC	-	-

RESULT AND DISCUSSION

The analysis of the development of the FTMWC diagnostic instrument was conducted with reference to the stages of the 4D model, and the results are described in the following sections.

Define

At this stage, a literature study was conducted on diagnostic tests that can be used to identify misconceptions, as well as a literature review on student conceptions, particularly in the material on mechanical wave characteristics. This includes the sub-concepts of wave definition, types of waves, physical quantities of waves, and properties of mechanical waves. Several misconceptions were found in previous studies on the material of mechanical wave characteristics (Mufida et al., 2024; Mufida et al., 2022; Kurniawan et al., 2023).

Design

After conducting the literature review, the researcher proceeded to design a diagnostic test. This included determining the question construction, indicators, and question grid, as well as creating the question content in a four-tier open-ended format. An example of the FTMWC design can be seen in Figure 2. The FTMWC open-ended format consists of four tiers: Tier 1 is a multiple-choice question with five answer options; Tier 2 represents the level of confidence of students in answering the questions in Tier 1; Tier 3 is an open-ended question that allows students to explain their reasoning for selecting the answer in Tier 1; and Tier 4 reflects the level of confidence students have when answering Tier 3. The FTMWC open-ended format is designed to identify students' initial conceptions and provide opportunities for students to express their ideas in Tier 3.

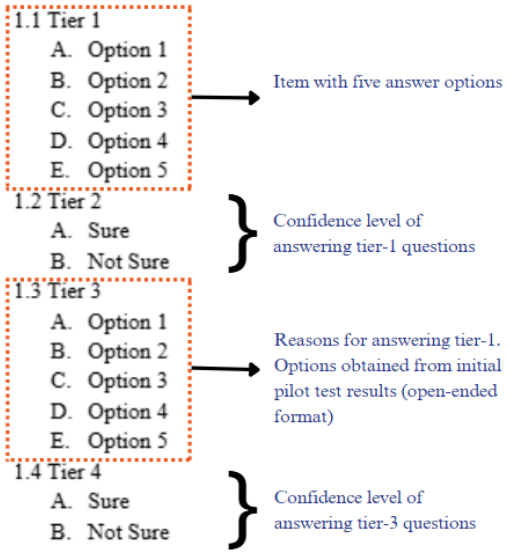

Figure 2. FTMWC Design

Develop

The development stage involves transforming a four-tier open-ended diagnostic test on the characteristics of mechanical waves into a four-tier close-ended diagnostic test. The change to a close-ended format occurred in Tier 3, which was originally an open-ended test but was modified to include five answer

options. These answers were derived from the students' reasoning in Tier 3 of the first trial test. At this stage, expert validation was also carried out. An example of the transformation from a four-tier open-ended diagnostic test to a four-tier close-ended test is shown in Figures 3 and 4.

Expert validation involved four physics education lecturers and two teachers who are experts in physics, physics education assessment, and misconceptions. The aspects assessed on the expert validation sheet included three statements on material aspects, four statements on construction aspects, and two statements on linguistic aspects.

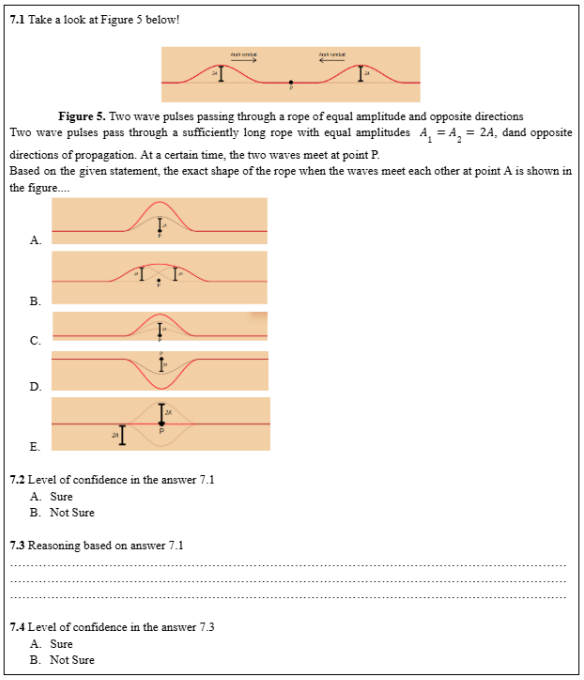

Figure 3. Example of Open-Ended Example

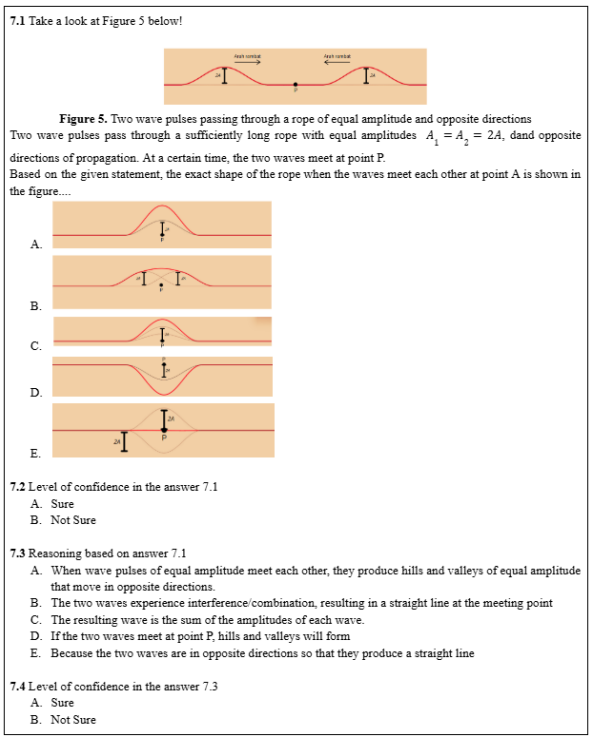

Figure 4. Example of Close-Ended FTMWC

Disseminate

In the final stage, the dissemination stage, testing was conducted with students, and the results were analyzed using the Rasch Model with the help of Winsteps 3.73 software to measure the validity and reliability of the instrument. The purpose of this test was to evaluate students' conceptions and misconceptions regarding the characteristics of mechanical waves. The categories of students' conceptions were then determined based on the references listed in Table 2. Students' conceptions and misconceptions were explained based on the results of the Wright map, the validity of the instrument from item dimensionality, and the reliability of the instrument from Cronbach's alpha and item reliability values.

Findings on Validity, Cronbach Alpha, and Reliability of FTMWC Items

The validity results of FTMWC are observed from the item dimensionality output table. Validity testing is based on the output table of item dimensionality, considering the raw variance explained by measures. The interpretation of the output table is considered fulfilled if the raw variance explained by measures exceeds 20%, categorized as good if above 40%, and very good if it reaches more than 60%. The validity of FTMWC can be seen in Figure 5.

Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)

		-- Empirical --		Modeled
Total raw variance in observations	=	11.4 100.0%		100.0%
Raw variance explained by measures	=	4.4 38.5%		38.1%
Raw variance explained by persons	=	.9 8.2%		8.1%
Raw Variance explained by items	=	3.5 30.3%		30.0%
Raw unexplained variance (total)	=	7.0 61.5%	100.0%	61.9%
Unexplned variance in 1st contrast	=	1.7 15.1%	24.6%	
Unexplned variance in 2nd contrast	=	1.6 13.8%	22.5%	
Unexplned variance in 3rd contrast	=	1.2 10.4%	16.9%	
Unexplned variance in 4th contrast	=	1.1 9.6%	15.6%	
Unexplned variance in 5th contrast	=	.8 6.7%	10.9%	

Figure 5. FTMWC Validity Result

PERSON RAW SCORE-TO-MEASURE CORRELATION = .96
CRONBACH ALPHA (KR-20) PERSON RAW SCORE "TEST" RELIABILITY = .61

SUMMARY OF 7 MEASURED (NON-EXTREME) ITEM

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	225.1	112.0	.00	.07	1.02	-.1	1.03	-.2
S.D.	69.7	.0	.35	.01	.23	1.7	.37	1.3
MAX.	365.0	112.0	.46	.08	1.46	2.7	1.87	2.3
MIN.	135.0	112.0	-.70	.07	.77	-2.3	.69	-2.0

REAL RMSE	.08	TRUE SD	.34	SEPARATION	4.41	ITEM RELIABILITY	.95
MODEL RMSE	.07	TRUE SD	.34	SEPARATION	4.69	ITEM RELIABILITY	.96
S.E. OF ITEM MEAN = .14							

Figure 6. FTMWC Reliability Results

Based on the dimensionality item output table, the raw variance explained by measures value of 38.5% indicates that the criteria are "met," so the FTMWC instrument is declared valid. The reliability of the FTMWC is indicated by the Cronbach Alpha and Item Reliability values, as shown in Figure 6.

Cronbach Alpha shows the interaction between the person and the items on the instrument (Sumintono & Widhiarso, 2014). Based on Figure 6, a Cronbach Alpha value of 0.61 was obtained, which means that FTMWC is an instrument with a "fair" category for measuring the interaction between persons and items. Additionally, Figure 6 shows an item reliability value of 0.95, which can be categorized as "excellent." Item reliability describes the quality of the items in the instrument (Sumintono & Widhiarso, 2014). Therefore, the FTMWC is a reliable or consistent instrument. Based on this analysis, the developed FTMWC can be used in research because it is valid and reliable for all items.

Findings on Students' Conception and Misconception

The conceptions and misconceptions of students were analyzed using Wright maps (Mufida et al., 2024), as shown in Figure 7 and Figure 8. Based on Figure 7, question number 7 was the most difficult, as indicated by the fact that the fewest students answered it, while the easiest question, question number 2, was answered by the most students.

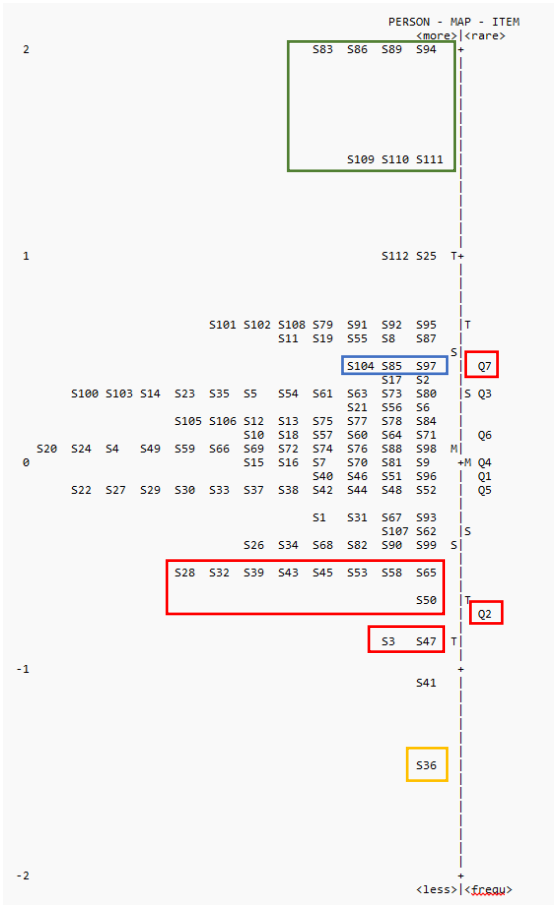

Figure 7. Conception Map

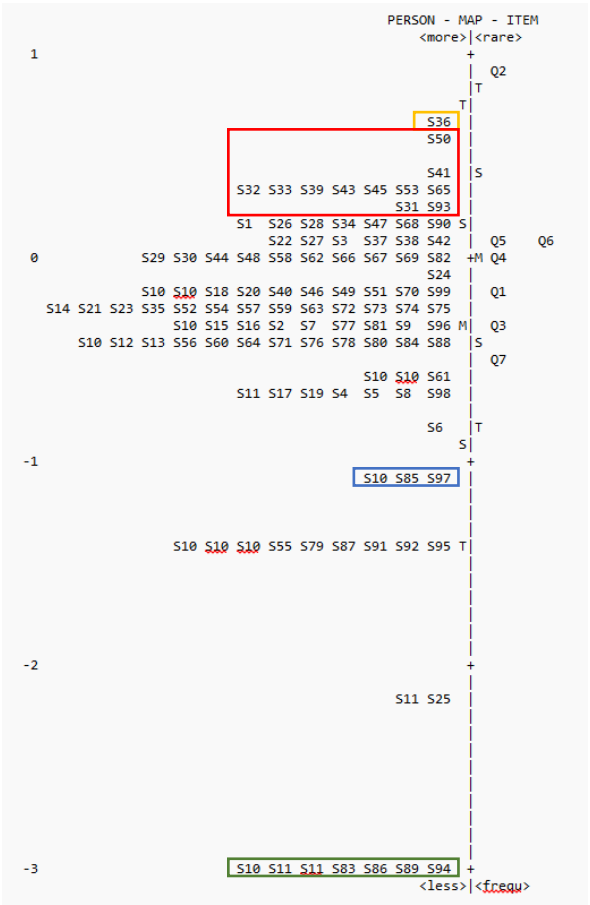

Figure 8. Misonception Map

Based on the concept map, we can analyze students' abilities. There are students who have the potential to demonstrate good understanding, namely

S104, S85, and S97, who can answer almost all questions, whether difficult, moderate, or easy. This is also reflected in the misconception map, which shows that these three students have the lowest potential for misconceptions.

Students with codes S41, S36, S3, and S47 are suspected of having low abilities because they are unable to answer all the questions given. Meanwhile, only S36 has a different low ability because it is outside the two standard deviation limits (T), making it an outlier (extreme ability) (Sumintono & Widhiarso, 2015). An explanation of the extreme abilities of respondents can be found by looking at the scalogram, also known as the Guttman Matrix, which shows a systematic response pattern (Sumintono & Widhiarso, 2015; Rahman et al., 2023; Hamdu et al., 2020). Judging from the scalogram, students with extremely low abilities, namely S36, could only answer questions 2 and 5, which were considered 'easy' questions, obtaining a conception score of 1 out of a maximum conception score of 4 (see Table 3).

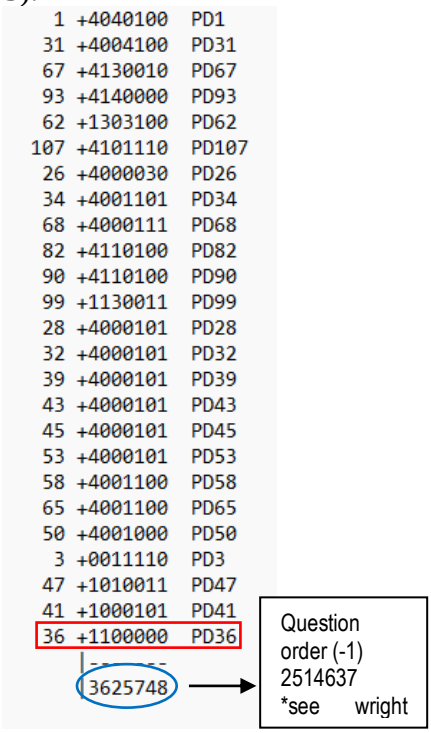

Figure 9. Scalogram of Low Abilities Students

Students with the codes S28, S32, S39, S43, S45, S53, S58, S65, and S50 potentially have low ability and a high potential for misconceptions. This can also be seen in Figure 8, which shows that S50, S41, S33, S32, S39, S43, S45, S53, S65, S31, and S93 fall into this category. Based on this identification, the students who have low ability and are at high risk for misconceptions are 7 students: S32, S39, S43, S45, S53, S65, and S50.

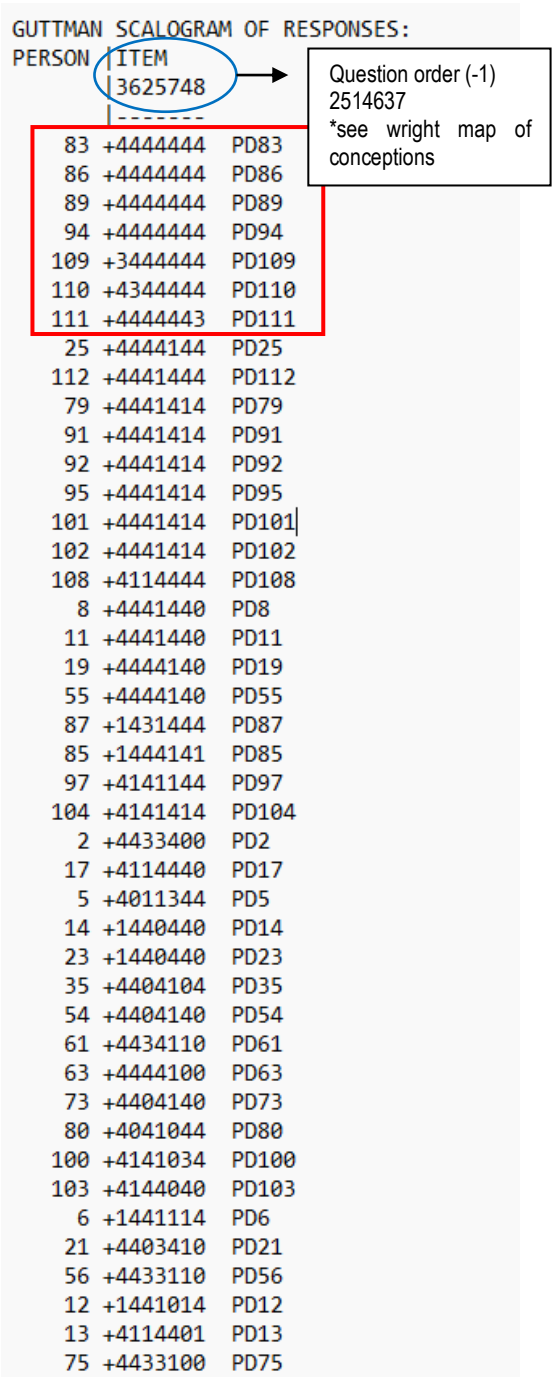

Figure 10. Scalogram of High Abilities Students

In addition, there are 7 students who display extreme high ability because they fall outside the limits of two standard deviations (T), known as outliers (extreme ability). These students, based on Figures 7 and 8, have the codes S83, S86, S89, S94, S109, S110, and S111. According to the scalogram, students with extreme high ability—S83, S86, S89, S94, S109, S110, and S111—could answer all items, ranging from 'difficult' to 'easy' questions, scoring 3 and 4 out of a maximum of 4 (see Table 3).

In the tested FTMWC instrument, the most common misconception is found in question number 7, where students assume that constructive interference causes waves to merge without summing the amplitudes of each wave. Overall, the percentage of misconceptions is presented in Table 4.

Table 4. Percentage of Student Misconceptions on Mechanical Wave Characteristics Material

Q1	Q2	Q3	Q4	Q5	Q6	Q7
29.46%	2.68%	29.46%	15.18%	13.39%	20.50%	45.54%

Q: Question

Students' misconceptions can be caused by several factors, such as teaching methods, school facilities and infrastructure, and the use of media and learning models that are solely teacher-centered (Samsudin et al., 2024). In addition, many misconceptions can be caused by the students themselves (Suhandi et al., 2020; Suprapto, 2020). Misconceptions that arise among students can be identified through various sources, such as students' preconceptions or initial conceptions. Before receiving formal instruction from teachers, many students already have initial concepts, preconceptions, or prior knowledge related to a topic. However, this initial understanding often contains errors. These errors can persist and affect students' understanding in subsequent physics lessons until they are corrected through the learning process. Students' misconceptions can also be identified through associative thinking patterns, humanistic approaches, incomplete or incorrect reasoning, inaccurate intuition, stages of cognitive development, ability levels, and learning interests (Suprapto, 2020; Ayu et al., 2025).

CONCLUSION

The analysis shows that the Four-Tier Mechanical Wave Characteristics (FTMWC) diagnostic test, developed using the 4D model, is valid and reliable. The FTMWC instrument has a validity of 38.5% raw variance explained, indicating good validity. Reliability is demonstrated by a Cronbach Alpha value of 0.61 (sufficient) and item reliability of 0.95 (exceptional), confirming the instrument's consistency in measuring students' conceptions. These findings align with Mufida et al. (2024), which identified high student misconceptions about waves but used different instruments. Unlike previous studies, this research specifically developed and tested a four-tier instrument that assesses students' answers, reasons, and confidence levels, offering a more comprehensive view of their understanding and misconceptions. Analysis of students' conceptions using Wright maps revealed variations in their understanding. Common misconceptions included the concept of constructive interference, where students mistakenly assume waves merge without considering the sum of amplitudes. The FTMWC diagnostic test has important implications for physics education, offering a reliable tool to diagnose misconceptions about mechanical waves. However, this study has limitations, including a small sample size from a single private school in Bandung and a limited number of items in the FTMWC instrument. The close-ended format in Tier 3 may also restrict deeper

exploration of students' reasoning. Future studies with a larger, more diverse sample and a triangulation approach, such as interviews, are recommended.

REFERENCES

Adriana Sari, N. P. E., Santyasa, I. W., & Gunadi, I. G. A. (2021). The Effect of Conceptual Change Models on Students' Conceptual Understanding in Learning Physics. *Jurnal Pendidikan Fisika Indonesia*, *17*(2), 94–105. https://doi.org/10.15294/jpfi.v17i2.27585

Aryadoust, V., Ng, L. Y., & Sayama, H. (2021). A comprehensive review of Rasch measurement in language assessment: Recommendations and guidelines for research. *Language Testing*, *38*(1), 6–40. https://doi.org/10.1177/0265532220927487

Astuti, I. R. W., Samsudin, A., Kaniawati, I., Suhendi, E., & Çoştu, B. (2023). Development and Implementation of a Four-Tier Close-Ended Test to Analyze Students' Misconceptions of Optical Instruments. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *8*(2), 283. https://doi.org/10.24042/tadris.v8i2.13733

Ayu, S. N., Sari, A. A., & Manaasika, Z. (2025). Development of UI/UX based microlearning to prevent misconception in physics learning with computational thinking approach. *SAKAGURU: Journal of Pedagogy and Creative Teacher*, *2*(1). https://doi.org/10.70211/sakaguru.v2i1.206

Christiani, M., Munzil, M., & Yulianti, E. (2021). Identifikasi miskonsepsi materi getaran dan gelombang pada siswa SMP kelas VIII menggunakan three-tier test. *Jurnal MIPA Dan Pembelajarannya*, *1*(4), 304–321. https://doi.org/10.17977/um067v1i4p304-321

Erna, M., Susilawati, S., & Ramadani, R. (2020). Reducing Senior High School Students' Misconceptions through Inquiry Learning Model on Thermochemistry Material. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *5*(1), 43–54. https://doi.org/10.24042/tadris.v5i1.5812

Etikan, I. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11

Fratiwi, N. J., Suhandi, A., Feranie, S., & Linuwih, S. (2024). *Reducing Alternative Conception of Action-Reaction Forces : The Impact of E-Rebuttal Texts After Learning and Over Time*. *9*(2), 321–334. https://doi.org/10.24042/tadris.v9i2.22995

Gressianita, E., Samsudin, A., & Danawan, A. (2024). Implementation of Cooperative Learning Model Three Stay Two Stray Assisted by ARaRaT to Reduce Students' Misconceptions on Fluid Dynamic Material. *Berkala Ilmiah Pendidikan Fisika*, *12*(2), 257. https://doi.org/10.20527/bipf.v12i2.18914

Hamdu, G., Fuadi, F. N., Yulianto, A., & Akhirani, Y. S. (2020). Items Quality Analysis Using Rasch Model To Measure Elementary School Students' Critical Thinking Skill On Stem Learning. *JPI (Jurnal Pendidikan Indonesia)*, *9*(1), 61. https://doi.org/10.23887/jpi-undiksha.v9i1.20884

Herliana, H., Maison, M., & Syaiful, S. (2024). Development and Implementation of a Five-Tier Diagnostic Test to Identify Student Misconceptions on Fractions: A Significant Step Towards Improving

Mathematics Education. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(2), 563–576. https://doi.org/10.22437/jiituj.v8i2.34159

Irwandani, I., Suyatna, A., Haenilah, E. Y., & Maulina, D. (2024). Readiness of Indonesian pre-service science teachers for society 5.0. *Journal of Education and Learning*, *18*(2), 391–402. https://doi.org/10.11591/edulearn.v18i2.21343

Kumalasari, E. D., & Mahmudi, I. (2024). *Analisis Pemodelan Rasch Pada Asesmen Pendidikan* (Issue February).

Kurniawan, F., Samsudin, A., Chandra, D. T., Sriwati, E., Zahran, M., Gani, A. W., Ramadhan, B. P., Aminudin, A. H., & Ramadani, F. (2023). Assessing conceptual understanding of high school students on transverse and stationary waves through Rasch analysis in Malang. *Journal of Physics: Conference Series*, *2596*(1). https://doi.org/10.1088/1742-6596/2596/1/012060

Mislawati, M., Lukman, I. R., Masyithah, A., Hayatul, M., Nazwa, M. M., & Sakdiah, H. (2025). Diagnostic Analysis of Students' Hydrocarbon Concept Mastery Using Two-Tier Multiple Choice Test. *Electronic Journal of Education, Social Economics and Technology*, *6*(2), 1063. https://doi.org/10.33122/ejeset.v6i2.1063

Mufida, S. N., Kaniawati, I., Samsudin, A., & Suhendi, E. (2022). Developing MOFI on Transverse Wave to Explore Students' Misconceptions Today: Utilizing Rasch Model Analysis. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2499–2507. https://doi.org/10.29303/jppipa.v8i5.2229

Mufida, S. N., Kaniawati, I., Samsudin, A., Suhendi, E., Aminudin, A. H., Umar, F. A., Astuti, I. R. W., Kunaedi, J., & Dewi, F. H. (2024). Developing Multitier Open-ended Transverse Wave Instrument (MOTWI): How to Assess Students' Misconceptions? *KnE Social Sciences*, *April*. https://doi.org/10.18502/kss.v9i13.16006

Rahman, Y. A., Rentina, L. H., & Dhini, U. R. (2023). Person Fit Analysis for Assessing Academic Writing Performance Using Rasch Model. *Jurnal Pendidikan Glasser*, *7*(2), 301. https://doi.org/10.32529/glasser.v7i2.2571

Samsudin, A., Afif, N. F., Nugraha, M. G., Suhandi, A., Fratiwi, N. J., Aminudin, A. H., Adimayuda, R., Linuwih, S., & Costu, B. (2021). Reconstructing Students' Misconceptions on Work and Energy through the PDEODE*E Tasks with Think-Pair-Share. *Journal of Turkish Science Education*, *18*(1), 118–144. https://doi.org/10.36681/tused.2021.56

Samsudin, A., Rusdiana, D., Efendi, R., Fratiwi, N. J., Aminudin, A. H., & Adimayuda, R. (2021). Development of Predict-Observe-Explain (POE) Strategy Assisted by Rebuttal Texts on Newton's Law Material with Rasch Analysis. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *6*(1), 103–115. https://doi.org/10.24042/tadris.v6i1.7641

Samsudin, A., Zulfikar, A., Saepuzaman, D., Suhandi, A., Aminudin, A. H., Supriyadi, S., & Coştu, B. (2024). Correcting grade 11 students' misconceptions of the concept of force through the conceptual change model (CCM) with PDEODE*E tasks. *Journal of Turkish Science Education*, *21*(2), 212–231. https://doi.org/10.36681/tused.2024.012

Soeharto, S., CsapÃ, B., Sarimanah, E.,

Dewi, F. I., & Sabri, T. (2019). A Review of Students' Common Misconceptions in Science and Their Diagnostic Assessment Tools. *Jurnal Pendidikan IPA Indonesia*, *8*(2). https://doi.org/10.15294/jpii.v8i2.18649

Suhandi, A., Surtiana, Y., Husnah, I., Setiawan, W., Siahaan, P., Samsudin, A., & Costu, B. (2020). Fostering high school students' misconception about boiling concept using conceptual change laboratory (cCLAb) activity. *Universal Journal of Educational Research*, *8*(6), 2211–2217. https://doi.org/10.13189/ujer.2020.080603

Sulman, F., Sutopo, S., & Kusairi, S. (2021). FMCE-PHQ-9 Assessment with Rasch Model in Detecting Concept Understanding, Cheating, and Depression amid the Covid-19 Pandemic. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *6*(2), 297–309. https://doi.org/10.24042/tadris.v6i2.9273

Sumintono, B., & Widhiarso, W. (2014). *Aplikasi Model Rasch Untuk Penelitian Ilmu-Ilmu Sosial*.

Suprapto, N. (2020). Do We Experience Misconceptions?: An Ontological Review of Misconceptions in Science. *Studies in Philosophy of Science and Education*, *1*(2), 50–55. https://doi.org/10.46627/sipose.v1i2.24