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Diagnostic Tests Based on Three Level Tests on Fixed Materials for Students with Misconceptions

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ABSTRAK

Miskonsepsi merupakan suatu hal yang dapat menghambat penerimaan materi baru dan mempengaruhi keberhasilan dalam menyelesaikan masalah matematika. Penelitian ini bertujuan untuk mengembangkan tes diagnostik Three-Tier untuk mengidentifikasi kesalahan konsep (miskonsepsi). Pengembangan tes ini bertujuan untuk mengidentifikasi jenis kesalahan pada himpunan serta mendeskripsikan kualitas test diagnostik ini. Penelitian yang dilakukan penelitian model pengembangan plomp yaitu model banyak digunakan untuk pengembangan produk-produk pendidikan seperti bahan ajar, media, atau pun pendekatan pembelajaran. Populasi dalam Penelitian ini adalah mahasiswa pendidikan matematika. Analisis data yang dilakukan meliputi validitas, reliabilitas, tingkat kesukaran, daya pembeda, analisis angket, interpretasi hasil tes diagnostik pilihan ganda tiga tingkat, dan analisis profil pemahaman siswa terhadap siswa. Hasil penelitian ini mendapatkan tes diagnostik yang dapat mengetahui kesalahan konsep pada mahasiswa yang telah dilakukan uji validitas dan dinyatakan valid. Sehingga dapat ditarik kesimpulan yaitu, Instrumen tes diagnostik materi himpunan dalam penelitian ini meliputi; kisi-kisi tes diagnostik, soal tes diagnostik, lembar kunci jawaban dan rubrik tes diagnostik, lembar jawaban tes diagnostik, lembar validasi perangkat tes diagnostik, lembar tes diagnostik telah dihasilkan.

ABSTRACT

Misconception is something that can hinder the acceptance of new material and affect success in solving math problems. This study aims to develop a Three-Tier diagnostic test to identify misconceptions. The development of this test aims to identify the types of errors in the set and describe the quality of this diagnostic test. The research conducted was the plomp development model research, which is a model widely used for the development of educational products such as teaching materials, media, or learning approaches. The population in this study were students of mathematics education. Data analysis performed included validity, reliability, level of difficulty, discriminating power, questionnaire analysis, interpretation of three-level multiple-choice diagnostic test results, and profile analysis of students' understanding of students. The results of this study obtained a diagnostic test that can find out conceptual errors in students who have been tested for validity and declared valid. So that it can be concluded that the diagnostic test instrument for the set material in this study includes; diagnostic test grids, diagnostic test questions, answer key sheets and diagnostic test rubrics, diagnostic test answer sheets, diagnostic test kit validation sheets, diagnostic test sheets have been generated.

1. INTRODUCTION

Mathematics is one of the basic materials that are important to learn. Mathematics is a means of logical, analytical, and systematic thinking so that it can support other subject matter (Mariamah et al., 2021; Maslihah et al., 2020; Rismawati, 2016). It is important for every individual to study mathematics from elementary school to college level. Even to carry out daily activities can not be separated from the role of mathematics (Muttaqin et al., 2021; Wirayuda, Wandai, et al., 2022). Referring to this opinion, the focus of learning mathematics is the individual or student's understanding of the mathematical concept itself. One of the basic materials studied in mathematics is set material (Manurung et al., 2019; Rizqi et al., 2021).

The concept of the set is the basis for studying all branches of mathematics. This is in line with the opinion of previous study which states that branches of mathematics such as geometry and algebra require

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the concept of sets in their discussion (Nur'aini et al., 2017). Therefore, by studying the concept of the set of students, it is hoped that they can improve their logical abilities and stimulate logical thinking. In fact, in the lecture process, many students still have difficulty solving problems related to the set material. In fact, there are still students who find it difficult to learn the set material so that understanding the set material will cause errors or misconceptions (Hasibuan et al., 2018; Permatasari et al., 2019; Surya & Munawarah, 2017). Misconceptions in any subject can create problems that cannot be taken lightly. Especially in terms of basic arithmetic skills like math.

Misconception is an understanding of concepts that is not in accordance with scientific explanations and is one of the causes of a student's learning difficulties (Dewi & Ibrahim, 2019; Latifah et al., 2020; Yuliati, 2017). Misconceptions usually develop along the learning process. If misconceptions are allowed to occur in students, it will result in more concepts that are not understood by students and are less able to answer the questions given and ultimately have an impact on low learning outcomes (Juhji, 2017; Mukhlisa, 2021; Wirayuda, Darmaji, et al., 2022). Therefore, misconceptions that occur in students must be identified and the causes known so that learning objectives can be achieved (Adrianto et al., 2017; Izza et al., 2021; Putra et al., 2016). Although misconceptions are difficult to eliminate, if they can be identified early, efforts can be made to prevent and correct misconceptions.

One way that can be done to detect misconceptions that occur in students is by developing a Three-Tier diagnostic test (Amrina et al., 2020; Nazura Saputri & Anggreni, 2021; Suwarti et al., 2019). Diagnostic test Three-Tier Test is a diagnostic test composed of three levels of questions where the first level (one tier) is in the form of ordinary multiple choice or ordinary questions, the second level (two tier) is a choice of reasons for choosing the answer at the first level and the last one is the third level (three tier) in the form of beliefs from students based on answers at the first and second levels (Fatonah et al., 2020; Kirbulut, Z. D. & Geban, 2014). Students who answered correctly and were sure of their answers on the Three-Tier indicated that the student did understand a certain concept, students who were sure of the answer even though the answer was wrong indicated that the student had misconceptions, while students who answered incorrectly and were not sure of the answer did not mean students experience misconceptions, but students experience lack of knowledge.

According to previous study the advantages of the Three Tier diagnostic test are that it can: (1) diagnose misconceptions experienced by students in more depth, (2) determine parts of the material that require more emphasis during learning, (3) plan appropriate learning (Mubarak et al., 2016). It is better to help reduce students' misconceptions. Based on the above, it is important to develop a Three Level diagnostic test to help reduce students' misconceptions. Other research which aims to identify misconceptions in mathematics education students who are prospective mathematics teachers, where half of all students experience misconceptions when doing proof by mathematical induction (Atiqoh & Hafiz, 2021). This is the main reference for researchers so that researchers are interested in developing a diagnostic test to find out the misconceptions of mathematics education students at Jambi University.

The position of this research is to develop a diagnostic test based on Three Tierang which was developed in the scope of students as prospective mathematics education teachers, where previous research was to identify misconceptions experienced by students using the CRI (Certainty Response Index) method (Apriyanto et al., 2022; Yuberti et al., 2020). Based on these rights, the researcher conducts a research that aims to produce a three tier diagnostic test to find out student misconceptions (misconceptions) as prospective mathematics education teachers. This test was developed to find out the types of errors in the set and describe the quality of this diagnostic test. So that students as prospective teachers will be able to minimize misconceptions among students from an early age.

2. METHOD

The research conducted is a development model research. The development model used to develop this diagnostic test is a modification of the plomp development model, namely the development model. This model consists of 5 stages, namely (1) preliminary investigation, (2) design, (3) realization/construction, (4) test, evaluation, revision (test, evaluation), and (5) implementation (Ramadoni et al., 2019; Sari et al., 2019).

This research was conducted at Jambi University. The population in the study is an area that wants to be studied researched by researchers (Ebitz & Hayden, 2021; Sugiyono, 2019). As for the population in this study, namely all students of mathematics education at the Faculty of Teacher Training and Education, Jambi University as many as 98 students. Data collection using simple random sampling with simple random sampling technique used by researchers to predict the variance of a sample population. The sample taken in this study were 26 active students whose allocation was used in small group trials and student responses

to the development carried out. Researchers took this sample referring to the research of Nazura et al., 2021 which stated that small group trials were carried out with 1 class.

The research focuses on the development of Three-Tier diagnostic test questions. The resulting diagnostic test was tested for item validity, discriminatory power test, difficulty level test, and test reliability test. The diagnostic test instrument that has been prepared must be analyzed for validity. Data on the validity of the diagnostic test instrument obtained from the validation sheet were assessed by 3 validators consisting of two lecturers of Mathematics Education at the University of Jambi. The validated aspects are content, construct and language aspects. The validation results were then analyzed quantitatively using a percentage calculation using 5 level Likert scale. The data in this study contained qualitative data and quantitative data. Qualitative data were obtained from comments, suggestions, and improvements from validators and small and large group trial participants (Amin et al., 2022; Widyastuti, 2019). Indicating improvement in the development of diagnostic test kits. In addition, qualitative data was also obtained from the analysis of the answers of the large group trial participants. How to read, analyze, and take action on the results of doing diagnostic tests.

The data analysis carried out included validity, reliability, level of difficulty, discriminatory power, questionnaire analysis, interpretation of three-tier multiple choice diagnostic test results, and analysis of student understanding profiles of students. The data analysis technique used is to record data, reduce data, as well as review and select data that will be followed up and not followed up because of a researcher's consideration. So that every comment, suggestion, and improvement that comes from validators, and test participants must have a clear and responsible reason to be accepted. Quantitative data were obtained from a questionnaire instrument using a Likert scale, and the results of the implementation of diagnostic tests using scoring data results (Yeh & Tseng, 2019; Yuberti et al., 2020).

3. RESULT AND DISCUSSION

Result

Initial Investigation (Prelimenary Investigation)

In this study, an initial investigation was carried out in the form of an initial evaluation of the results of student learning outcomes in the real analysis course. There are four sub-topics in the real analysis course, namely sequences, series, metric spaces, and topology. Based on the quiz results for each sub-topic in the real analysis lecture, it was found that students experienced some basic errors. These errors affect the understanding of the material in the real analysis course. This relates to the concept of numbers, the concept of sets, and the concept of functions. Especially for the concept of the set, this material has been studied by students since junior high school learning to be precise in Class VII. So that the set material is not only intended for real analysis courses but several other courses in the mathematics education study program.

Stage Design (Design)

The second stage is the design stage, the researcher formulates the question indicators by referring to the indicators of competency achievement that have been obtained. This indicator will be used to construct a diagnostic test grid. Based on the competency standards, the set material is obtained. Then from the indicators formulated the topics of discussion of the set and an analysis is carried out to determine the direct object of Bell which includes facts, concepts, principles and skills on the set material. Next is the design of diagnostic test kits which include diagnostic test grids, diagnostic test questions, answer key sheets and diagnostic test rubrics, diagnostic test answer sheets, and diagnostic test kit validation sheets. The diagnostic test grids that are arranged is show in Table 1.

Table 1. Compiled Diagnostic Grid

CompetenceBase	Indicator
• Understand Definition and set notation, as well aspresentation	A. Students can recognize the meaning of set B. Students know the symbol and notation of membership of a set C. Students can state a set D. Students know the empty set E. Students know about the universal set
• Understand the concept of subsets	a. Students are able to determine subsets of a set b. Students are able to determine the number of subsets of a set
	a. Students can determine the intersection and union of two sets

CompetenceBase	Indicator
• Performing operations of intersection, union, difference, and complement on sets	b. Students can determine the meaning of the size (difference) of a set from other sets. c. Students can determine the complement of a set.
• Serveset with diagram venn	a. Students can present the intersection, union and difference of two sets with Venn diagrams b. Students can read Venn diagrams
• Using the concept of sets in problem solving	a. Students can solve problems using the concept of sets.

Realization (Construction Stage)

At the realization/construction stage, the diagnostic test kits that have been compiled and produced at the design stage are reassembled into a test sheet accompanied by clear instructions. All supporting instruments also undergo a validation process until they are declared valid for use.

Test, Evaluation, Revision Phase

At this stage, validation of all research instruments is carried out, product validation of diagnostic test equipment consisting of diagnostic test grids, diagnostic test questions, and diagnostic answer rubrics. This validation was carried out by 2 mathematics education lecturers. The results of the validation test by the validator are contained in Table 2.

Table 2. Validator validity results

Aspect	Percentage (%)	criteria
Contents	86.35%	Very good
Construct	82.72%	Very good
Language	84.55%	Very good

Base on Table 2 show the diagnostic instrument research instrument has been validated and the results are that the test instrument validation instrument is stated to be good, the readability sheet instrument is stated to be very good, the lecturer response questionnaire instrument is stated to be good, and the student response questionnaire instrument is stated to be very good with the percentage of content, construct and language respectively 86, 35, 82.72%, and 84.55%. The diagnostic test kit has been validated with comments and suggestions for improvement provided. The validity of the direct object integrated diagnostic test grid according to Bell, diagnostic tests, scoring rubric sheets and answer keys, answer sheets. The results of the One-on-one Evaluation (Trial) and small group trials produced comments and suggestions for improvement of diagnostic tests so as to produce practical diagnostic tests.

The results obtained are in the form of item analysis consisting of validation, rehabilitation, level of difficulty, distinguishing power, and distractor functioning. If one question is given a score of 1 (one), the lowest score obtained is 25 and the highest score is 70 out of 83 questions. Meanwhile, there was 1 question which was declared an error because there was no correct answer from the four answer choices. If the score is converted to a scale value of 100, then the average class obtained is 59.27 with the lowest score of 30.12 and the highest score of 84.34.

Implementation (Implementation)

After evaluating the diagnostic test kits through small group trials, and the next step is large group trials. In the large group trial, the test kits were given to respondents as many as 26, semester 5 students. All respondents answered each question on the diagnostic test kit by simulating the actual situation. The actual situation in question is the implementation of the diagnostic test device according to the work instructions that have been designed. From the large group trial, it can be seen that students experience misunderstandings (misconceptions) and the types of errors and misconceptions can be obtained.

Discussion

The results showed that the product in the form of a diagnostic test kit produced had valid, practical and effective qualities to achieve the research objectives. Valid meant here is valid from the validator's assessment. The product in the form of a grid of questions that is integrated with direct objects according to Bell is declared valid by both validators, as well as the diagnostic test as a whole is declared valid. This shows that the diagnostic test is valid in terms of content and constructs, as stated by previous study that the assessment tool must reflect the taxonomy of the area intended by the instructional objectives

(Maharani et al., 2019; Morocho-Lara et al., 2022). The basis for the expert's consideration of the learning outcome assessment tool was stated that it was in accordance with the instructional objectives that were intended to be measured (Irawan & Wilujeng, 2020; Yuberti et al., 2020).

The results of individual trials and small group trials are in the form of responses and suggestions for improvement. After following up on these suggestions for improvement, diagnostic tests can be used in large group trials whose results can be interpreted. So that a practical diagnostic test is obtained in accordance with the practical requirements of the assessment tool according to previous study which is practical and economical in terms of time and cost, easy to implement and score, the results can be interpreted and used accurately by the test administrator (Yuniati & Sari, 2018).

Diagnostic tests also have high reliability, which indicates that the resulting diagnostic tests meet the quality requirements of an assessment tool. Test reliability is one of the most important basic requirements (Harahap & Novita, 2020; Muslim et al., 2022). Beside shows the stability and internal consistency of a test, but also provides a guarantee that the test is able to have a good standard of measurement error. From the 82 questions developed, there are 42 questions that are suitable for use because they have fulfilled all the characteristics of the diagnostic test. There are 40 questions that are not suitable for use, because the questions are invalid and have a high level of difficulty. A high level of difficulty can cause test items to be invalid. This can be caused because the test questions developed are not in accordance with the material received by students (Agustina et al., 2021; Wulandari et al., 2020).

In this study there are results of item analysis, for questions that have an easy level of difficulty (21 of 33) have poor discriminating power (21 of 46), 15 of the 21 questions were invalid (15 of 40) this indicates that the upper group subjects are the same. There was a wrong answer with the lower group subject, after observing it turned out that the upper group subject had misconceptions regarding the material on these questions. Furthermore, researchers can find out the misconceptions that occur and their causes in questions that have poor and invalid distinguishing power, meaning that questions that have sufficient and bad distinguishing power, valid and invalid can both provide information on misconceptions that occur (Prodjosantoso & Hertina, 2019; Suwono et al., 2021).

The discussion above says that the diagnostic tests produced in this study meet the requirements of a good assessment tool, namely valid, reliable and practical. In accordance with the opinion that the third main requirement for a good quality assessment tool after validity and reliability is the practicality of its use (usability) (Aldila et al., 2020; Yuliati, 2017). Likewise previous study state that Instructional goal(s) and objectives as foundation for assessment of the most essential of these are validity, reliability and usability (Prodjosantoso & Hertina, 2019; Resta et al., 2020; Rismawati, 2016). Diagnostic tests when used in large group trials, information is obtained about the misconceptions that occur, the types of misconceptions and the causes of the misconceptions, this confirms that the diagnostic test can be said to be effective in accordance with the purpose of making this test, namely to find out conceptual errors (misconceptions) and the types of errors.

From the results of the analysis of the three tier test instrument categories, namely misconceptions, understanding concepts, not understanding concepts and guessing/lucky students experience greater misconceptions than other categories. The high level of student misconceptions cannot be separated from the cause according to Suparno, misconceptions have several factors, namely the teacher himself, students, textbooks, context and learning methods (Andriani et al., 2015; Korganci et al., 2015). Misconceptions in students can also occur due to a mathematical calculation error in calculating the value of a sought quantity. For students, they can improve their learning methods to reduce and prevent misconceptions (Didik et al., 2020; Maison, Lestari & Widaningtyas, 2020). Students can also reproduce learning references and ask teachers or experts if there are still concepts that are not understood.

Seen from previous research conducted an analysis of the misconceptions of prospective elementary school teachers using the Three Tier Diagnostic Test on the number concept material carried out on students (Nurwahida & Munir, 2022). However, it was found that there was no development of a Three-Tie diagnostic test on the specified material, so the novelty of this researcher developed a Three-Tie diagnostic test on the set material. A similar study was also conducted by other study state that the diagnostic test had the following characteristics: 1) developed based on the analysis of the source of difficulty, 2) used the form of questions with short answers, and 3) if using multiple choice questions it was necessary to include a choice of reasons (Rusilowati, 2015). The gap in this research, the source of student difficulties is obtained from the reasons students answer questions during small-scale trials, so that it can be seen whether students have misconceptions or not. Then the test developed in this study is a multiple choice form accompanied by a choice of reasons.

The implications of this study provide an overview of diagnostic tests based on three level tests on fixed materials in order to solve students' misconceptions. Recommendations for teachers that this three-tier test instrument can be used to identify students' misconceptions on the set material so that the results

can be followed up by subject teachers so that students do not experience obstacles in the next material. For further research, it is expected to be able to develop similar diagnostic instruments on other basic materials and be implemented using other variables. The research is expected to be able to provide implications by continuing to the implementation stage on a wider scale so that it can really be used by teachers, both prospective teachers, teachers and lecturers in overcoming problems caused by misconceptions of set material. In other words, the developed instrument has been working properly.

4. CONCLUSION

Based on the results of the research conducted, the conclusions obtained are, the diagnostic test instruments for the set material in this study include; diagnostic test grids, diagnostic test questions, answer key sheets and diagnostic test rubrics, diagnostic test answer sheets, diagnostic test device validation sheets, diagnostic test sheets have been generated. Judging from the purpose of making diagnostic tests when used in large group trials, information was obtained about the misconceptions that occurred, types of misconceptions and causes of misconceptions.

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