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DEVELOPMENT OF TEST INSTRUMENTS FOR THE METACOGNITION ABILITY OF LINEAR PROGRAM MATERIALS

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ABSTRACT Metacognition ability has a crucial role in the learning process, especially in solving complex problems, therefore it is important to develop a metacognition ability test instrument. This study aims to provide an effective instrument in measuring students' metacognition ability in linear program materials for high school students. The method used is the R&D model of the ADDIE, with the research subject being conducted at SMAN 8 Kota Serang by involving 25 students of grade XI MIPA 2 as research subjects. The research produced four instrument questions, with an average item validity score of 0.70, indicating that the test instrument is valid. The reliability of this instrument was also well-tested, achieving a score of 0.73, which demonstrates a high level of reliability. Based on the student response questionnaire, 71% indicated that the instrument is practical for implementation. Overall, the developed test instrument can be concluded as an effective tool for measuring students' metacognitive abilities in understanding linear programming material in a high school educational setting.

Keywords: instrument development, linear programs, metacognition ability

ABSTRAK Kemampuan metakognisi memiliki peran krusial dalam proses pembelajaran, terutama dalam pemecahan masalah yang kompleks, oleh karena itu penting untuk mengembangkan instrumen tes kemampuan metakognisi. Penelitian ini bertujuan untuk menyediakan instrumen yang efektif dalam mengukur kemampuan metakognisi siswa pada materi program linear untuk siswa SMA. Metode yang digunakan adalah R&D model ADDIE, dengan subjek penelitian yang dilakukan di SMAN 8 Kota Serang dengan melibatkan 25 siswa kelas XI MIPA 2 sebagai subjek penelitian. Hasil penelitian menghasilkan empat buah soal instrumen, yang mana validitas butir soal rata-rata mencapai 0,70 menandakan instrumen tes tersebut valid. Reliabilitas instrumen ini juga teruji dengan baik, memperoleh nilai 0,73 yang menunjukkan tingkat reliabilitas yang tinggi. Berdasarkan angket respon siswa didapatkan 71% yang dimaksudkan bahwa instrumen praktis untuk dapat diimplementasikan. Secara keseluruhan, instrumen tes yang telah dikembangkan dapat disimpulkan sebagai alat yang efektif untuk mengukur kemampuan metakognisi siswa dalam memahami materi program linear di lingkungan pendidikan SMA.

Kata-kata kunci: pengembangan instrumen, program linear, kemampuan metakognisi

INTRODUCTION

Mathematics education is an essential part of the curriculum at various levels of education, from elementary school to university. Mathematics is taught at every level with the aim of enhancing students' abilities to think logically, analytically, and critically, as well as preparing them to face various challenges that arise in everyday life (Hendi, Caswita, & Haenilah 2020). Various topics on concepts and skills are taught in mathematics, ranging from basic arithmetic operations, geometry, and algebra to more complex subjects like calculus and statistics. One of the subjects studied by 11th-grade high school students is the linear program, which is an important part of the math curriculum.

Linear programs involve complex mathematical concepts such as linear equation systems, objective functions, and constraints in the form of inequality. Students are expected to gain a better understanding of how mathematics is used in real-world decision-making by studying linear programs (Nurajijah, Khaerunnisa, & Hadi FS 2023). In addition, studying linear programs students learn graphical and algebraic methods to find the best solutions to problems involving various variables and constraints (Amadea & Ayuningtyas 2020).

In the research of Rizki & Linuhung (2016), students' linear program materials have difficulties in understanding the concept of modeling problems. In linear program learning, this problem is the main challenge. This is because students need to learn the problem model before proceeding to the solution and analysis stage. Explained in Ayuningsih, Setyowati, & Utami (2020), errors in solving linear program problems are found in conceptual errors of 83% which include general information what is known and asked, errors in writing information data on questions and others. Students also have difficulty determining the steps that can be used to solve problems correctly (Rahmawati & Permata, 2018).

With these errors, students must develop the ability to identify and analyze the thought process in order to avoid mistakes that often occur. Metacognition ability are needed to deal with problems where students are able to observe, regulate, and reflect on their cognitive actions (Wisnanti, Sunardi, & Trapsilasiwi 2014). Metacognition allows students to regulate their cognitive skills and recognize their weaknesses, so that they can improve their actions in the future (Nurmalasari, Winarso, & Nurhayat 2015).

O' Neil & Abedi in Panaoura & Philippou (2005) views metacognition as consisting of awareness of planning, implementing, and monitoring cognitive strategies. For the successful solution of any complex problem, various processes of metacognition ability are required. Flavell states metacognition as an effective learning tool and an important predictor of various cognitive abilities such as reading comprehension, writing, and problem-solving (Öztürk, 2022). Metacognition is essential for students

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because it allows them to observe and assess their abilities and knowledge, determine appropriate strategies for solving problems, and use information effectively to achieve goals (Kamaliyah et al., 2022). Metacognition ability are the main focus because they play an important role in helping students understand and solve complex problems. Metacognition involves the ability of students to be aware, control, and direct the student's thought process during learning and problem-solving. With metacognition ability, students can identify the right strategies, evaluate and reflect on mistakes that occur so that they can overcome learning difficulties more independently and efficiently. Metacognition ability contributes to learning success especially in the problem-solving process (Kusuma and Nurmawanti 2023). Providing questions that hone metacognition ability to students is very important because it can increase students' awareness of thinking in the learning process, encourage students to plan strategies and reflect on the results they get during solving problems, thereby deepening the understanding obtained by students. In addition, metacognition-based questions help students think strategically and systematically, choose the right approach, and evaluate mistakes, which ultimately makes them more effective in problem-solving (Wisnanti et al. 2014).For this reason, the right tools or instruments are needed to support this ability. With the right instruments, teachers can more easily identify students' weaknesses in thinking metacognitively and provide appropriate interventions in the linear program learning process.

From this discussion, this study focuses on the development of instruments that can be used to measure students' metacognition abilities in linear program materials. The linear program material was chosen because it is one of the topics that is considered quite complex and crucial, not only teaching mathematical concepts such as linear equation systems and inequality, but also involving critical thinking in decision-making, which is very relevant to real-life situations. So it is hoped that teachers can use the test instrument so that student metacognition is formed.

METHODS

Using this type of research and development to help produce valid, realistic and practical test instruments can be used to help improve students' metacognition abilities in schools in linear program materials. The research uses the ADDIE development model based on Sugiyono (2017), which consists of five stages including: 1) Analysis, 2) Design, 3) Development, 4) Implementation, dan 5) Evaluation.

The initial stage is the analysis stage, which is used to analyze needs, curriculum analysis, and literature analysis as a basis for developing instrument products. The next stage is design, which is used to compile the product, write test instruments, review the questions, and determine the scoring guidelines. At this stage, it is the initial product (prototype) of instrument development based on the results of the

analysis. The third stage is development containing product validation, the initial product (prototype I) is validated by 3 experts to validate from the material, construct, and language aspects. The stage was accompanied by comments and suggestions from validators who improved the instrument as prototype II. The fourth stage is implementation where the prototype II instrument is field tested to students and then analyzed including reliability tests, difficulty levels, and discriminating power. The last stage is an evaluation which is carried out to check students' responses to the instruments given.

The instrument developed includes four items using metacognition ability indicators. This research was conducted in class XI MIPA 2 SMAN 8 Kota Serang, as many as 25 students were selected using the purposive sampling technique. The data analysis method uses qualitative data analysis to analyze suggestions and criticisms from validators through validation sheets and quantitative data analysis is the results of the expert validation questionnaire test, the analysis of the results of question instruments through field tests, and the results of the student response questionnaire test. The data was analyzed using the Microsoft Excel and Anates applications for the analysis of the data used, namely the analysis of validity, reliability, difficulty of questions, discriminating power, and analysis of the practicality of the results of the student response questionnaire. Validity assessment criteria in the instrument using a Likert scale of 1-5 with assessment criteria.

Table 1. Validity Assessment Criteria

Percentage(%)	Level of Validity
81-100	Very Valid
61-80	Valid
41-60	Sufficiently Valid
21-40	Invalid
<21	Very Invalid

(Rahmania et al., 2023)

Reliability testing is used for the reliability of instruments used with reliable criteria as a result of the interpretation of (Son 2019)

Table 2. Reliability Criteria

Reliability Coefficient	Level of Reliability
$0{,}00 \leq r_i < 0{,}50$	Low Reliability
$0{,}50 \leq r_i < 0{,}70$	Medium Reliability
$0{,}70 \leq r_i < 0{,}90$	High Reliability
$0{,}90 \leq r_i \leq 1{,}00$	Very High Reliability

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The student response questionnaire was used to collect empirical data on students' perception of the questions, the level of difficulty, clarity of the questions, and their relevance. Practicality criteria based on student response questionnaires based on (Widoyoko 2017).

Table 3. Practicality Criteria

Practicability Criteria (%)	Level of Practicability
$p < 80$	Vey Practical
$60 < p \leq 80$	Practical
$40 < p \leq 600$	Fairly Practical
$20 < p \leq 40$	Less Practical
$p \leq 20$	Very Practical

FINDING AND DISCUSSION

Analysis

The development of the instrument aims to produce a test instrument that can measure students' metacognition ability in mathematics learning, especially linear program materials so that it can be used as an assessment instrument to increase students' awareness of the thinking process, increase learning effectiveness, and of course can be used by teachers in promoting good teaching. Curriculum analysis is used to identify the suitability of suitable materials according to the scope of the main points in accordance with the applicable curriculum. Linear program materials are adjusted to the components of the independent curriculum that apply based on Phase F with predetermined learning outcomes. The linear program material to be taken is to make a model of the problem of the problem and determine the optimal value. The optimal problem of a linear program is the maximum and minimum problem of linear functions in a linear inequality system that includes the value of optimizing the objective function (Yolanda & Wahyuni, 2022).

Metacognition plays an important role in supporting the math learning process especially in terms of problem solving, students consciously evaluate and build deep structures to choose the right solution (Atmaja, 2021). Fadhillah & Aini (2019) Learning with metacognition provides regulation for students in carrying out learning well and students in solving problems will also be directed. Schraw & Dennison (1994), the stages in metacognition include planning, monitoring, and evaluation activities with the stages in metacognition maximizing students in carrying out learning and solving problems. So that metacognition ability is able to manage cognitive activities well so that it has the potential to solve problems.

Design

The scope of linear program material that has been analyzed based on the learning outcomes applicable in Phase F in the previous stage is used as a basis for compiling a fromwork of question instruments. This formwork is developed according to the framework of metacognition indicators from Magiera & Zawojewski (2011) which was adapted by the author to create a suitable test instrument product based on the previous analysis.

Table 4. Framework of Instruments with Metacognition Ability

Learning Objectives	Metacognition Ability Indicators	Question Indicators	Question Form	Number
Learners determine mathematical models and optical values by applying appropriate procedures for Solve linear program problems related to daily life problems	Planning (Identify students' awareness to be able to determine initial information and clues related to the problem)	Students can write down the information obtained from the problem	Description	1a
	Monitoring (Able to prepare plans or settlement steps from the information obtained in sequence)	Students can make a mathematical model of a problem into a two-variable linear inequality		1b
	Monitoring (Able to prepare plans or settlement steps from the information obtained in sequence)	Students can make a mathematical model of a problem into a two-variable linear inequality	Description	2
	Evaluation (Can use strategies appropriately to solve problems from the information obtained)	Students can determine the optimum value of a two-variate linear program problem		
	Evaluation (Can use strategies appropriately to solve problems from the information obtained)	Students can determine the problem of a two-variable linear program by determining the optimum value	Description	3
	Evaluation (Can make conclusions from the answers that have been obtained)			
	Evaluation (Can use strategies appropriately to solve problems from the information obtained)	Siswa dapat menganalis nilai optimum suatu masalah program linear dua variabel	Description	4

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Using the fromwork, the development instrument products are arranged as prototype I by creating scoring guidelines as an accurate evaluation tool. At this stage, it is also used to design a validity questionnaire that will be used to validate the product developed and a student response questionnaire to get feedback from students regarding the use of the product. The validity of the contents of the instruments used is tested through the consideration of experts to ensure compatibility with fromwork, rubrics, evaluation sheet, scaling, and scoring (Wahyuni, 2022).

Development

Instrument products that have been created based on a fromwork with indicators of metacognition ability will be validated by three expert validators. These validators consist of two high school mathematics teachers who have earned a master's degree, and one high school mathematics teacher who is pursuing a master's degree. This validation process includes an assessment of three domain: material, construct, and language. Each aspect will be evaluated through a total of 13 questions designed to measure the extent to which the instrument is valid and in line with the expected objectives. Assessments from these experts will provide valuable input to ensure that the instrument is not only valid, but also easy to understand and use by students in the field.

Table 5. Expert Validation Result

Domain	Presentage	Criteria
Material	88%	Very Valid
Construct	86,67%	Very Valid
Language	81,67%	Very Valid

From table 5, it can be seen that from the material aspect of the question instrument developed, there is a correspondence between the question items and the indicators of metacognition ability and the question indicators according to the grade level by showing an expert test score of 88%. Then in the construction aspect, the expert test score was 86.67% which indicates that the question items developed have clear guidelines and instructions for working by including the help of pictures or tables. As for language, it gets 81.67% from experts. All aspects are on very valid criteria. In expert validation, the language aspect received comments and suggestions from the first expert regarding the use of names in question items, preferably using names or figures that are easily recognized by students to be more relevant to students' lives. These comments and suggestions are used as weighing material for revising test instruments. The results of the revision of the instrument based on comments and suggestions on expert validation resulted in prototype II which will be used in field tests to subject students.

Implementation

The results of prototype II, which is a revision of the previous stage, were tested on 25 students of Class XI MIPA 2. Each student was given 4 description questions to measure their metacognition skills. The results of this test were then analyzed to evaluate from the 4 questions that had been developed from prototype II.

Table 6. Level of Difficulty, Dicrimination Power, And Reliability

No.	Difficulty Level	Difficulty Level Criteria	Discrimination Index	Discrimination Index Criteria	Validity Test	Validity Test Criteria
1	0,82	Easy	0,47	Good	0,68	Valid
2	0,26	difficult	0,30	Accepted	0,69	Valid
3	0,61	Moderate	0,52	Good	0,67	Valid
4	0,72	Easy	0,65	Good	0,78	Very Valid

Based on table 6, it is stated that the 4 questions of prototype II results have a reliability value of 0.73 which shows that the instrument product has good internal consistency and is reliable to measure students' metacognition ability, which shows that the instrument is quite stable and can produce consistent results every time it is used. The results of the difficulty test showed that the questions given to Class XI MIPA 2 students had different levels of difficulty. Of the four descriptive questions used to evaluate metacognition ability, two questions were considered easy, one question was considered moderate, and one question was considered difficult. Questions with varying levels of difficulty ensure that the instrument can assess metacognition abilities more thoroughly and fairly, as these levels of difficulty show a balanced distribution.

Evaluation

This stage aimed to evaluate the practicality of the developed instrument by analyzing students' responses to the question items. A total of 10 questions were administered to 15 students who were randomly selected from the target population. These students were asked to respond to the items in the metacognitive ability instrument, which was designed to assess understanding in the context of linear programming for high school mathematics.

The responses obtained were then analyzed to determine the level of practicality of the instrument. The result showed that the instrument achieved a practicality score of 71%, which falls under the "practical" category. This indicates that, from the students' perspective, the instrument was understandable, feasible to complete, and appropriate in terms of content and format.

The 71% score reflects the general acceptance and ease of use of the instrument by the students, suggesting that the instrument can be confidently implemented in actual classroom settings. Therefore, it can be concluded that the metacognitive

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ability instrument is adequately practical and has the potential to be used effectively in mathematics instruction, especially in teaching linear program topics.

This development research is prepared based on metacognisical indicators by adjusting learning outcomes according to the applicable curriculum. The shape of the question items on the metacognition ability test instrument is made varied with the addition of the context of the student's environment so that students can easily understand the questions. Each question item developed on the test instrument has paid attention to each stage of metacognition in line with Schraw & Dennison (1994), the stages in metacognition include planning activities, monitoring, and evaluation.

In the planning stage, the metacognition ability indicator is used to identify student awareness to be able to determine initial information and clues related to the problem. The question items presented ask students to describe the information that is known and asked in the problems presented by this hail aims to be able to explore students' skills in finding important information. In this indicator, in accordance with research conducted by Wisnanti et al., (2014) that in the initial phase of metacognition, information search is carried out in solving problems. In the monitoring stage, the metacognition ability indicator used can prepare a plan or solution step from the information obtained in order. The metacognition skills developed at this stage are to develop a plan that can be used in solving a given problem. The monitoring stages in the developed instrument also use appropriate strategies to solve problems from the information obtained, this is in line with research by Amir & Kusuma W (2018) in solving problems can check each solution step by giving a check mark on the part that has been examined. And at the evaluation stage, the metacognition ability indicators used can use the right strategy by completing the information and making conclusions from the answers that have been obtained.

Based on this description, this test instrument can be a tool to measure the metacognition ability of high school students, especially in linear program materials in solving problems in line with the research of Safitri et al. (2020) The stages of planning, monitoring, and evaluation can help solve student problems.

CONCLUSIONS AND RECOMMENDATIONS

Based on the stages of research and development of metacognition ability test instruments, four question items have been designed by paying attention to the fromwork that includes important indicators of metacognition ability. The validity of this instrument was evaluated by experts with satisfactory results: the material aspect reached 88%, the construction aspect 86.67%, and the language aspect 81.67%. These values show that the instrument is classified as very valid. Meanwhile, the reliability of this instrument was tested with a value of 0.73 reflecting a high level of reliability. The test instrument also underwent a discriminating power test, where the majority of questions received a good classification. These questions cover

varying levels of difficulty, consisting of two easy questions, one medium question, and one difficult question. And from the results of the questionnaire student response to the practicality of the test instrument, a score of 71% was obtained, which was categorized as practical to be implemented in mathematics learning in schools. Thus, the test instrument that has been developed can be concluded as a valid, reliable, and practical tool to measure students' metacognition ability in understanding linear program material. In this study, the researcher wants to provide suggestions to future researchers to be able to develop other assessment products and with a variety of materials to support students' metacognition skills.

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