
THE DEVELOPMENT OF OBJECTIVE TEST FOR CONCEPTUAL KNOWLEDGE OF MECHANICAL WAVES TOPIC IN HIGH SCHOOL

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Abstract

This study aims to develop an objective test of conceptual knowledge of physics on Mechanical Waves material in high school that meets good test qualification standards, covering aspects of validity, reliability, level of difficulty, discriminating power, and effectiveness of distractors. This type of research is research development or Research and Development (R&D), with the ADDIE model. The population of this study was all students of SMA Negeri 2 Percut Sei Tuan with the subject of all students of class XI MIA SMA Negeri 2 Percut Sei Tuan. The instrument used in this study was a multiple-choice test of 50 items to measure conceptual knowledge. The results showed that the content validity by experts of the objective test of conceptual knowledge of physics on Mechanical Waves material in high school was very good. Judging from the empirical validity of the broad field test, 37 valid items, and 13 invalid items were obtained. The reliability of the test is 0.91. The level of difficulty obtained 7 easy questions, 27 moderate questions, and 4 difficult questions. The discriminatory power obtained 30 items very good, 5 items good, 2 items enough, and 1 item not good. Based on the effectiveness of the distractors, 20 distractors were found to be inefficient or the distractors were not functioning. This conceptual knowledge test can be used as a standard test to measure students' conceptual knowledge of the Mechanical Wave material in high school.

Keywords: Conceptual Knowledge, Mechanical Waves, Validity, Reliability

Learning is a process or method that is carried out so that someone can carry out learning activities. One of the duties of the teacher in the learning process is to assess every activity that is carried out in the learning process (Zainal, 2016). Assessment is one component that cannot be separated from the learning process. According to Zainal (2016) Assessment is a systematic and continuous process or activity to gather information about the learning process and outcomes of students to make decisions based on certain criteria and considerations, one of the steps to support the success of the assessment system is to prepare a tool or instrument in the form of a test that meets the requirements of a quality test.

In general, the test is defined as a tool used to measure knowledge or

mastery of a measuring object of a certain set of content and material (Djaali & Muljono, 2008). In the learning achievement test, the behavioral aspect to be measured is the level of students' ability to master the subjects that have been delivered. A good test is a test that meets the requirements of validity, reliability, practicality, objectivity, economics, and usefulness, therefore, to get a good test, the test must be tested first and the results analyzed so that it meets these requirements (Zainal, 2016). Based on the form of students' answers, the test can be divided into three types, namely written tests, oral tests, and action tests.

The written test has two forms, namely the form of description and the objective form (Arikunto, 2017). An objective test is a type of learning outcome test by writing (filling in) answers in the form of certain words or symbols in the space provided for each item (Suwanto, 2012). The objective test consists of several forms, namely true-false tests, multiple-choice tests, matchmaking tests, and complete or short answer tests (Arikunto, 2018). The objective test that is widely used in the evaluation of student learning outcomes in schools is a multiple choice objective test.

Based on this, the test instrument is adjusted to the characteristics and objectives of the learning material in the form of questions that are in the realm of conceptual knowledge of the Revised Bloom Taxonomy theory where the test is standardized through a feasibility test. While the dimensions of the cognitive process are divided into six categories, namely the ability to remember (C1), understand (C2), and apply (C3) including the ability to think at a lower level (lower-order thinking) and the ability to analyze (C4), evaluate (C5) and create (C6). including higher-order thinking skills (Anderson *et al.*, 2001)

For physics learning, students often do not learn to apply the facts and ideas they learn in class to understand their experiences in everyday life. Therefore, it is very important for students to have conceptual knowledge, because most students only know general knowledge and do not understand

conceptual knowledge (Bakar et al., 2019). Conceptual knowledge is knowledge about the interrelationships between elements of basic knowledge that function together. Conceptual knowledge includes three types, namely knowledge of classification and categories, knowledge of principles and generalizations, and knowledge of models, theories, and structures (Anderson et al., 2001). Based on a preliminary study conducted by researchers at SMA Negeri 2 Percut Sei Tuan, interviews were obtained from one of the physics teachers that the teacher did not have a standardized conceptual knowledge test available at school. In general, teachers still give physics learning outcomes tests that include general knowledge. The test instruments used still measure aspects of memorization so that students do not understand the concepts and theories in the lesson. In addition, the tests used in schools that have been made by teachers still do not meet the criteria for a good test because the tests made have not been validated and tested, because the time in developing questions according to evaluation theory takes quite a long time.

Several researchers have researched the development of conceptual knowledge tests. For example, Nurlena and Sahyar (2019), in their research at SMA Negeri 9 Medan class XI on the Business and Energy material that the content validity by experts from the objective test of conceptual knowledge of physics on the Work and Energy material in SMA is very good with an average value of 3,86, and the empirical validity of the extensive field test, obtained 33 valid items and 7 invalid items. Research conducted by (Ramadhani & Sahyar, 2019) shows that the development of a Higher Order Thinking Skill (HOTS) objective test instrument on fluid material in SMA/MA that meets good qualifications includes aspects of validity, reliability, discriminatory power, level of difficulty, and effectiveness. distractors, the results showed that the empirical validity, obtained 29 items (58%) valid and 21 items (42%) invalid. Research conducted by Harahap and Sahyar (2019) in their research that the development of the HOTS objective test on Temperature and Heat material in SMA/MA is in a

good category and suitable for use with 32 questions accepted and 18 questions rejected. In addition, Hadijah and Anggereni (2016) in their research at Jeneponto Special High School class XI on the Impulse and Momentum material that the cognitive learning outcome test instrument that has been developed meets the valid category.

Based on the description of the background above, the researcher will conduct further research on the development of an objective test instrument for the conceptual knowledge of Mechanical Wave material in high school to measure students' conceptual knowledge. This study aims to determine the validity, reliability, level of difficulty, discriminatory power, and distractor effectiveness of the developed conceptual knowledge objective test. The benefits of this research are as follows: (1) for students, objective test questions for conceptual knowledge that have been developed can be a medium to train and measure their conceptual knowledge; (2) for teachers, the objective test questions for conceptual knowledge that have been developed can be a reference in conducting assessments to determine students' conceptual knowledge; and (3) for other researchers, this research can be used as a reference if they want to conduct similar research.

METHOD

This research has been conducted at SMA Negeri 2 Percut Sei Tuan which is located at Jl. Pendidikan Pasar XII Desa Bandar Klippa, Kec. Percut Sei Tuan, Kab. Deli Serdang, North Sumatra. The research was carried out in the even semester of the 2020/2021 school year. The population in this study were all students of class XI MIA Academic Year 2020/2021. The sample in this study consisted of three classes, namely class XI MIA 3 as a small group test, and class XI MIA 4 and XI MIA 5 as a large group test, each consisting of 35 people and 70 people.

The method used in this research is Research and Development (R&D) with the ADDIE method which consists of five stages which include analysis, design, development, implementation, and evaluation (Branch, 2020). This is because the ADDIE development

model is effective, dynamic, and supports the performance of the program itself. The ADDIE model consists of 5 components that are interrelated and structured systematically, which means that from the first stage to the fifth stage in its application, it must be systematic and cannot be ordered randomly. The flow of this research can be seen in Figure 1.

The data analysis method that is used in this research is the Classical Test Theory (CTT). The approach used in the classical test theory is by calculating the validity, reliability test, level of difficulty, item difference index, and reliability or function of the distractor (Sugiyono, 2019).

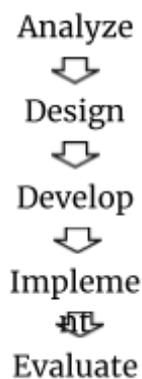


Figure 1. The process of developing an instrument using the ADDIE model

RESULT AND DISCUSSION

Research Result

This study was conducted to analyze the quality of objective test items for conceptual knowledge on Mechanical Waves at SMA Negeri 2 Percut Sei Tuan, based on qualitative analysis covering aspects of the material, construction, and language and based on quantitative analysis covering validity, reliability, level of difficulty, differentiation, and fraud effectiveness. This research is a research and development based on the ADDIE model (Analysis, Design, Development, Implement, Evaluate).

1. Analysis Stage

The analysis phase is the process of assessing needs, identifying problems, and conducting task analysis. Based on the results of interviews

with physics teachers at SMA Negeri 2 Percut Sei Tuan, information was obtained that teachers were still 30% in making their questions when they wanted to give evaluations to their students, such as making daily test questions, mid-semester tests, and semester tests.

In making questions, the teacher always aims for students to understand the questions before working on them. The questions made by the teacher were also not analyzed for the quality of the tests, such as validity, reliability, and item analysis (level of difficulty, discriminatory power, and effectiveness of distractors). From this needs analysis stage, it is known that students' conceptual knowledge is still lacking because assessment instruments designed specifically for conceptual knowledge are still not available in schools, so it is necessary to develop a conceptual knowledge test instrument.

2. Design Stage

The results obtained at the design stage in this study are a grid of conceptual knowledge questions and a test instrument validation sheet. Conceptual knowledge questions that will be developed are in the form of ordinary multiple-choice questions with 50 questions with a competency distribution of 6 questions C1, 12 questions C2, 24 questions C3, 5 questions C4, 2 questions C5, and 1 item C6.

3. Development Stage

At this stage, the researchers compiled an objective test of the conceptual knowledge of Mechanical Waves material in the form of an ordinary multiple-choice test of 50 questions with a competency distribution of 6 questions C1, 12 questions C2, 24 questions C3, 5 questions C4, 2 questions C5, and 1 item C6. Next, the questions are submitted to the validator to be validated using the validation sheet that has been created. Based on the results of expert validation from the objective test of the

conceptual knowledge of material physics, Mechanical Waves is very good (worth using). A total of 50 questions were declared valid, 40 questions were in the very good category, while 10 questions needed a little revision. This shows that the three experts agree that the instrument for testing the conceptual knowledge of the physics of Mechanical Waves material was tested in limited scope.

4. Implementation Stage

The limited field test was carried out in one class, namely class XI MIA 3, which consisted of 35 students. Furthermore, student answer sheets are analyzed so that the quality of the items can be determined, from the aspects of validity, reliability, level of difficulty, discriminating power, and effectiveness of distractors. 120 minutes. Following are the results of the quantitative analysis of the limited field test.

Item validity is calculated using the product-moment formula. Based on the analysis of the 50 items, it is known that 38 items are valid and 12 items are invalid. The percentage of item validity can be seen as shown in Figure 2.

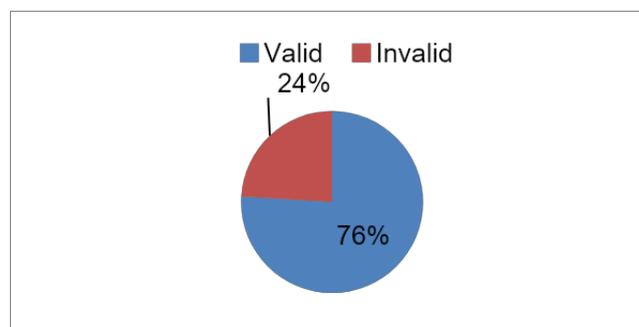


Figure 2. Validity of test items in small class

The reliability of the test in this study was calculated using the Kuder-Richardson-20 (KR-20) formula and it was known that the reliability of the test was 0.883, meaning the test used had good reliability.

The level of difficulty is usually expressed in the form of an index with a proportion between 0.00-1.00. The smaller the difficulty index, the more difficult the question will be. A good item is an item that has a difficulty

index between 0.31–0.70, which is a question with a moderate level of difficulty. Based on the results of the analysis of the level of difficulty obtained 5 easy questions, 37 moderate questions, and 8 difficult questions. The percentage of difficulty level can be seen as shown in Figure 3.

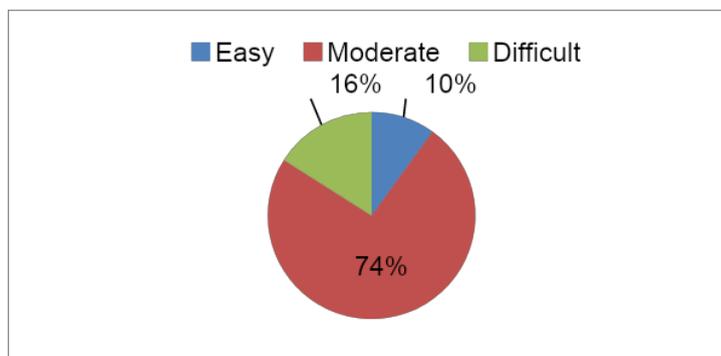


Figure 3. Difficulty level of test items in small class

The discriminatory power of the questions is known by looking at the size of the item discrimination index, which is 0.00–1.00. the percentage of discriminating power can be seen as shown in Figure 3.

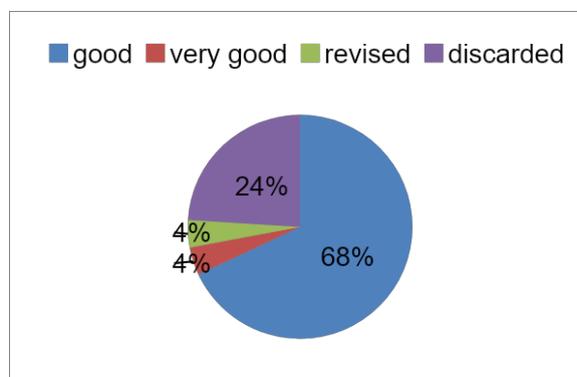


Figure 3. Distinguishing power of of test items in small class

The effectiveness of the distractors that exist in an item is analyzed from the distribution of answers to the item in question in each of the alternatives provided. The effectiveness of the distractors is checked to see if all the distractors or all the answer choices that are not the answer key have worked. The more an exploiter is chosen by the lower group, the better the distractor will carry out his duties. In the limited field test, the number of test participants was 35 students. The effectiveness of the distractor was

evaluated by traditional point-biserial correlation (r -PB). The effectiveness of the distractor is said to be efficient if r -PB < 0 . (Testa, et all. 2018). Based on the biserial point equation, 21 distractors are produced which are inefficient.

5. Evaluation Stage

A wider field test was carried out in three classes, namely class XI MIA 4 and XI MIA 5, totaling 70 students. Furthermore, student answer sheets were analyzed to determine the quality of the items, from the aspects of validity, reliability, level of difficulty, discriminatory power, and effectiveness of distractors.

The reliability of the test in this study was calculated using the Kuder-Richardson-20 (KR-20) formula and it was known that the test reliability was 0.91 (high test reliability).

According to Arikunto (2017), a good item is an item that has a difficulty index between 0.31-0.70, which is a question that is not too easy and not too difficult. Based on the results of the analysis of the level of difficulty, there were 7 easy questions, 27 moderate questions, and 4 difficult questions. The percentage level of difficulty can be seen as shown in Figure 4.

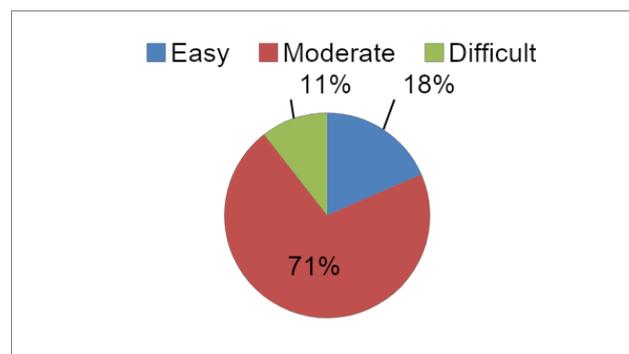


Figure 4. Difficulty level of test items in large class

The discriminatory power of the questions is known by looking at the size of the item discrimination index, which is the value ranges from 0.00-1.00. Based on the results of the discriminatory analysis, it was found that 30 items were very good, 5 items were good, 2 items were adequate,

and 1 item was bad. The percentage of discriminating power can be seen as shown in Figure 5.

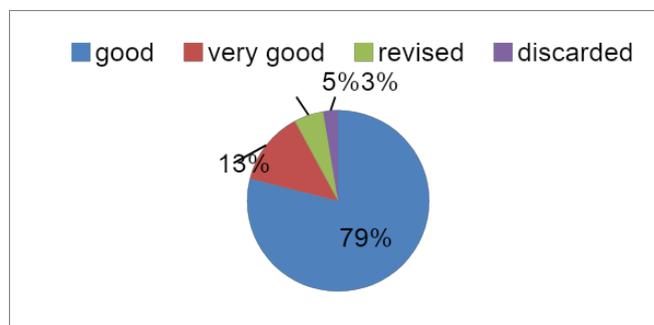


Figure 5. Distinguishing power of test items in large class

The test participants in the wide field test were 70 students. The effectiveness of the distractor was evaluated by traditional point-biserial correlation (r -PB). The effectiveness of the distractor is said to be efficient if r -PB $<$ 0. (Testa, et all. 2018). Based on the biserial point equation, 20 distractors are produced which are Inefficient

Discussion

Qualitative Question Analysis

The results of the item analysis on the conceptual knowledge of Mechanical Waves material in SMA there are 40 valid questions and 10 revised questions, meaning that almost all items meet the appropriate criteria. In terms of material, construction, and language aspects, 9 items do not meet the construction aspect and 1 item that does not meet the language aspect criteria.

Quantitative Question Analysis

The results showed that the objective test of the conceptual knowledge of Mechanical Waves material in high school that had been developed was in a good category. The reliability of the test is calculated using the KR-20 formula, in the small class trial it has test reliability of 0.883, while in the large class trial the test reliability reaches 0.910. Objective test questions

Conceptual knowledge that has been developed has high reliability so that the question can be used as a research instrument.

Items that have a good level of difficulty are at a moderate level. Problems that are too easy do not stimulate students to increase their efforts to solve them. On the other hand, questions that are too difficult will cause students to become discouraged and not have the enthusiasm to try again because they are beyond their reach. Based on the results of the analysis of the level of difficulty in the small class trial, it was found that 5 items (10%) were easy, 37 items (74%) were moderate, and 8 items (16%) were difficult. While in the large class trial, 7 items (18.4%) were easy, 27 items (71%) were moderate, and 4 items (10.6%) were difficult. Thus, the level of difficulty of the objective test of conceptual knowledge of Mechanical Wave material describes the level of difficulty from the easy, medium, and high ranges.

Judging from the differentiating power of the small class trial results, 34 items (68%) were very good, 2 items (4%) were good, 2 items (4%) were sufficient, and 12 items (24%) were bad. While in the large class trial, 30 items (78.9%) were very good, 5 items (13.2%) were good, 2 items (5.3%) were sufficient, and 1 item was (2.6%) bad.

The effectiveness of the distractors that exist in an item is analyzed from the distribution of answers to the item in question in each of the alternatives provided. The effectiveness of the distractors is checked to see if all the distractors or all the answer choices that are not the answer key have worked. In the small class trial, the number of test participants was 35 students. The effectiveness of the distractor was evaluated by traditional point-biserial correlation (r -PB). The effectiveness of the distractor is said to be efficient if r -PB $<$ 0. (Testa, et all. 2018). Based on the biserial point equation, 21 distractors are produced which are inefficient. The test-takers in the large class trial were 70 students, in the large class trial there were 20 inefficient distractors or distractors. Based on the results of data analysis, it is known that 30 questions can be accepted and stored in the question bank

for the conceptual knowledge test of Mechanical Waves in SMA because they have met the criteria of validity, level of difficulty, discriminatory power, and distractors. There are 7 items that have been revised and cannot be stored in the question bank because they do not meet the criteria, and 1 item is rejected because it does not meet the criteria for a good test at all.

The suggestions in this study include the following: (1) objective test instruments for conceptual knowledge can be developed on materials other than mechanical waves; (2) the test instrument that has been tested and analyzed can be used as a question bank for conceptual knowledge of Mechanical Wave material that can be used in schools; (3) other researchers who wish to conduct similar research are advised to follow the rules of good preparation of questions and choose other materials so that conceptual knowledge questions for all physics materials are available in the field; (4) other researchers who wish to conduct similar research as far as possible take subjects from schools of varying quality, so that many subjects with different conceptual knowledge will make the data more accurate and varied; (5) other researchers are advised to use other applications to analyze the items quantitatively so that the time required becomes more effective.

CONCLUSION

The conclusions that can be drawn from this research development refer to the research objectives and the discussion are as follows:

1. An objective test of the conceptual knowledge of Mechanical Waves material has been developed in high school. The development of this objective test uses the revised ADDIE development research model based on expert input, namely 2 lecturers and 1 teacher and a limited field test for 35 students and a broad field test for 70 students of class XI MIA SMA Negeri 2 Percut Sei Tuan. Judging from the qualitative analysis, the quality of the objective test of conceptual knowledge of Mechanical Waves material in SMA is very good. Meanwhile, in terms

- of quantitative analysis, 40 items (80%) were valid and 10 items (20%) were revised because they did not meet the existing criteria.
2. The objective test of conceptual knowledge that has been developed has a reliability of 0.91 (high test reliability).
 3. Based on the level of difficulty, 7 items (18.4%) were easy, 27 items (71%) were moderate, and 4 items (10.6%) were difficult.
 4. Based on the discriminatory power, 30 items (78.9%) were very good, 5 items (13.2%) were good, 2 items (5.3%) were sufficient, and 1 item (2.6%) was bad.
 5. Based on the effectiveness of the distractors, 20 distractors were found to be inefficient or the distractors were not functioning.

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