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The Development of a Four Tier-Based Diagnostic Test Diagnostic Assessment on Science Concept Course

The Development of a Four Tier-Based Diagnostic Test Diagnostic Assessment on Science Concept Course

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Abstract. A learning success could be seen from the material mastery and conceptual understanding inculcation obtained by the students. To find out how students' misconceptions occur, it could be done by developing a diagnostic assessment. This research aims to develop and describe the instrument validity of the *four-tier* diagnostic test for diagnosing misconceptions by the Primary School Teacher Education program of Universitas Muria Kudus on Science Concept course. This research applies the *Research and Development* design. It consists of a preliminary study, diagnostic test development, and diagnostic test validation. This article discusses the development and *four-tier* diagnostic test instrument validation results. The developed instrument consisted of 40 question items. They were Physics and Biology materials. The validation stage involved content and face validities. The expert judgment results showed an average score of 93.09, with very valid criterion. Thus, the four-tier based diagnostic test was valid and could be implemented. The reliability calculation obtained the r-count score = 0.698, while the r-table score = 0.514. The r-count is higher than r-table, then the instrument was reliable. It showed that the instrument was valid and reliable and could be implemented for the students of Primary School Teacher Education. Based on the validation result, the *Four-Tier* based diagnostic test was valid and reliable to apply for diagnosing the students' misconceptions in science concept course.

1. Introduction

A learning success could be seen from the material mastery and conceptual understanding inculcation obtained by the students. As educator candidates, conceptual understanding internalization is an important matter to be mastered by the students of Primary School Teacher Education program. Identifying students' misconceptions are important. It is because they are the primary school teacher candidates and will share their conceptual understanding for the next generations. The science conceptual understanding mastery becomes the success indicator of the science concept of course learning. Based on the observation on the following course, Science Application, the science conceptual understanding masteries of the Primary School Teacher Education program students were still low. Several students had difficulties in applying the science concept into their tasks to make manipulative props for primary school learners. The students had difficulties in explaining and connecting the material concepts and their implementation as the basis of the manipulative prop arrangements. It indicated that most students had difficulties in learning science materials. The researchers assumed there were several students having misconception or even did not understand the concept. Sometimes the students could not provide a correct explanation about the science concept, especially about Biology or Physics. Preliminary research had been done, it was about the conceptual

understanding of the Primary School Teacher Education Program students on Science Application course taught by Project Based Learning [1]. It found the experimental group's conceptual understanding was better than the control group. The t-test and N-gain test results showed the experimental group behaviours. The experimental group, taught by PjBL during the Science Application course had an N-gain score with a moderate criterion.

On the other hand, the control group, taught by direct learning, had an N- n- gain score with a low criterion. It showed that several students' conceptual understandings had problems when specific interventions were not applied. It is supported by the findings of Fakhriyah et al [2]. The findings showed that the Primary School Teacher Education students' scientific literacy skills obtained a percentage of 66.2%, at the nominal level. Meanwhile, on the other hand, 33.8% of students were at the functional level. The data showed the students who had the concept to connect science with other disciplines could write a scientific term. However, it was found the still had misconceptions or incorrect concepts.

On the other hand, 33.8% of students remembered the theory and explained the concept correctly, but they had limited concept and difficulties to connect the concept to their arguments. A lack of conceptual mastery consistently will influence students' further learning process effectiveness [3]. The students construct concepts gradually. When it is inappropriately constructed; or it deviates from the original concept, then students will have difficulties to construct further concepts. Therefore, it is important to find out their difficulties in understanding the concepts they have already known and understood. Then, it could be continued by analysis and formulating solution. Initial identification of student misconceptions based on cluster analysis shows that 38.1% of students had misconceptions [4].

The occurring misconception was due to a mismatch between the understood explanation and the experts' agreed concepts. The occurring daily life experience becomes their basis for constructing their concepts based on their rationales. These rationales, actually, need to be ensured. The occurring misconception remains consistently in learners' mind to interpret a concept into conception or into a fact [5]. Tayubi [6] argues that when the constructed intuition of learning is incorrect, it will be difficult to correct it. It is due to such coincident matter consistently allows the incorrect concept to be the basis for the learner. When such misconception is allowed, it will become a hereditary mistake. It also hinders students from being creative. It is strengthened by Keshavaraz [7]. He argues that misconception is an incorrect individual who understood the concept of expert theories. When misconception is allowed, it hinders the students' learning achievements. Many factors influence misconception. They are such as the initial concepts of the students, teachers, environment, languages, textbooks, or reading sources [8], [9], [10], [11].

Many applicable ways could be applied to measure students' misconceptions. One of them is a diagnostic test. A diagnostic test was an alternative to measure the students' misconceptions on Science Concept course. It was applied at the beginning and the ending of learning. It functioned as a standard measurement worked by the students. It could also provide accurate descriptions about the experienced misconception on certain materials. The students' mistakes while answering these diagnostic questions would be the basis of their lack of understanding of certain materials. It could also be used as the basis of their mindset in sharing the responses of the incorrect answers [12].

The diagnostic test instrument development had been promoted by other researchers. It consisted of two, three, and four-tier multiple choices. Each level has different strengths and weaknesses. Chandrasegaran et al. [13] applied a two-tier diagnostic test to access or identify the scientific conceptions of Taiwanese learners. On the other hand, Tan et al. [14] applied it to access the conceptual understanding of ionized energy from Singaporean learners. Tsui and Treagust [12] applied it to evaluate the teachers' arguments dealing with the genetic field. Caleon and Subramaniam [15] developed and applied the three-tier diagnostic test to access the conceptual understanding of wave on Singaporean learners. Cetin-Dindar and Geban [16] also used it to access the concept of acid and base of the senior high school learners. This current research develops a four-tire diagnostic test. The four-tier test is a development of the three-tier diagnostic test. This development adds the students' levels

of confidence in selecting or writing the reasons. Caleon & Subramaniam [15] state that the developed level of confidence is within a range of one until six. The four-tier test has several better features such as 1) the lecturers could differ the levels of confidence on the learners' answers; therefore, it could investigate the strength and weakness of the students' concepts, 2) the lecturers could diagnose the experienced misconception of the students better, 3) the lecturers could determine the required materials to be further discussed, and 4) the lecturers could use it as a suggestion to determine learning that could decrease the students' misconceptions. The diagnostic test is a test to accurately find out and ensure the weakness and the strength of learners in certain courses [3]. Heretofore, this misconception condition has been measured by the appropriate instrument. The diagnostic test was developed to identify the weakness and strength of students in understanding conceptual science materials. The test implementation had the purpose of improving the subsequent learning process and motivating them to learn [17], [18]. Therefore, the diagnostic test is expected to be able to describe the students' skills and to determine in what concepts the students have misconceptions.

Therefore, it needs a diagnostic test development which is capable of measuring the students' misconceptions on science concept course. This development could provide suggestions to improve and to overcome any students' misconceptions or incorrect conceptions. By developing a four-tier diagnostic test, the students' science conceptual understanding would be facilitated and could be measured. This research aims to develop and describe the instrument validity of the four-tier diagnostic test for diagnosing misconceptions by the Primary School Teacher Education program of Universitas Muria Kudus on Science Concept course.

2. Method

This research applies the Research and Development design. It consists of a preliminary study, diagnostic test development, and diagnostic test validation. It is in line with Research and Development design characteristics within an educational context. It functions as a method that works systematically to a problem solution. Then, this problem solution is realized and tested [19]. The preliminary stage consisted of unachieved learning target identification. Then, it was continued by determining the misleading concept sources. From the preliminary study, the researcher determined the main discussion that had misconceptions and incorrect understandings. Then, in the development stage, the question forms were arranged and applied by using a reasoned-multiple choice. It was also complemented by levels of confidence to answer or express the reasons. During providing the reasons, it was entailed by levels of confidence. This matter revealed that the multiple-choice instrument could reveal higher thinking skill levels due to broader mastery level varieties [20]. The type of multiple choice questions is able to get students to answer questions carefully because there are choices where the choices contain distractors [21].

The next step dealt with diagnostic test question rubric arrangements, question writing, and question reviews. The questions were completed by assessment criteria and direction to work on them. It was strengthened by Putri et al. [22]. They found that the test question arrangement required detailed instruction by working on them. The developed diagnostic test consisted of 40 items. They were divided into 20 Biology and 20 Physics content items. All of them were taught in science concept course. These could be seen in Table 1.

Table 1. The diagnostic test question rubrics

Theme		Question Number	The Bloom Taxonomy Domains
Science Context			
Biology	Cells (structures and functions of plants and animals)	1,2,3	C3, C4, C5
	Biodiversity (Species, population, evolution, genetic variation)	4,5,6	C3, C4, C6
	Food chain, energy and material flow.	7.8	C4, C5

	Theme	Question	The Bloom
	The natural sustainability	9, 10, 11	C3, C4, C5
	The human body system (health, nutrition, digesting system, respiratory system, blood flow system, nerve system, and movement system).	12, 13, 14, 15, 16, 17, 18, 19, 20	C6, C4, C5, C6, C5, C3, C6, C5, C4
Physics	Materials (changing states, heat transfer, and electricity)	21, 22, 23, 24	C3, C4, C6, C4
	Kinematics (Force and Movement)	25, 26, 27	C5, C5, C4
	Energy and its changes	28, 29	C6, C5
	The radio, light, and sound waves	30, 31, 32	C3, C4, C6
	The history of Earth (the origin and evolution of Earth)	33, 34	C3, C5
	The structures of Earth (atmosphere, lithosphere, and hydrosphere)	35, 36	C5, C5
	Earth and outer space (gravity and solar system)	37, 38	C4, C3
	The energy inside of Earth system (tectonic plate, constructive and destructive forces)	39, 40	C4, C6

After developing the diagnostic test instrument, its quality, appropriateness, and reliability were analyzed. Therefore, a validation sheet of the instrument was arranged and used for the experts. The used results of validation were content and construct validities. Three experts validated the instrument. They were two Physics experts and a Biology expert. Besides that, in these stages, the question item analysis had purposed to measure the reliability, the discrimination power, and the difficulty level.

3. Finding and Discussion

This test development and arrangement could be applied to measure the experienced misconceptions of the students on the science concept. Of course, once the test had been validated by experts in terms of its reliability with quantitative calculation. The validation results were from three material experts of biology and physics. It is strengthened by Siswanto [23]. He revealed that the applicable criteria for validation required two independent groups or individuals in constructing a test by using the same specifications. Thus, this research results had been in line with the content validity criteria. The applied validation sheet contained information about content clarity and accuracy (based on the given indicators), grammar, relevance, communicative question sentence formulation, and clear instruction to work on them. The experts assess the validity of the contents of the diagnostic test items developed based on the validation sheet. The assessment used is a rating scale where the score is 1 if the question is not suitable and needs improvement overall, a score of 2 if the question is quite appropriate but needs a lot of improvement, a score of 3 if the question is appropriate but needs a little improvement, and a score of 4 if the question is suitable without any improvement can be used for research. After that the data were analyzed descriptively based on the criteria in Table 2

Table 2. Content validity criteria

Skor	Kriteria
$81 \leq X \leq 100$	Very Valid
$61 \leq X \leq 80$	Valid
$41 \leq X < 60$	Enough Valid
$21 \leq X < 40$	Less valid
$0 \leq X < 20$	Very Less Valid

The validation results showed the diagnostic test instrument was valid, as shown in Table 3. Thus, the instrument could be used to measure the experienced misconceptions by the students.

Table 3. The expert validation result recapitulation

No	Code	Score
1	Expert 1	92.95
2	Expert 2	94.82
3	Expert 3	91.50
	Average	93.09
	Criteria	Very Valid

The instrument was revised based on the experts' comments. These revisions for each question were:

a) the scientific naming and writing system for questions with scientific names. These scientific names had to be written based on the *binomial nomenclature* writing system.
b) The length of the presented options in the multiple-choice should have estimated the given time.
c) It was also important to differ each topic of material so the misconception could be clearly measured.
d) The misconception causes should also be found by applying additional data.
e) Need to add a distractor to the answer choices based on material that students do not understand.

The characteristics from the develop test instrument had been valid based on the experts. They were 1) the test questions had been developed based on scientific literacy aspects; 2) the material content scope that became the basis of broader question item arrangements, and 3) the Google form test sheet version had already had test direction to do.

From the experts' suggestions, the instrument was revised and its question items, dealing with Biology aspects that had not been in line with the principles of the scientific naming system, were adjusted. Indrawan [24] argues that all Biology experts in the world have agreed with the flora or fauna naming standard system. Their names are written in Latin language or scientific names. Thus, all scientific names had to be adjusted. Tsalasatunnisa [25] strengthened that *binomial nomenclature* could mediate students to understand all organisms in the world.

Besides, dealing with multiple-choice options, a multiple-choice question should only have equal phrase lengths of its options. It is to avoid probability for students to merely guess the answers. Thus, it will make them thinking of the answers based on their knowledge and understanding. Alternative parallel answers, same-length answers, logical distractors are practical requirements in compiling multiple choice questions [26]. The quality of a question is also determined by the functioning of the distractors. This distractor contributes to the distinguishing power of questions and also the difficulty level of test because it can distinguish between high-ability students and low-ability students [27], [28], [29]. This distractor can also be useful for exploring student misconceptions [30].

In the developed test instrument, specific diagnostic test measurement of a material topic or discussion had not been made. The reason was to find out the understood material distributions of the students. Thus, any misconception could be noticed. Even so, this test instrument could differ the students' skills and understanding. It is in line [31]. They found that excellent test items should be able to identify the students who had mastered certain materials to those who had not.

The revised test instruments were shared to a group of students that had already had science concept background knowledge. The validation was continued by reliability analysis. It used the Alpha Cronbach and discrimination power. The discrimination power was measured from the correct and incorrect answer proportion of the students. On the other hand, the question levels of difficulty were analyzed by comparing the correct answers of the students and the obtained total scores. Based on the question item analysis, the questions were reliable, so they could be applied. The complete

analysis is shown in Table 4. The table is about the analysis recapitulation of reliability, discrimination, power, and difficulty level of the test.

Table 4. The test item analysis result recapitulation

Number	Types	Results	Criteria
1.	Reliability	$r_{count} = 0{,}698$ $r_{table} = 0{,}514$	reliable
2.	Distinguishing Power	- 4 questions - 18 questions - 12 questions - 6 questions	-Remove -Revise -Accepted -Accepted excellently
3.	Difficulty levels	- 20 questions - 14 questions - 6 questions	-Difficult -Moderate -Easy

After carrying out the development stages and ensuring the instrument's validity and reliability, then this instrument could be used for students to measure their misconceptions. Instrument validation was important to obtain standardized and reliable instruments. It is in line with Siswanto [23]. He stated that question items with content validities could direct students to demonstrate the required skills and competences for the sake of the learning objectives. A good test has a balanced level of test difficulty, as well as the distinguishing power of questions which is very important to use to determine the allocation of students who have high and low abilities [32]. The greater the difficulty or the more difficult the question is, the ability to differentiate between students with high abilities and low abilities [33]. Fariyani et al. [34] argues that evaluative instrument development that could detect misconception is important to be developed. If students had misconceptions and they remained in them, it could hinder the students from studying the subsequent materials.

From the content and construct validities, this instrument had been valid and reliable to use. The developed instrument had met the characteristics demanded by [35], started from 1) test design to detect learners' difficulties, 2) the test development based on misleading sources or possible difficulties, and 3) the existence of reason provision to avoid guessing habits.

This test development is important to detect students' misconceptions. This type of four-tier diagnostic test is able to reveal more detailed misconceptions because in each student's choice there is a level of confidence that follows so as to avoid students from speculating. This four-tier diagnostic test can measure misconceptions in more detail [36]. The students who had misconceptions would have troubles to accept new knowledge [37]. Such misconceptions when they were allowed to be instilled longer could mislead them. They would probably assume such concepts were the correct ones. They would tend to apply their prior concepts rather than the latest concepts they obtained. Therefore, it was important to find out whether the students had misconceptions and which parts the students experienced it. Thus, it would allow teachers to follow up and to suppress these misconceptions.

4. Conclusion

The four-tier diagnostic test instrument development was done by promoting a preliminary study, a development stage, and validation. The four-tier diagnostic instrument consisted of four answer levels, confidence levels of the answers, four main options, and confidence levels to choose the reasons. The test instrument had been deemed valid and reliable. It is ready to be applied and to measure the misconceptions for the Primary School Teacher Education students.

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