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Development of a Web-Based Four Tier Diagnostic Test to Identify Students' Misconceptions In Physics

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ABSTRACT

This study aims to develop a web-based four tier diagnostic test to identify students' physics misconceptions on heat and temperature. This research uses the Research and Development (R&D) method with the ADDIE development model which consists of five stages, namely analysis, design, develop, implementation, and evaluate. The research data includes quantitative data in the form of validator evaluations and qualitative data in the form of comments and suggestions given by validators and analysis of student answers. Based on the results of the feasibility validity test from media, design and material expert validation, this product shows a very feasible category to use. The results of the interpretation of student answers show that students experience misconceptions in all the questions given.

Keywords: Four Tier Diagnostic Test; Web; Misconceptions; and Heat and temperature.

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I. INTRODUCTION

Physics is one of the science families that consists of various concepts, principles, theories, laws and discovery processes. Through physics learning, students are expected to develop their ability to think critically and analytically by involving their physics concepts and principles. The number of principles and concepts found in physics learning causes students to have difficulty in understanding some concepts. As a result, there is a discrepancy between the conceptions that students have with existing scientific concepts or what is called misconceptions [1], [2].

Several studies have shown that heat and temperature materials in physics learning are often a source of misconceptions for students. [3], [4], [5]. The concepts in this material are often found in life, but some of them cannot be observed directly. [6], [7]. This condition can be the main factor that causes misconceptions in students.

The basic problems or misconceptions that are still often experienced by students on the concept of heat and temperature, namely students cannot distinguish between heat and temperature. [8], [9]. Students assume that heat and temperature can both move from objects with high temperatures to objects with low temperatures. This can affect students' understanding of subsequent concepts, such as the concept of specific heat, the effect of heat on temperature and phase changes, and the concept of heat transfer. Therefore, the problem of misconceptions in heat and temperature material is very important to be addressed immediately and identify the factors that cause misconceptions to occur and know the sub-materials that need more in-depth emphasis. [10].

One type of diagnostic test that can be used to identify student misconceptions in more depth and detail is the four tier diagnostic test. [11], [12]. This test consists of four tiers, namely multiple choice answers (tier-1), confidence level of answers in tier-1 (tier-2), reasons for choosing answers in tier-1 (tier-3), and confidence level of reasons in tier-3 (tier-4) [13]. Generally, this four-tier diagnostic test is developed paper-based to identify student misconceptions. So that the identification carried out requires a longer time [13] and accuracy in

analyzing the students' misconceptions. [10]. In addition, the application of paper-based four-tier diagnostic tests also lacks the ability to provide effective feedback on student answers [14]. Therefore, to maximize the application of this diagnostic test, web-based development is carried out.

The application of web-based test instruments can assist teachers in optimizing identification, analysis, and can be time efficient, as well as provide sufficient feedback on student answers. [15], [16]. Web-based tests also allow students to self-assess [16]. In line with [17] who revealed that web-based diagnostic tests have advantages when compared to paper-based or manual diagnostic tests. This web-based test is able to check the results of working on questions automatically [13], so that the test results can be immediately identified and analyzed. This is certainly very helpful and makes it easier for teachers to prepare, process, and make decisions.

II. METHOD

The research method used in this research is the Reseach and Development (R&D) method with the ADDIE model which consists of five stages, namely; analysis, design, develop, implementation, and evaluate[18]. This ADDIE model is one of the models developed systematically and based on the theoretical basis of learning design. In addition, the ADDIE model can also be applied as a guiding framework for developing educational products and other learning resources. [19].

The data analysis technique used in this research is descriptive qualitative. This technique is used to analyze and review the results of comments, input, and suggestions from both expert validators and the results of limited trials by lecturers, teachers, and students. The results of the analysis were then used as a reference for revising the developed product to produce a product that was feasible and could be implemented as needed. In addition, the data obtained from the questionnaire instrument was analyzed quantitatively through score conversion with the aim of translating the quality of the developed web-based four tier diagnostic test instrument. The criteria and Likert scale scores used to describe the feasibility level of the developed web-based four tier diagnostic test are shown in Table 1 below.

Table 1. Criteria for Rating the Validation Sheet

Precentage	Criteria
81,25% < score ≤ 100 %	Highly Feasible
62,50% < score ≤ 81,25 %	Feasible
43,75% < score ≤ 62,50 %	Fairly Feasible
25,00% < score ≤ 43,75 %	Not Feasible

Meanwhile, to describe the level of students' physics misconceptions on heat and temperature material, the answers can be categorized based on the criteria shown in Table.2 below.

Table 2. Interpretation of the Four Tier Diagnostic Test Results

Category	type of answer			
	Answer	Answer Confidence Level	Reasons	Confidence Level Reasons
Conceptual Misunderstanding	True	Sure	True	Sure
Conceptual Misunderstanding	True	Sure	True	Not Sure
Conceptual Misunderstanding	True	Not sure	True	Sure
Conceptual Misunderstanding	True	Not sure	True	Not Sure
Misconception	True	Sure	False	Sure
Conceptual Misunderstanding	True	Sure	False	Not Sure
Conceptual Misunderstanding	True	Not sure	False	Sure
Conceptual Misunderstanding	True	Not sure	False	Not Sure
Conceptual Misunderstanding	False	Sure	True	Sure
Conceptual Misunderstanding	False	Sure	True	Not Sure
Conceptual Misunderstanding	False	Not sure	True	Sure
Conceptual Misunderstanding	False	Not sure	True	Not Sure
Misconception	False	Sure	False	Sure
Conceptual Misunderstanding	False	Sure	False	Not Sure
Conceptual Misunderstanding	False	Not sure	False	Sure
Conceptual Misunderstandings	False	Not sure	False	Not Sure

Sumber: [20]

III. RESULTS AND DISCUSSION

A. Analysis

The initial stage in the development of this web-based four tier diagnostic test is a needs analysis. This analysis was conducted to identify the level of concept understanding and misconceptions experienced by students, as has been stated by several previous studies [21]. One effective method to uncover these misconceptions is through the use of a four-tier diagnostic test [22].

The main purpose of this needs analysis stage is to obtain a comprehensive picture of the urgency and relevance of developing a web-based four tier diagnostic test in the context of physics learning, especially in temperature and heat materials. Through this analysis, it is expected to know the extent to which students experience misconceptions and how their level of conceptual understanding of the material. This information is important as a basis for designing evaluation tools that are able to detect students' misconceptions more deeply. To obtain the necessary data, a survey method was conducted with data collection techniques in the form of distributing questionnaires and interviews to a number of students who had studied temperature and heat materials.

Based on the results of filling out a questionnaire from several students, 70% of respondents stated that they still found difficulties in following physics subjects, especially in the heat and temperature sub-material. Then based on the results of interviews conducted, the average respondent argues that the sub-material about heat and temperature still often experiences errors or conceptual errors even though the heat and temperature material is one of the sub-materials whose application is widely found in everyday life. Therefore, respondents expect a diagnostic test that is able to identify misconceptions and can provide an overview of the extent of understanding that respondents have of a material. The results of filling out questionnaires and interviews conducted showed that all respondents agreed to the web-based four-tier diagnostic test conducted to identify student misconceptions. In addition, based on the results of filling out the questionnaire and interviews, it was also found that almost all students had never done a diagnostic test to identify misconceptions.

In the application of diagnostic tests to identify physics misconceptions in students, it is known that teachers still face various obstacles, especially in the implementation process. One of the main obstacles faced is the need for a large enough time allocation, both in the instrument preparation stage and when conducting tests in class [13]. Besides, the limited skills and expertise of teachers in preparing diagnostic test instruments are also a significant inhibiting factor in their optimal implementation. Thus, based on the results of interviews conducted with teachers and students, it shows that these obstacles are very likely to be overcome by utilizing web-based diagnostic tests. Diagnostic tests themselves consist of several types, but diagnostic tests that can provide answers and identification results that are more in-depth and thorough are four tier diagnostic tests [11], [12], [22] So that the application of this web-based four tier diagnostic test can later help teachers and students in knowing the extent of the concepts that students have of a material.

B. Design

The next stage in this study begins with the preparation of a grid of four-tier diagnostic test questions on heat and temperature material. After that, proceed with the preparation of a four-tier diagnostic test instrument consisting of four stages of questions. The first stage, in the form of ordinary multiple choice consisting of 5 answer choices. The second stage, in the form of the level of confidence of students' answers consisting of 2 types of choices, namely “sure” and “not sure” of the answer choices in the first stage. The third stage, in the form of answer reasons consisting of 4 choices of reasons that have been provided and other options if you have reasons outside the options provided. Finally, the fourth stage is the level of confidence in the chosen reason which consists of 2 types of choices, namely “sure” and “not sure”.

The four-tier diagnostic test instrument consists of 10 questions with each question consisting of 4 stages. The focus of the developed material lies on heat and temperature material which consists of several sub-topics, namely temperature and expansion, heat and its effect on changes in temperature and form of objects, specific heat and heat capacity, and heat transfer. The tests developed are adapted to the application of heat and temperature materials that are relevant to life.

The next preparation process is to draft a web-based diagnostic test. Several things need to be considered before compiling or developing the web, including the display model, suitable colors, type of writing, and the content components contained therein. The application of this diagnostic test was chosen to be web-based to make it easier for teachers to correct, save time [13], and be adapted to the development of science and technology (IPTEK). This web-based can be one of the solutions that can be utilized in the learning process and also greatly supports the students' self-learning process [16].

C. Development

The next stage is to develop the test instrument lattice and make a web-based development design based on the design that has been prepared previously. The web-based four tier diagnostic test that has been developed is then validated by several experts, namely content or material experts and media and design experts. The suggestions given by the experts were used as a basis for improving and perfecting the diagnostic tests developed. The results of the validity of several experts on the feasibility of the developed web-based four tier diagnostic test are presented in table 3 below.

Tabel 3. Feasibility Validity Test of a Web-based Four Tier Diagnostic Test

No	Content test	Score	Categories
1	Media and Design Expert	93%	Highly Feasible
2	Content Expert	96%	Highly Feasible

In terms of product validity, both in terms of content, media and design used, the web-based four tier diagnostic test that has been made is in the category of very feasible and suitable for use as a tool to identify students' physics misconceptions in heat and temperature material. The figure below is a display of the development of a web-based four tier diagnostic test used to identify students' misconceptions on heat and temperature.

Fig. 1. Cover

Fig. 2. Information about the four tier diagnostic test

Fig. 3. Test requirements

Fig. 4. Contact person

Fig. 5. Information on heat and temperature misconceptions

Fig. 6. Instructions

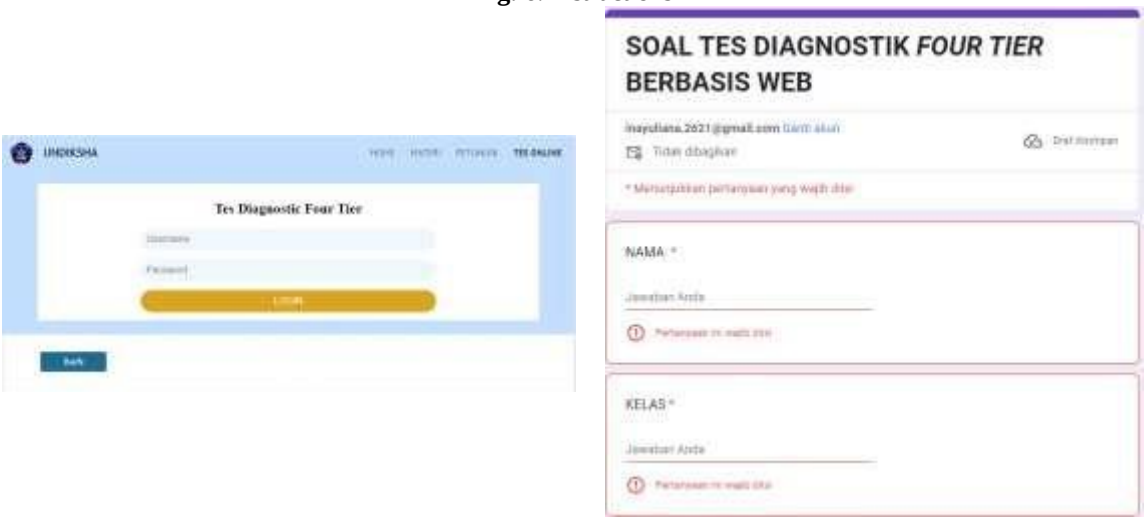

Fig. 7. Cover Test

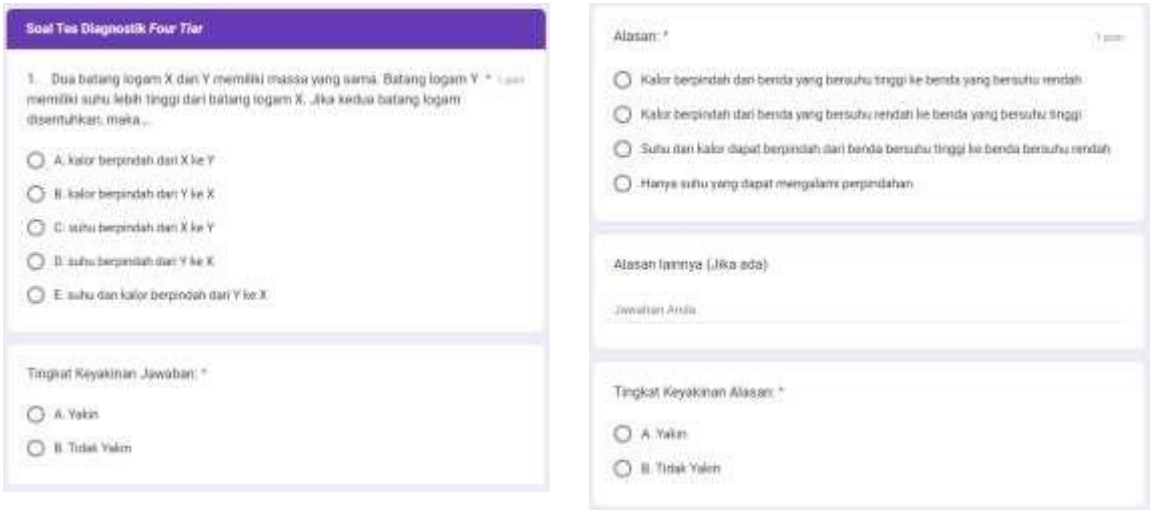

Fig. 8. Diagnostic test

D. Tahap Implementasi (Implementation)

The next stage is the implementation stage of the instrument and web development results that have been developed at the previous stage. Diagnostic tests that have gone through previous validity are then implemented to students who have studied heat and temperature material. The students who served as subjects in this study amounted to 27 people. The four-tier diagnostic test instrument tested on students was 10 questions with four sub-topics, namely temperature, expansion, heat and the effect of heat on temperature and phase changes, and heat transfer.

The table below presents the results of the analysis of student answers after being interpreted into the categorization table previously presented.

Table 4. Results of Data Analysis Interpretation

Question Number	Kategori		
	Conceptual Understanding	Misconception	No Conceptual Understanding
1	9	12	3
2	7	7	10
3	0	16	8
4	0	4	20
5	5	9	10
6	3	15	6
7	2	11	11
8	12	4	8
9	9	9	6
10	6	12	6

Based on the interpretation of the data, the results of the analysis show that in each sub-material on heat and temperature students experience misconceptions. The number of students who have the most misconceptions is in question no. 3 which discusses the concept of specific heat. While the lowest number of students with misconceptions is in question no. 4 about the concept of the effect of heat on temperature changes and question no. 8 about the concept of the effect of heat on phase changes.

E. *Evaluation*

The evaluation stage is the last stage in this development research. The purpose of this evaluation stage is to assess whether each level of activity and product that has been developed is in accordance with the desired specifications or not. The form of evaluation carried out in this study is by distributing questionnaires to students and teachers to find out the perceptions of students and teachers towards the development of diagnostic tests that have been implemented. In addition, to find out in more detail, an interview was also conducted with the teacher concerned after the implementation in the classroom. Formative tests like this are carried out with the aim of getting continuous improvement feedback in order to produce a good quality final product.

The results of the questionnaire analysis and interviews with teachers regarding the implementation of the web-based four tier diagnostic test show that this test is very helpful for teachers in identifying misconceptions in depth. In line with [12], [22], The study states that this type of test can provide accurate results in detecting students' misconceptions. Through students' answers, the teacher can analyze which submaterial needs further reinforcement [3]. In addition, the results of interviews with students also revealed that this test helped them assess their level of concept understanding, so that they could prepare themselves and strengthen the submaterial that was still not understood.

IV. CONCLUSION

Based on the description of the results and discussion, it can be concluded that the development of a web-based four tier diagnostic test is in accordance with the needs that exist in schools. This disgnostic test was developed to identify the occurrence of students' physics misconceptions on heat and temperature material. Based on the results of the validity test of the feasibility of the web-based four tier diagnostic test, a score of 93% was obtained in the “very feasible” category from the validation of media and design experts, while from the content/material validation a score of 96% was obtained in the “very feasible” category. Then related to the results of the interpretation of student misconception data on heat and temperature material can be categorized into three categories, namely students who experience misconceptions, understand concepts, and students who do not understand concepts. The results obtained are that students experience misconceptions in all the questions given. The highest percentage of students' misconceptions is in question number 3 (specific heat) and the lowest percentage is in question number 4 (the effect of heat on temperature changes) and 8 (the effect of heat on shape changes).

Misconceptions can prevent students' understanding of the next concept, thus impacting on students' concept mastery ability, critical thinking skills, and problem-solving ability. Therefore, misconceptions must be identified immediately to help students' understanding become more systematic and accurate. To support this, the development of similar diagnostic tests for other materials or other fields also needs to be developed.

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