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Four Tier-Relativity Diagnostic Test (4T-RDT) to Identify Student Misconception

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ABSTRACT
Misconceptions in physics lessons are still the main problem faced by teachers and students. Misconceptions of physics occur at various levels of education and many physics materials at the high school level. The results of observation to class XII students in Semarang obtained data that the material on the theory of relativity is material with a low level of mastery of concepts. In addition, teachers also have difficulty in identifying physical misconceptions experienced by students. Therefore, this study aims to develop an instrument in the form of a Four-Tier Diagnostics Test to identify students' physics misconceptions on the material of relativity theory, determine the level of validity, reliability, and characteristics of the four-tier diagnostics test. The type of research is Research and Development (R&D). The methods used are documentation, interviews, questionnaires and tests. The results showed that the instruments were valid and reliable. The diagnostic test consists of four levels, namely: a question with one answer key and four distractor, the degree of confidence of the answer, the reason, and the level of confidence of the reason. The resulting instrument consists of a grid, work instructions, test questions, answer keys, answer sheets, scoring guidelines, and result interpretation guidelines. Validity testing by expert validators shows the developed instrument is valid and reliable.

INTRODUCTION

One of the main problems encountered in physics learning is misconceptions [1] [2]. Misconceptions of physics are still often experienced by students in learning physics [3] [4]. Misconceptions of physics do not only occur in Indonesia [5] [6] [7], but also occur in several other countries [8] [9] [10]. Misconceptions also occur at various levels of education ranging from primary school to higher education levels [11] [12] [13] [14]. Misconceptions have a bad impact on students' level of understanding of physics material properly and correctly [15] [16].

Misconceptions can arise from the daily experiences that students experience when interacting with their surroundings [17] [18]. Through this experience, students will build their own theories in their minds that are not necessarily true [19]. If the intuition formed is not correct, it will be very difficult to correct because it accidentally consistently corrects the wrong physics concepts it has become knowledge that is considered correct [19] [20].

In physics learning at the high school level, almost all students experience misconceptions in physics materials [21] [22] [23] [24]. One of the interesting physics materials to research to see misconceptions is the material of the theory of realtivity. The theory of relativity is the basic material for studying the next physical sciences such as statistical physics, modern physics and quantum physics. The misconception of physics in theory of relativity materials is urgent to study because it will have an impact on the mastery of other materials. Many studies have been conducted to look at student misconceptions in the physics material of the theory of relativity [25] [26] [27]. However, it has limited instruments in diagnosing physical misconceptions in the material of the theory of relativity.

One way to find out misconceptions in students is with diagnostic tests [28]. The use of diagnostic tests at the beginning and at the end of learning can help teachers find student misconceptions in the material studied [29] [30]. A good diagnostic test can provide an accurate picture of the misconceptions a student is experiencing based on the information he or she made. A good diagnostic question not only shows that the student does not understand a particular part of the material, but can also show how the student thinks in answering a given question even if their answer is incorrect [30] [31].

The four-tier diagnostic test is a development of the three-level multiple-choice diagnostic test. The development of three-level multiple choice is found in the addition of the level of confidence of students in choosing answers and reasons. The first level is a multiple-choice question with three tricks and one answer key that students must choose from. The second level is the level of confidence of students in choosing answers. The third level is the reason students answer the question, in the form of three choices of reasons that have been provided and one reason is open. The fourth level is the level of confidence of students in choosing a reason. The level of confidence developed is in the range of numbers one to six accordingly. The advantage that a level choice diagnostic test has is that through a four-level diagnostic test [32] [33] [34], the teacher can: (1) distinguish the level of confidence of the answers and the level of confidence of the reasons chosen by the student so that it can dig deeper into the strength of the student's concept understanding, (2) diagnose the misconceptions that students experience more deeply, (3) determine the parts of the material that require more emphasis, (4) plan better learning to help reduce student misconceptions.

Based on the results of a survey of class XI students in Semarang a total of 577 to find out the level of understanding of physics concepts in physics material, data was obtained that students who understood the material of the theory of relativity were 127 students or around 22%. While the remaining 450 students stated that they did not understand the concept of physics in the theory of relitivity. In the section of students who do not understand or understand, it can be indicated that there is a misconception in the material of the theory of relativity. On this basis, it is necessary to develop a four-level diagnostic test instrument to identify physical misconceptions in the material of the theory of relativity. This study aims to develop a four-tier diagnostics test instrument on relativity theory material called 4T-RDT (Four-Tier Relativity Diagnostics Test).

METHOD

This research uses survey research design conducted at High School in Semarang to grade XII students. The study included 577 students as respondents. Respondents were selected using a simple random sampling technique. This research is a research with a Research and Development approach

(R&D). The product produced in this study is a four-tier diagnostic test instrument to uncover student misconceptions on the material of the Theory of Relativity. This research procedure is carried out using the 4-D model research and development procedure.

The research stages consist of: needs analysis and information collection, research goal setting, product development, small-scale trials, product revisions, broad-scale trials, revisions product, field test, final product revision, dissemination and implementation. The product development phase consists of: analysis of learning tools, preparation of test question grids, writing of question items, and study of questions and revisions of questions.

The data collection method consists of documentation, interview, questionnaire, and test methods. Interviews were conducted with teachers to find out the teacher's opinion regarding the four-tier diagnostic test and the assessment application developed. Questionnaires are distributed to students, consisting of assessment questionnaires and response questionnaires. Assessment questionnaires are given during small-scale and broad-scale trials, while response questionnaires are given during final field trials.

The data analysis carried out includes validity, reliability, difficulty level, differentiating power, questionnaire analysis, student misconception analysis, and interpretation of four-tier diagnostic test results. Validity testing using the validity of the contents conducted by 3 expert lecturers. Reliability testing using Cronbach's Alpha formula. Interpretation of student misconceptions is carried out by classifying students in groups of understanding, partially understanding, not understanding, and misconceptions. The interpretation of the four-tier diagnostic test results can be seen in Table 1 below.

Table 1. Decision making for four-tier test

1st Tier	2nd Tier	3rd Tier	4th Tier	Decision
C	CF	C	CF	U
C	CF	C	NCF	PU
C	CF	C	NCF	PU
C	CF	W	CF	PU
C	CF	W	NCF	PU
C	CF	W	CF	PU
C	CF	W	NCF	PU
W	CF	C	CF	PU
W	CF	C	NCF	PU
W	NCF	C	CF	PU
W	CF	W	NCF	NU
W	NCF	W	CF	NU
W	CF	W	NCF	NU
W	CF	W	CF	MISC

W = Wrong; C = Correct; CF = Confident; NCF = Not Confident; U = Understanding; PU = Partial Understanding; NU = Not Understanding; MISC = Misconception

To find out students' misconceptions in physics subjects using table 1, the instrument developed based on its type has four levels, consisting of questions, answers, confidence levels of answers, reasons, and confidence levels of these reasons. The four tier diagnostic test instrument framework is shown in Table 2 below.

Table 2. The four-tier test diagnostic instrument framework

The developed four tier test diagnostic instrument framework	
1. Question A. Option B. Option C. Option D. Option	3. Reasons toward the selected answer A. Option B. Option C. Option D. Option
2. The confidence level of the selected answer A. Confident B. Not confident	4. The confidence level of the selected reason A. Confident B. Not Confident

RESULTS AND DISCUSSIONS

The results of the developed products are presented in Table 3. Characteristics of four-tier diagnostic tests that have been developed are as follows:

Table 3. Four Tier Diagnostics Test Instrument Product Overview and Assessment Applications

Developed products	**Content**
Four-tier diagnostics test question grid	Sub-subjects, question indicators, level categories questions, number of questions
Instructions for working on the question	Instructions for students in doing the questions
Four-tier diagnostics test questions	Title, subject, class, subject, time workmanship, test questions, answer choices, level the confidence of choosing the answer, the choice of reason, the degree beliefs of choosing a reason
Answer key	Question number, answer choice and choice of correct reason
Scoring guidelines	Guidelines for scoring and determining test results
Guidelines for interpretation of results	Guidelines for classifying the answers that students give

The Four-Tier Relativity Diagnostic Test (4T-RDT) physics instrument developed has the following characteristics, namely that each question item developed has four levels. The first level is a multiple-choice question with three deceptions and one answer key that students must choose from. The second level is the level of confidence of students in choosing answers. The third level is the reason students answer the question, in the form of three choices of reasons that have been provided and one open reason. The fourth level is the level of confidence of students in choosing a reason. The level of confidence in choosing answers and reasons is divided into two scales, namely being sure and unsure.

The final test questions used were 15 questions, consisting of 4 subjects, namely coordinate transformation, Micheleson-Morley Experiment, Einstein's Theory of Relativity, and the Impact of Einstein's Theory of Relativity. In addition, it also consists of 9 sub-subjects. The sub-subjects used are Lorentz Transformation, Summation of velocities based on Einstein's relativity, Long contraction, Time Dilatation, Relativistic mass, Relativistic momentum, kinetic energy, and Momentum and relativistic energy.

Scoring is given by giving a score of 1 for the answer choice as well as the correct reason choice and a score of 0 is given for choice of answer as well as choice of reason wrong. The confidence level in this 4T-RDT instrument only uses a sure and unsure scale to ask students for confidence in the answer choice and the reasons given when giving answers to test items.

The test results of students in doing test questions with the 4T-RDT instrument will analyze and interpret the results to identify student misconceptions in the material of relativity theory. The misconception analysis is carried out in a continuous manner to each student for each item. Each student is suspected of experiencing misconceptions in previously studied material. Some research results state that misconceptions experienced by students in learning are natural, this is an indication of the non-achievement of learning objectives in the learning process. However, it is very important to develop an instrument to evaluate, especially detecting misconceptions experienced by students. One of the evaluation tools that diagnostic tests can use. Diagnostic tests are designed to detect students' learning difficulties, these tests are developed based on an analysis of the difficulties that may be the cause. The form of diagnostic tests that are usually developed is in the form of descriptions and brief fills. Meanwhile, if using the multiple choice form must be complemented by an explanation in choosing the answer, this is done to reduce students' guessing in answer which can lead to a low level of grain vaidity and instrument reliability.

The validation carried out on the 4T-RDT Instrument involved 3 experts. Validation is carried out to determine the feasibility of the developed instrument [35]. The grain validity test must be carried out by a person who is an expert in their field. The developed 4T-RDT instrument has been declared valid by validators. This shows that the question items developed are in accordance with the content of the physics material, namely the theory of relativity for class XII and this instrument can already be used to identify the profile of students' misconceptions in the material of the theory of relativity.

The validity of the test questions is assessed by each item by an expert, each question item consists of 20 aspects of assessment, including material aspects, language and test construction. The assessment of each question item is carried out in detail, so that the questions to be used are declared feasible so that they are appropriate in measuring what they want to measure in this case, namely students' physics misconceptions on the material of relativity theory. A detailed assessment of each item is intended to make it easier to detect the part of the question that needs improvement.

In addition to validation tests, 4T-RDT instruments are also carried out reliability tests. The reliability test is carried out to see the accuracy of the questions in assessing the one to be assessed. The results of the reliability analysis obtained a value of 0.868. This means that the money test instrument was developed in a reliable manner. This means that the 4T-RDT diagnostic test instrument developed has a degree of accuracy in uncovering student misconceptions in the material of relativity theory.

Good test questions must be valid and reliable [36] [37]. In addition, the test questions must have a good level of difficulty and distinguishing power. The level of difficulty and distinguishing power are characteristic of the test questions, including four-level diagnostic test questions. The characteristics of the question items of the final product developed are as follows, namely the difficulty level of 15 questions consisting of 3 questions included in the easy category, 9 questions included in the medium category, and 3 items included in the difficult category. The grain difficulty level is in the range between 0.25 to 0.78. For differentiating power, the question has a good category and can distinguish, for the instrument differentiating power number, it is in the range between 0.26 to 0.82.

The difficulty level of the questions developed in this 4T-RDT instrument mostly belongs to the moderate category. The level of difficulty that is high in an test is necessary so that students who are not good at it do not have difficulty in doing the questions and vice versa for students who are good at doing the questions are also not too easy to do the questions. Questions with moderate difficulty in the 4T-RDT instrument are in accordance with the characteristics of the questions that must be used in the diagnostic test questions.

The differentiating power of the 4T-RDT instruments developed is mostly in the acceptable category and is able to distinguish between students who are smart and not good at it. This is in accordance with research that states that a good question item must be able to distinguish between students who really master the material and those who do not master. For question items that have poor distinguishing power, they cannot be used because they will not be able to distinguish between students who are good

and those who are not. This may cause the purpose of the test to not be achieved.

The analysis was carried out to determine student misconceptions on the material of the theory of relativity by looking at the level of student confidence in choosing the right answers and reasons. The student's confidence in answering and giving reasons indicates a negative result, this indicates that students cannot distinguish between what they understand and what they do not understand, or in other words students experience misconceptions without them realizing it. A recapitulation of the results of the analysis of student misconception interpretations is presented in table 4 below.

Table 4. Recap of the results of the analysis of the interpretation of student misconceptions

Category	Highest (%)	Lowest (%)	Average (%)
Understand	25,8	2	13,9
Partial Understanding	53,8	0	26,9
Don't Understand	88,6	0	44,3
Misconceptions	76,7	0	38,3

Based on the results of the recap of the results of the misconception interpretation analysis, it is known that students tend to be unable to distinguish what they understand and what they do not understand correctly. These results indicate a strong misconception experienced by students. Misconceptions experienced by students will interfere with them in receiving new knowledge. The wrong concept has been deeply ingrained in the students and they assume the concept they understand is correct. They are likely to apply concepts they already believed in before with concepts they have just accepted. This is in accordance with the opinion that many misconceptions are resistant to change [38] [39]. The misconceptions experienced will be firmly attached to the students because they construct the knowledge. Therefore, it is very important to immediately know whether the student has a misconception and in which part the student has a misconception so that it can be remidiated before the concept is more firmly ingrained in the student.

With these results, teachers must be able to distinguish students who can understand concepts well, do not understand concepts, and experience misconceptions in order to work on how to solve problems appropriately [40] [41]. The problem that often arises is when the teacher will seek treatment but the teacher has problems distinguishing students who understand the concepts well, do not know the concepts (lack of knowledge), or students who misconceptions [42]. Students understand, do not understand, and misconceptions are grouped in high, medium, and low categories.

Students were classified as understanding in the low category at 54.67%; medium category at 27.48%; and a high category of 17.85%. The results showed that students understood the concept of relativity theory in physics subjects only by 17.85% of all questions tested. Most students have a low level of understanding of the material of the theory of relativity. Students who are classified as not understanding the concept in the high category by 0%. This percentage suggests that there are no students who simply do not understand the concept of the theory of relativity in physics lessons. The percentage of not understanding concepts in the low and medium categories was 46.52% and 53.48%. This shows that half of the number of relativity theory questions tested have not been mastered well by students. Students who do not understand the concept are known from the student's unconvincedness in giving answers. The uncertainty is seen from the choice of low confidence level.

Students experienced misconceptions in the low category of 26.32%; medium at 53.21%; and a high of 20.47%. The results showed that almost all students experienced misconceptions as much as 20.47% of the relativity theory material in the questions tested. Students also experienced moderate misconceptions at half of the number of questions tested. Students share the same belief in a concept that does not correspond to the concept of a scientist. Their belief in the wrong concept is heightened when their friends also share the same belief in the concept. This needs to be watched out for because misconceptions have become widespread and will certainly cause problems for students in receiving new knowledge.

Misconceptions are based on the results of the student's answers and confirmed by the results of interviews with students. The first misconception in the theory of relativity is that the error in understanding the Big bang theory is like a bomb exploding at a certain location in a previously empty space, the error being that the universe appears when matter explodes out of some specific location. The pressure was highest in the center and lowest in the surrounding void; This pressure difference pushes the outside material. Whereas the truth is the Big Bang is an explosion of space itself. The space we live in is evolving on its own. There is no center of this explosion (big bang has no center); it happens everywhere. The same density and pressure everywhere, so there is no pressure difference to push a conventional explosion.

In addition there are some student misconceptions in the theory of relativity namely The speed of retreat (recession) cannot exceed the magnitude of the speed of light, We cannot see light from galaxies whose recession speed exceeds the speed of light, Cosmic redshift is caused by the doppler effect, Because the age of the universe is about 14 billion years, then the radius of the universe is 14 billion light years, As the universe expands, the objects in it also expand.

Based on the results of student interviews, sources of misconceptions were found, including: students, teachers, friends, books, the internet, and practicum results. The results of the research can be used as a reference for teachers to make improvements in learning, especially in the material of Relativity Theory. Teachers can find out which parts are detected with student misconceptions. Thus, teachers can plan learning better to overcome misconceptions experienced by students.

CONCLUSION AND SUGGESTION

The resulting four-tier diagnostic test instrument consists of a grid of test questions, instructions for working on questions, test questions, answer keys, sheets answer, scoring guidelines, and result interpretation guidelines. The test questions consist of four levels, namely: questions with one key answer and three deception, answer confidence level, reason choice, and reason confidence level. The final product produced amounts to 15 valid question items. Both validators state Each item of the test question is valid so that it can be tested to the subject of the study. The resulting test questions are reliable, meaning that the questions have Ineptitude in exposing student misconceptions. some misconceptions found in the theory of relativity include The speed of retreat (recession) cannot exceed the magnitude of the speed of light, We cannot see light from galaxies whose recession speed exceeds the speed of light, Cosmic redshift is caused by the doppler effect, Because the age of the universe is about 14 billion years, then the radius of the universe is 14 billion light years, As the universe expands, the objects in it also expand.

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