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The 3 Tiers Multiple-Choice Diagnostic Test for Primary Students' Science Misconception

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Abstract

The goal of this study was to determine how the 3 Tier Multiple Choice Diagnostic Test developed in primary students' scientific understanding. This research and development includes fundamental studies, model development, and model testing. 161 fourth-graders served as research subjects. Tests, surveys, and observations are all used to collect data. The Miles and Huberman interactive model was used to analyze qualitative data, and the paired sample t-test and N-Gain Score test were used to analyze quantitative data. The findings indicate that 3 Tier Multiple Choice Diagnostic Test instrument has a V index of 0,80 and a Cronbach's Alpha value of 0,890, indicating that the instrument is valid. Thus, all test items are legitimate and dependable. The instrument was able to identify misconceptions regarding science learning in light material that fit the following profile based on the results of the trials: 28,7% of students do not grasp the idea of light sources; 43,3% have misunderstandings; 17,8% have incomplete comprehension with misconceptions; 20,2% have incomplete understanding without misconceptions; and 14,9% have complete understanding.

Keywords: misconception, primary student, science, 3 Tier Multiple-choice diagnostic tests.

Introduction

Numerous scientific concepts lack solidity. In this context, Abbas (2016) argues that mastering a thought that is not concrete is unquestionably more difficult than mastering a real concept. In primary science education, abstract concepts must be based on a solid understanding of the fundamentals. The students' capability of analyzing abstract subjects by utilizing their capacities for critical thinking will be contingent on their level of comprehension of the appropriate concept.

A person is said to be suffering from the state of misconception when they are unable to construct the experience for which they have gained new knowledge. Narjaikaew (2013) asserts that students will confront misconceptions if they are unable to connect their earlier experiences with new concepts offered during scientific instruction.

Misconception is notoriously challenging to identify. A person who has misconceptions is not synonymous with a person who does not comprehend the topic. This was also noted by Auli (2018), who stated that even with high-quality lectures, misconceptions would be tough to eradicate. Based on these statements, we can know if students are unable to grasp the concept, they will when the teacher explains effective learning. However, if students encounter misconceptions, even with an adequate explanation, they will struggle to embrace the proper concept.

Misconceptions among students can have a detrimental effect on the learning process. According to the findings of Uzun et al. (2013), some students were unable to explain a phenomenon connected to their linguistic and scientific knowledge. Many students are capable of providing correct answers that are not backed by scientific justifications. Thus, students can be said to have misconceptions in this scenario.

This misunderstanding appears to be widespread among students of various subjects, including science (Ojose). Researchers, intellectuals, and science educators have long been concerned about misconceptions and inaccuracies in science learning. Numerous research have been conducted on misconceptions and blunders in science (e.g., Aliustaoglu et al., 2018; Burgoon et al., 2017; Mohyuddin & Khalil, 2016).

Numerous studies have revealed a profile of educational misunderstandings, particularly at the elementary school level. According to Pesman and Eryilmaz (2010), up to 69% of 124 students have misconceptions regarding electrical circuits. Additionally, Maier et al (2016) revealed the data about students' misconceptions, stating that 19,7% students had preconceived notions regarding the material's ability to accommodate live organisms in their environments.

An error may occur as a result of incompetence regarding the need to verify the answers provided (Hansen et al., 2014). Persistent misconceptions can impair students' capacity to comprehend science topics, resulting in frequent repeating of the errors (Im & Jitendra, 2020). Such an inaccuracy may result in poor performance, generating concern about the

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topic, resulting in unfavorable attitudes and a negative image of mathematics (Belbase, 2013).

Numerous variables contribute to a person's misconceptions. Mursalin (2013) believes that a person can encounter misconceptions if he has an incorrect preconception, engages in associative thinking, engages in humanistic thinking, engages in incorrect or inadequate reasoning, or engages in incorrect intuition. Associative thinking of students towards everyday terms sometimes causes misconceptions. This happens because usually students already have certain concepts with certain meanings before taking part in learning. While humanistic thinking can cause misconceptions because students usually look at everything from a human point of view. Objects and situations are interpreted in terms and experiences humanely, so that there is no connection. In addition, incomplete or incorrect reasoning can also lead to misconceptions because the information obtained or the information obtained by students is incomplete. The last aspect is intuition. Intuition is a feeling contained in a person who spontaneously expresses his ideas or attitudes towards something that has not been studied objectively and rationally. When students follow their intuition, misconceptions will arise because students' intuitive thinking makes students uncritical

Besides that misconceptions and errors could be attributed to a variety of factors, including student disposition toward science (Kusmaryono et al., 2019), teaching framework (Skott, 2019), students' preconceptions (Diyanahesa et al., 2017), limited understanding (Saputri & Widyaningrum, 2016), a lack of appropriate modeling (Blazar & Kraft, 2017), and a lack of Science misunderstandings appear to be related with incorrect beliefs that students develop in science as a result of a lack of conceptual clarity. Such misconceptions may stem from prior information that they inappropriately generalized (Im & Jitendra, 2020), and they believe either that what they are doing is correct or that they are unsure of what they are doing (Neidorf et al., 2020).

Keles et al. (2011) emphasize a crucial point: the foundational ideas held by students are an important factor in the success of their educational endeavors. Aydin (2013) says that prior to delivering instruction, teachers should be able to recognize and address the misunderstandings that their pupils have. As a result, in order to initially map and then identify pupils' misconceptions, specialized devices are required.

The three-tier test is a modification of the two-tier instrument (Ardiansyah & Rahardjo, 2018). The distinction between a three tier test and a two tier test lies in the capability of the instrument to identify. Three-tier tests employ a straightforward method for identifying misunderstandings and distancing them from a lack of expertise of the subject. Judge (2012) said that three-tiered test takes into account the pupils' level of self-assurance regarding their responses, allowing for differentiation of students' misconceptions and conceptual comprehension.

Each item on the 3 Tier Multiple Choice Diagnostic Test (TTMCDT) instrument is composed of three major components. Cetin (2011) notes that For the first level, typical questions are asked, followed by possible explanations for those answers, and the third level is based on how confident one is in their first and second-tier responses.. The TTMCDT instrument can categorize students' comprehension levels according on the scores earned for each item through analysis of these three tier.

The knowledge concept of the TTMCDT instrument employed in this study is analyzed using a classification system developed by Pacala (2018: 4) into five groups. The five groups are as follows: First, total comprehension, then partial comprehension without a misinterpretation, then misinterpretation, and finally the lack of conceptual literacy or knowledge.

The TTMCDT instrument's capacity to categorize students' degree of understanding becomes a benefit in identifying misconceptions. Additionally, Mubarak et al (2016) stated that the TTMCDT instrument has the following advantages: 1) it can diagnose profound misconceptions, 2) it can identify material that needs to be emphasized more during the process of learning, and 3) it can assist teachers in planning learning more effectively. These instruments' advantages provide teachers with an opportunity to eliminate students' misconceptions about learning.

This study uses quantitative and qualitative data. Quantitative data is provided in the form of instrument feasibility test results. Meanwhile, qualitative data is offered in the form of descriptions of test findings and interviews. The formulation of the research problem is as follows: What are the stages of developing the TTMCDT misconception identification instrument in elementary school science learning? The purpose of this study is to explain the stages of developing the TTMCDT misconception identification instrument in elementary school science learning.

Method

Research Design

This research aims to develop an effective and efficient TTMCDT product for identifying elementary school students' misconceptions in science learning. According to Sukmadinata (2013), this research is a sort of Research and Development (R&D) model since it entails preliminary studies, model development, and model testing. The TTMCDT instrument developed for elementary school pupils' science study of light material is the result of this research. The hope is that if misconceptions can be identified early on in the learning process, students will have scientifically accurate fundamental

Table 1: Research Design

Pre-test	*Treatment*	*Post-test*
O1	X (TTMCDT)	O_2

O1 = Value before treating (Given TTMCDT)
X = Treatment (TTMCDT Giving)
O1 = Value before treating (Given TTMCDT).

concepts. This can aid students in mastering more complex learning materials, allowing them to develop superior critical thinking skills.

The stages of model creation are followed in this study, which include preliminary investigations, validation, field trials, and product efficacy testing. Experts then validate the instrument's prototype to solicit feedback and suggestions until it receives final approval from the expert panel. There are two specialists involved: one who specializes in lighting materials and another who specializes in appraising educational devices. Meanwhile, this study's field effectiveness test employed pre-experimental research procedures and a one-group pretest-posttest design (Table 1).

Population and Sample

The research took place in Surakarta, Central Java, Indonesia. SDN Semanggi Lor, SDN Mojo I, SDN Tegalrejo, SDN Wiropaten, and SDN Gurawan were used as samples in this study. There are 161 students. The experimental group was 43 students in class IV at SDN Mojo I and 38 students in class IV at SDN Wiropaten. Meanwhile, the control group consisted of 42 students in class IV at SDN Gurawan and 38 students in class IV at SDN Semanggi Lor. Purposive sampling is used to determine the sample, which means that the sample is selected with a certain purpose and attention

Data Collection Tools and Data Analysis

For the purposes of this study, we used the following procedures for data analysis in an interactive data analysis paradigm (Cohen Manion and Morrison, 2007), which included: A) data analysis, which includes data about thematic learning instruments; (b) revision of data, which includes the establishment of links or connections between linguistic aspects (network), summaries (structured summaries), and learning model scripts (material scripts); (c) data validation, which includes peer-debriefing methodologies to ensure the validity of the research findings.

The content and construct validity techniques were utilized to validate the data in this study. The instrument's initial validity is established through expert opinion. This validity test is used to determine the construct description's dimensional accuracy. Eight professionals validated the data using expert judgment. This research involves a number of specialists, including those with experience generating science education materials, those with expertise in teacher training, and those with expertise in instrument development who examine the feasibility of building instruments. The content validity index can be determined using Aiken's V. The formula for calculating the Aiken's V validity coefficient is as follows:

$$V = \frac{[n(c\text{-}1)]}{[n(c\text{-}1)]}$$

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The projected V value is then compared to the Vtable value at a significance level of 0,05. The item is considered legitimate if Vcount exceeds Vtable.

The second stage of validation is to try out the draft. The second level of validity is to experimentally validate all of the items validated by the expert. The second validity was derived from a larger sample size. Instrument evaluations were conducted at slam Diponegoro Elementary School.

Findings

The prototype of the TTMCDT instrument is created by examining the curriculum in order to decide the material that will be included in the TTMCDT. This is to ensure that the instruments designed can assist students in understanding the right concept effectively mastering the content being studied. Elementary school students study nature of light emitted during the seeing process, light sources, and optical devices.

This results in the creation of a TTMCDT instrument. Questions and answer sheets, answer sheet keys, scoring rules, and result interpretation guidelines make up the seven major components of the instrument. Teachers keep four and students give three of the seven components needed for this activity. Teachers' components include question matrices, answer keys, scoring standards, and a set of procedures for evaluating the outcomes of the test. TTMCDT and a response form are also available for students' use at this time.

The instrument prototype was evaluated by material specialists and received an average score of 3.41. According to the material expert's judgment, the TTMCDT Instrument can aid in the processing of concept understanding abilities. Student participation in information gathering, data analysis, and problem solving is an important factor in this. Students' ability to comprehend concepts linked to light's qualities has been hampered by the use of only theoretical expla nations.

Meanwhile, based on the results of the instrument prototype's assessment by a learning instrument evaluation expert, it is clear that the instrument's TTMCDT instrument effectively presents evaluation questions. The prototype, however, was updated in various aspects, including the difficulty level, the variety of questions, and the unsettling function.

The biserial point correlation algorithm was used to determine the items validity. If r arithmetic> r table at a 5% significance level, the problem is considered to be legitimate. The results of the validity test indicate that all test items are legitimate.

The dependability test is designed to determine the amount of reliability of critical thinking abilities. Alpha Cronbach's alpha coefficient is employed. Value is determined using a price with a 5% significance threshold. If r count> r table, the problem is said to be reliable. The reliability of the test instruments was a value of r of 0.784 at the 95 percent confidence level or a significance level of 5%, indicating that the instrument was reliable.

A question's difficulty level varies; some are simple, while others are moderately complex. The data collected during the large-scale trial are used to not only examine the reliability of the TTMCDT items, but also to determine their difficulty level (Table 2).

In addition to determining the level of reliability, data from large-scale trials are utilized to establish the differentiating power of each item. Discriminatory analysis was used to determine the ability level of each learner. Each student possesses a unique set of abilities; some possess exceptional powers, while others possess mediocre abilities (Table 3).

In addition, the next measured aspect is the distractor function. Distractors are made in order to attract the attention of students to test their accuracy in choosing the answer (Table 4).

An independent sample t-test may be used during the evaluation step. The significance of differences in the experimental group's and control group's average concept understanding was determined using an independent sample t-test. The gains of the experimental and control groups are compared (Table 5).

Using a 95 percent degree of confidence, it can be stated that H0 has been rejected with a probability of 0.000. Because of this, the 95 percent confidence interval for average post-test concept understanding scores differs across the two populations. The experimental group's Concept Understanding Skill is superior than the control group's, according to the results of the test.

Evaluation questions must pose contextual and application-oriented queries. This is an example of a natural phenomenon involving the qualities of light; the illustration is provided. Additionally, when selecting an answer option, each incorrect answer must possess the cheater's function. Students are prompted to think critically in order to arrive at the correct

Table 2: Recapitulation of the Difficulty Level Analysis of the TTMCDT

		Question Number	
No	*Difficulty Level*	*Tier I*	*Tier II*
1	Easy	1, 5, 7, 8, 10, 11, 13, 16, 20	5, 10, 11, 16
2	Medium	2, 3, 4, 6, 14, 15, 17, 19	1, 2, 4, 6, 7, 8, 13, 14, 15, 17, 19, 20
3	Difficult	9, 12, 18	3, 9, 12, 18

Table 3: Recapitulation of the Differentiating Power Analysis of the TTMCD

		Number of Question	
No	*Differentiating Power Category*	*Tier I*	*Tier II*
1	Disposed	11	3, 10
2	Accepted with revision	3, 7, 9, 10, 12, 18, 20	1, 9, 11, 12, 18
3	Good, No revision needed	1, 8, 15, 16, 17, 19	4, 5, 6, 14, 20
4	Very Good	2, 4, 5, 6, 13, 14	2, 7, 8, 13, 15, 16, 17, 19

Table 4: Recapitulation by a Distractor of Ineffective Answer Choices

Number of Question	*Distractor*	*Point Biseria*	*Students who make a selection*
9 (Tier I)	B	0,045	2 students
10 (Tier I)	A	0,043	2 students
	C	0,053	3 students
13 (Tier I)	D	0,007	None
17 (Tier I)	B	0,001	None
19 (Tier I)	D	0,067	3 students

Table 5: Independent Sample t-Test

Levene's Test for Equality of Variances	*F*	*Sig.*	*T*	*Df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*
Equal variances assumed	1.625	.203	5.535	100	.000	12.293	2.225

Table 6: Results of the Normality Test Independent Sample t-test analysis

Tests of Normality							
		Kolmogorov-Smirnova			*Shapiro-Wilk*		
Score	*Condition*	*Statistic*	*Df*	*Sig.*	*Statistic*	*Df*	*Sig.*
Concept understanding	Pre-Test	.093	51	.200*	.975	1	.344
	Post-Test	.086	51	.200*	.977	1	.427

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

answers and justifications based on accepted scientific theories via these unpleasant responses.

The prototype of the TTMCDT instrument is next tested on a modest scale called preliminary field testing after it has been altered based on expert advice. Small-scale experiments were conducted in this study to ascertain the expected time required to administer the TTMCDT. Students spend roughly 70 minutes working on the questions, which means that each student's item can work for approximately 3.5 minutes.

Following the successful completion of a restricted trial, this instrument was advanced to the broad stage of testing. The student assessment questionnaire for the TTMCDT questions on a small-scale exam revealed that the TTMCDT questions were characterized as adequate for direct testing of the 20 updated questions on a large-scale test. The purpose of this study's large-scale experiment was to establish the reliability, difficulty level, differentiation, and functionality of the TTMCDT instrument, as well as to analyze student misconceptions. Additionally, at this stage, teacher interviews and student replies are undertaken. At this step, interviews were performed with teachers to ascertain their replies and thoughts regarding the TTMCDT instrument.

During the product testing phase, the TTMCDT instrument will be evaluated for its effectiveness in boosting primary school classes' concept acquisition while learning science using light material. While conducting pre- and posttests, a single group was used.

A normality, homogeneity, and balancing test are all prerequisites for the independent sample t-test before it can be performed. Pretest averages are compared between the groups and the experimental group to determine normality, and the Kolmogorov-Smirnov technique is used to determine homogeneity (Table 6).

According to what is presented in Table 6, the normality of the data tests performed at a significance level of 5% obtained a possibility of 0,200 for the experiment class's pretest data, and the same probability was obtained for the experiment class's posttest data. A probability of 0,200 is attained for the controller class using the data from the pre-test, and the same probability is obtained using the data from the post-test. It is possible to draw the conclusion that the test results in both of the experimental and control classes follow a normal distribution. This is due to the fact that the probability of a comprehensive normality test is greater than 0,05 (Table 7).

Table 7: Results of the Homogeneity Test Analysis of Independent Samples t-test

Test of Homogeneity of Variances			
Critical Thinking Skill			
Levene Statistic	*df1*	*df2*	*Sig.*
7.318	1	100	.052

A probability value of 0,052 was obtained via Levene's test to determine whether or not the experimental group and the control group were homogeneous. This acquisition has a significance level that is more than 0,05 (sig.> 0,05). It is possible to draw the conclusion that the test data for the experimental and control classes have the same variants, or that the data come from populations that have variants that are comparable to one another (Table 8).

For the purpose of the balance test, a comparison of the experimental group's and the control group's pre-test averages of their critical thinking skills was carried out. In light of the fact that the value of H0's probability is calculated to be 0,178, which corresponds to a confidence level of 95 percent (= 5 percent and sig.> 0.05), one can deduce that H0 is plausible. At this level of confidence, it is clear that there is no significant difference in the average level of critical thinking ability between the experimental group and the control group. These data demonstrate that both groups are comprised of individuals with equivalent abilities.

Following the completion of the analysis and the tests to prepare for it, an independent sample t test can be carried out. The independent sample t-test was utilized in order to investigate the significance of variations in the levels of average

Table 8: The Balance of the Independent Sample t-test Results

Levene's Test for Equality of Variances	*F*	*Sig.*	*T*	*Df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*
Equal variances assumed	7,318	,052	1,544	100	,178	3,490	2,261
Equal variances not assumed			1,544	89,440	,178	3,490	2,261

Table 9: Results of the Independent Sample t-test

Levene's Test for Equality of Variances	*F*	*Sig.*	*T*	*Df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*
Equal variances assumed	1,635	,204	5,525	100	,000	12,294	2,225
Equal variances not assumed			5,525	96,278	,000	12,294	2,225

Table 10: Results of the N-Gain Score

No	*Experiment Class N Gain Score (%)*	*Experiment Class N Gain Score*
Average	49,3752	0,493921569
Minimum	25	0,25
Maximum	89,29	0,89

critical thinking ability exhibited by the experimental group and the control group (Table 9).

With a probability value of 0,000, and corresponds level of confidence to a 95%, it may be stated that H_0 is rejected or the average post-test score of students' concept understanding is not the same in the two populations. The test findings indicate that the experimental group's concept understanding is superior to that of the control group (Table 10).

According to the N-Gain Score test calculation results, the average Ngain score for the experimental class is 0,493752 or 49,4%, with a minimum N-Gain value of 25 and a maximum N-Gain value of 89,29. According to Melzer's distribution criteria for the N-Gain score, 0,3 0,49 0,7 is considered moderate. While the control class's average Ngain value is 0,262 or 26,15 percent, with a minimum of -54,76 and a maximum of 70,91. According to Melzer's rules for dividing the N-Gain score, 0,26 0,3 falls into the low range.

Thus, the TTMCDT instrument is capable of identifying fourth grade students' misconceptions about learning light material in Science throughout the 2019/2020 academic year. The following is a profile of fourth-grade students' misconceptions about learning about light science.

Based on comparison of each indicator of understanding the concept of light for class IV students, it is evident that there are misconceptions regarding each learning indicator based on various comparisons. Concepts that students do not comprehend (category 1) are present in varying proportions across all indicators. The concept of seeing is the least understood by students, with 30 students not understanding it, while the concept of a light source has the lowest level of understanding with 5 student. In the category of misconceptions (category 2), the concept of the viewing process has the highest number of misconceptions with 87 students, while the concept of a light source has the lowest with 28 students. Furthermore, in the category of partial understanding with misconceptions (category 3), the concept of the nature of light has the highest number of students, 144 students, while the concept of light sources has the lowest number, 80 students. The highest number of students in the category of partial understanding without misconceptions (category 4) is 131 for the concept of the nature of light, while the lowest number is 66 for the concept of optical instruments. In category 55, the highest number of students is in the process of seeing, with as many as 27 students, and the lowest number is in the concept of light sources and optical instruments, with as few as 9 students.

Discussion

The purpose of this development research is to create a TTM-CDT instrument to ascertain students' misconceptions about learning science with light material in Grade IV Elementary School. The process of developing a prototype of the TTM-CDT instrument in light material learning is based on the results of an analysis of the Diagnostic Test instrument in light scientific learning needs of students and elementary school teachers in grade IV. Following that, experts evaluated the prototype of the TTMCDT instrument and provided feedback for prototype refinement. Following that, a restricted trial phase was conducted with the updated prototype. The limited trial results indicate that the media prototype is in a good category, although enhancements are being made based on user feedback from the limited trial. The outcome of the improvement is consistent with user feedback from a small experiment. The results of the media prototype's enhancement were subsequently evaluated on a larger scale. The TTMCDT prototype was tested in a larger trial stage and it was determined that the instrument possessed a distracting function, validity and reliability, high discriminatory power of the questions, and a moderate level of difficulty.

The TTMCDT is validated on an item-by-item basis. The Instrument TTMCDT validation results indicated that 17 of the 20 questions assessed were legitimate. Reliability refers to the question's consistency in assigning a value to the item being evaluated. The reliability study revealed a value of 0.784 for reliability. This demonstrates that the TTMCDT exam devised has a high degree of consistency in recognizing students' mistakes about the light content.

A distractor (detractor) might be considered beneficial if it appeals to a sizable proportion of test takers who do not understand the idea (Arikunto, 2013) and is picked by at least 5% of students (Ministry of National Education, 2008). A question may contain 3-5 distractors (Arifin, 2012), however the TTMCDT contains three answer choice distractors and three rationale choice distractors. While there are numerous deceivers that operate well, there are also numerous deceivers that do not work at all. There are six distractor answer choices that are ineffective on Tier I (Answer Choices) and five distractor answer choices that are ineffective on Tier II (Reason for answers). This is because students have encountered misconceptions, and what they believe to be accurate is actually erroneous, and hence do not choose the distractor.

The level of difficulty indicates the probability of correctly answering a question at a certain level of competence, which is typically stated as an index. A good inquiry is neither too simple nor too complicated. Too simple problems do not motivate students to work harder to solve them. On the other hand, excessively tough questions cause pupils to struggle with answering them and often lack the will to attempt to solve them. The TTMCDT instrument established this time contains 32,5 percent questions classified as easy, 50 percent questions classified as medium, and 17,5 percent questions classified as challenging. The percentage of questions corresponds to the findings of Wahyuningsih et al. (2013), Handayani (2014), and Fariyani (2015), who indicated that the average identification questions produced to ascertain students' misconceptions employed questions of the medium category. This is because if clever students work on classified problems, they will not find them too easy, and if less intelligent students work on them, they will not find them too tough. As a result, category questions are chosen to accommodate the abilities of all pupils.

The distinguishing power of an object is a term that refers to an item's ability to tell the difference between students who have mastered a subject and those who have not, have lacked, or have not mastered it (Kuswana, 2011). The TTMCDT instrument developed categorizes 35% of the questions as very good (excellent questions that can be used immediately), 27,5 percent as good (excellent questions that do not require improvement and can be used immediately), 30% as sufficient (excellent questions that can be used with revisions), and 7,5 percent as bad (the questions cannot be used). Before becoming a product of the TTMCDT instrument for identifying students' misconceptions, questions with sufficient category were altered according to their need for improvement. Questions that meet the criteria for discriminating power will be able to identify students who are brilliant and those who are not. This is consistent with Nugraeni et al. (2013) assertion that good items distinguish between intelligent and less bright pupils. As a result, questions with low discriminating power cannot be employed, as they cannot detect the difference between intelligent and less intelligent students.

The superiority of the designed TTMCDT instrument aids in finding misconceptions in scientific learning for fourth grade elementary school pupils learning about the properties of light. The testing step employs a pretest posttest control group design. This design can be explained by the presence of two groups: the experimental and the control. The experimental group was taught about the properties of light via the TTMCDT, whereas the control group was taught via a multiple choice instrument. Prior to the session, each group completed a pretest of critical thinking abilities. Following instruction, both groups completed a post-test of critical thinking abilities.

The average pretest score for students' concept understanding in the experimental class was 49,20 but after learning how to use the TTMCDT, the average score climbed to 73,08. The average score for students' concept understanding abilities in the control class was 45,71 but climbed to 60,78 after learning. Even if both are increasing, a difference test using the Independent Sample t-test is necessary to determine the difference in students' concept understanding between the experimental and control classes. Meanwhile, using the impact size test, determine the effect of employing the TTMCDT instrument on recognizing fourth grade elementary school students' misunderstandings.

With a significance value of 0.000, i.e. at the 95 percent confidence level (= 5% and sig. 0.05) obtained from the independent sample t-test, it may be stated that H_0 is rejected. Thus, it can be concluded that there is a significant (significant) difference in effectiveness between the TTMCDT instrument and multiple-choice instruments for identifying misconception and improving Critical Thinking Skills in learning science on light material in grade IV elementary school students in Surakarta during the 2019 academic year.

The outcomes of the students' responses were then assessed by assigning a Tier I, II, or III rating to each response in accordance with the Pacala scoring rules. The studied data is then classified into the categories of Partial comprehension without misconceptions, Partial comprehension with misconceptions, misunderstandings, and not understanding concepts.

According to the data collected, 28,7% of students do not understand the concept of light sources; 43,3% have misconceptions; 17,8% have partial understanding with misconceptions; 20,2% have partial understanding without misconceptions; and 14,9% have complete understanding. The second indicator pertains to the nature of light; 41,8%

of students lack comprehension; 20,4% have misconceptions; 38,7% have partial comprehension with misconceptions; 24,3% have partial comprehension without misconceptions; and 32,2% have complete comprehension. Thirdly, 38,25% of students are classified as not understanding the concept; 45,5% as having misconceptions; 43,25% as having partial understanding with misconceptions; 40,5% as having partial understanding without misconceptions; and 25% as having complete understanding. According to the fourth indicator, 34,5% of students do not understand the concept of optical instruments; 48% have misconceptions; 42,3% have partial understanding with misconceptions; 17,5% have partial understanding without misconceptions; and 10% have complete understanding.

We can conclude from the results of the research analysis of the TTMCDT Instrument that the instrument has the advantage of identifying students' skills to comprehend the notion of light. Additionally, the developed instrument is capable of identifying which concepts are not well grasped by a large proportion of pupils and therefore have a high potential for causing misconceptions. These benefits are not inherent in the instruments used by teachers to assess student learning results.

Through product testing, the experimental group outperformed the control group in terms of students' critical thinking skills in science learning. The effectiveness testing of this study product indicates that the developed TTMCDT instrument can effectively boost the critical thinking skills of fourth grade elementary school pupils when it comes to learning about the nature of light.

Conclusion

The following conclusions are drawn from the findings and discussion. To begin, the TTMCDT instrument is developed using curriculum indicators, evaluation tools, scientific theories and concepts, and student demands. The prototype was developed through a combination of limited and thorough trials, with subsequent revisions including experts. The enhancement of the study product led in the development of a TTMCDT instrument ideal for use by teachers in identifying students' misconceptions about science learning, particularly on the metrics of light qualities.

Second, a quasi-experimental test with a pretest-posttest control group design was used to evaluate the TTMCDT instrument. This phase of product development results in a TTMCDT Instrument that is successful at identifying primary school students' misconceptions about scientific learning.

Suggestion

The Three-Tier Multiple Choice Diagnostic Test instruments are quite versatile in their application. This instrument can be used by teachers as a diagnostic test. Additionally, teachers can utilize this instrument as instructional material to assist students in comprehending scientific concepts, hence improving students' critical thinking abilities. As a result, it is advised that teachers implement the instrument using a constructivist learning methodology.

The findings of this study can be utilized as a guide and point of reference for future comparable studies. Diverse research and development objectives can be accomplished through the selection of distinct materials and competencies.

Limitation

The instruments produced are limited to a few items in science education that have a relatively high percentage of misconceptions or misconceptions, including sound, light, energy, and force, as well as the earth and the cosmos. The Three-tier Multiple Choice Diagnostic Test instrument measures three domains of knowledge: factual, conceptual, and procedural knowledge.

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