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Development of Essay Test Assessment Rubric for Polya Theory-Based Mathematical Problem-Solving

Muhammad Rizki Cahyadi[1], Bhaskoro Prasetyo Adi Maryanto[2], Mohammad Syaifuddin[3*]
[1,2,3]Universitas Muhammadiyah Malang, Indonesia

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ABSTRAK

Penilaian merupakan bagian penting dalam proses pembelajaran. Namun penilaian sering kali dilakukan secara subjektif oleh pemeriksa, khususnya pada tes esai. Rubrik penilaian menjadi salah satu solusi untuk meminimalisir subjektifitas penilaian sehingga menghasilkan nilai yang lebih objektif dan konsisten. Oleh sebab itu perlu dilakukan pengembangan rubrik penilaian tes esai. Penelitian ini bertujuan untuk menghasilkan rubrik penilaian tes esai kemampuan pemecahan masalah matematis berbasis teori Polya. Metode pengembangan rubrik penilaian menggunakan model Plomp yang terdiri dari tiga fase, yaitu fase penelitian awal, fase prototipe, dan fase penilaian. Hasil uji validitas oleh ahli memperoleh skor 3,40 pada skala 1-4. Rubrik hasil validasi kemudian diimplikasikan pada penilaian tes esai yang diberikan kepada 30 orang siswa menengah pertama (SMP). Implikasi rubrik sekaligus menjadi uji empirik efektifitas rubrik. Hasil uji empirik menggunakan tiga kelompok rater memperoleh koefisien korelasi sebesar 0,9290. Berdasarkan hasil uji validitas dan uji empirik, maka dapat disimpulkan bahwa rubrik penilaian tes esai kemampuan pemecahan masalah matematis berbasis teori Polya valid dan fisibel.

Keywords:

Mathematical Problem Solving,
Polya,
Rubric Assesment,
Essay Test.

ABSTRACT

Assessment is an important part of the learning process. However, assessment is often carried out subjectively by the examiner, especially in essay tests. The scoring rubric is one of the solutions to minimize the subjectivity of the assessment to produce more objective and consistent grades. Therefore, it is necessary to develop an essay test assessment rubric. This study aims to produce a rubric for evaluating essay tests for mathematical problem-solving abilities based on Polya's theory. The method for developing an assessment rubric uses the Plomp model which consists of three phases, namely the initial research phase, the prototype phase, and the assessment phase. The results of the validity test by experts obtained a score of 3.40 on a scale of 1-4. The rubric of the validation results was then implicated in the assessment of the essay test given to 30 junior high school students. The implication of the rubric is as well as an empirical test of the effectiveness of the rubric. The empirical test results using three groups of raters obtained a correlation coefficient of 0.9290. Based on the results of validity tests and empirical tests, it can be concluded that the rubric for assessing essay tests for mathematical problem-solving abilities based on Polya theory is valid and feasible.

Corresponding Author:

Mohammad Syaifuddin
Program Studi Pendidikan Matematika, Universitas Muhammadiyah Malang,
Jl. Raya Tlogomas No. 246, Malang, Jawa Timur, Indonesia.
Email: mrizkicahyadi@webmail.umm.ac.id

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Introduction

Assessment is an integral part of the learning process. Assessment is defined as a systematic and continuous effort to obtain information about student learning outcomes (Darmayanti, Syaifuddin, et al., 2022; Hung & Wang, 2021; Leacock & Nesbit, 2007). The results of the assessment provide an overview of student performance in understanding subject matter or certain competencies expected in learning objectives (Choirudin et al., 2022; Nurtanto et al., 2021; Otgonbaatar, 2021). Assessment must follow principles in order to provide a fair and accurate picture of student learning outcomes. The principles of assessment include: (a) Skill-based; (b) valid; (c) appropriate; (d) objective; (e) sustainable; (f) Comprehensive; (g) open; and (h) means (Özer et al., 2020; Palinussa et al., 2021; Suwarno & Aeni, 2021a).

Assessment is generally done by test. There are various types of tests, such as written tests, oral tests, and practice tests (Asrul et al., 2015). Specifically for written tests, it is divided into two forms, namely objective tests and essays. Objective tests are examined according to the objectivity of student answers without being influenced by the examiner's point of view or subjectivity (Prayitno, 2019). In contrast to essay tests which often involve subjectivity in the examination (Nurhaifa et al., 2020). (Asmana, 2018)revealed that teachers often only use personal intuition in making assessments without specific guidelines. Subjectivity will give habit in the assessment so that the learning outcomes or achievement of student competence becomes invalid. This will be a big problem if it continues, considering that the essay test is a test that is often used to measure and assess student competency.

One of the competencies that is often assessed using essay tests is problem solving ability. Problem solving ability is the ability of individuals or groups to be able to find a way out or solution to the problem at hand (Rismen et al., 2020). Problem solving abilities are generally formed through learning mathematics, so they are often referred to as mathematical problem solving abilities. The National Council of Teachers of Mathematics (NCTM) even states that problem solving ability is the main objective of learning mathematics (NCTM, 2000). Students' mathematical problem solving abilities can be observed and analyzed through the work process of solving the problems they describe, so that the essay test is a suitable test for assessing students' mathematical problem solving abilities (Darmayanti, Sugianto, et al., 2022; Lastuti, 2018; Zulfa et al., 2019). However, if the essay test is not examined objectively then the results of the mathematical problem solving ability test will be biased and invalid.

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The subjectivity and habit of essay tests can be minimized by using a scoring rubric. Rubrics are assessment guidelines used by teachers to interpret criteria or levels of student learning outcomes (Febriana, 2021; Sesanti & Ferdiani, 2017). Rubrics are designed as a guide for teachers to provide more accurate and objective assessments and to be able to describe actual student competencies (Jonan, 2020; Nurhaifa et al., 2020). For students, rubrics represent learning expectations so that students are more motivated in learning (Suwarno & Aeni, 2021b). The rubric has four basic features, namely: 1) title or description of achievement; 2) scores; 3) component or aspect of achievement; and 4) description of the quality of work in each aspect of achievement (Stevens & Levi, 2013).

Based on the exposure to these problems, it is necessary to develop a rubric for assessing essay tests for mathematical problem solving abilities. This is in line with research (Hull et al., 2013)which concludes that it is necessary to develop a problem-solving rubric. One of the developments that can be made to the problem solving rubric is to design a rubric according to Polya's problem solving theory. There are four aspects to the Polya problem-solving model, namely understanding the problem, devising a plan, carrying out the plan, and looking back (Polya, 1973).

Several rubric developments have been carried out, such as (Fitriani & Yarmayani, 2018) developing a creative thinking rubric, (Kurniasih et al., 2020) developing a critical thinking performance assessment rubric, developing a performance assessment (Nurhaifa et al., 2020) rubric, (Hermawan et al., 2017)and (Hairida et al., 2021) equally developing a collaborative skills rubric. The development of a problem-solving ability rubric has also been carried out by (Docktor et al., 2016) the rubric, but the development of the rubric is carried out in the realm of physics. Likewise with research (Salazar-Torres et al., 2021) that develops rubrics in physics learning. Research (Lertyosbordin et al., 2019) is also the development of a problem solving rubric but aims at assessing computer science learning. Based on previous studies, there has been no research on developing a mathematical problem solving rubric that focuses on essay tests and is based on Polya theory. Therefore , it is necessary to develop an essay test assessment rubric for mathematical problem solving abilities based on the Polya theory.

Based on this description, this study aims to develop a rubric for assessing essay tests for mathematical problem solving abilities based on Polya theory.

Method

Research and development (R&D) research is the method used in this research. The Plomp model was chosen as a step-in development. The Plomp model consists of

three phases, namely: 1) preliminary research phase; 2) prototype phase; and 3) the assessment phase (Plomp, 2010). Showed at Figure 1.

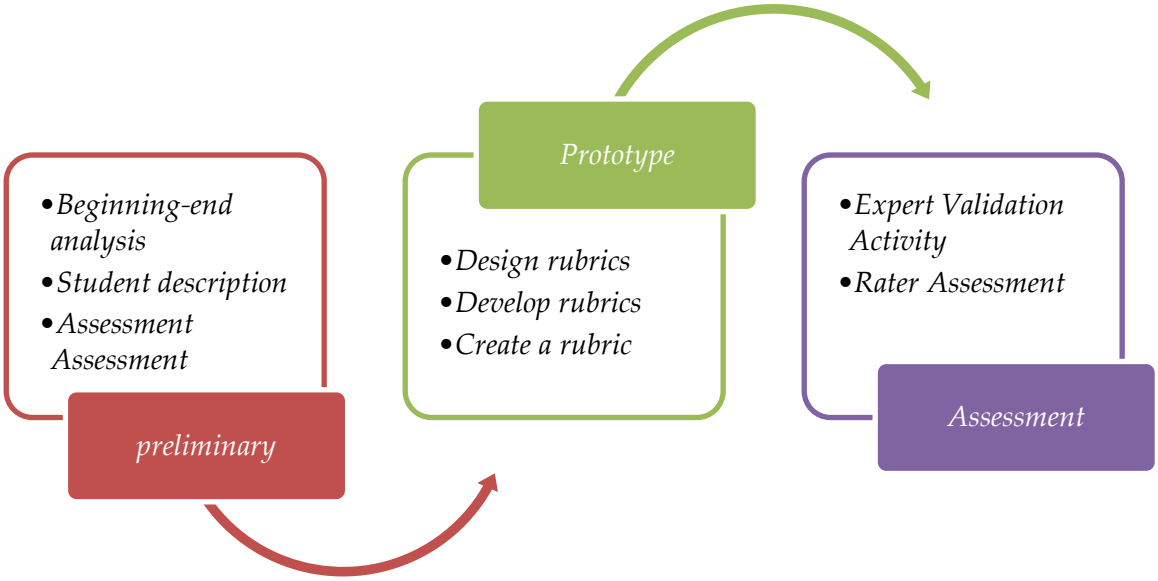

Figure 1. Plomp Development Model Procedure

Making an essay test rubric as an assessment rubric begins with the development using stages by Plomp . The background for using this development stage is in accordance with magazine references and previous observations that the plomp stage is easy to use as a learning tool when creating rubrics. Then the following processes were carried out: (1) preliminary (beginning-end analysis process, student description, assessment assessment); 2) prototyping (the process of designing, compiling, and creating rubrics). The last process is the assessment (assessment) through the validation stage by the validator.

The subjects used in this study were class VIII students of SMP IT Baiti Jannati Medan for the 2022/2023 academic year. The data sources used in this study were qualitative data in the form of content validation sheets and item review forms as well as quantitative data in the form of student test results conducted by three expert validators (2 mathematics education lecturers and 1 mathematics teacher). The method of collecting data on mathematical problem-solving abilities uses a test in the form of an essay consisting of five questions. This test is also known as the Polya Math Problem Solving Essay Test (TEPMMP). TEPMMP is made by referring to sequence patterns, number pattern rules, calculating the number of the first n terms of a sequence. The TEPMMP rating is related to the Polya problem resolution index (Darmayanti, Sugianto, et al., 2022; Fauza et al., 2022). The TEPMMP validation instrument grids, guidelines or evaluation rubrics are shown in Table 1 and Table 2.

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Table 1. Validation Instrument Grid

No	Aspect	Indicator	Many Grains	item th
1	Fill	The suitability of Polya's theory	1	1
		Completeness	2	2,3
2	Presentation	Element compatibility	2	4,5
		Ease of understanding	2	6,7
3	Language	straightforward	2	8,9
		communicative	1	10

Table 2. TEPMMP Assessment Rubric

Aspect	Answer Criteria	Interpretation of Problem Solving Ability	Score
Identification of problems	Students write down all the required information correctly	Students are able to analyze, identify, and understand the problems they face	3
	Students only write down some of the information needed correctly	Students are less able to analyze, identify, and understand the problems they face	2
	Students write down the wrong information	Students are not able to analyze, identify, and understand the problems they face	1
	Students do not write down information at all	Students are unable to analyze, identify, and understand the problems they face or are lazy to write down information	0
Planning Strategy	Students choose effective and efficient strategies	Students are able to plan problem solving solutions and are able to think critically	3
	Students choose effective but inefficient strategies	Students are able to plan solutions to problem solving but lack critical thinking	2
	Students choose strategies that are ineffective and inefficient	Students are not able to plan problem solving solutions and do not think critically	1
	Students don't work	Students failed to solve the problem	0
Execute Strategy	Students carry out the strategy correctly and get the right solution	Students are able to carry out strategies and are able to find solutions	3
	Students carry out the strategy correctly but the solution is not correct	Students are able to carry out strategies but are unable to find solutions	2
	Students do not execute the strategy correctly	Students are not able to carry out the planned strategy	1
	Students run the wrong strategy	Students failed to solve the problem	0
Check again	Students check their work again	Students have a problem solving attitude	1
	Students do not check back their work	Students lack a problem-solving attitude	0

The data analysis technique used is qualitative and quantitative data analysis. Qualitative analysis was carried out during the research to determine the adequacy

of the content of the test kits between the test items and the indicators developed earlier (Mutiara et al., 2017). This applies to content effectiveness where device content is a representative sample of all content being measured. While quantitative analysis was carried out to determine the strength of the items and the internal consistency of the test (test reliability) (Srirahayu & Arty, 2018; Ulrich et al., 2020). Since the problem solving test item is an essay question, difficulty is not used much in essay questions.

Results and Discussion

Essay test assessment rubric was developed using the Plomp's model. This model consists of three phases: the preliminary research phase, the prototyping phase, and the assessment phase. The description is explained as follows.

Preliminary Research Phase

This stage begins with the initial-end analysis activities. The analysis was carried out by observing at SMP IT Baiti Jannati, Medan, and unstructured interviews with teachers in the field of mathematics. This phase is carried out to obtain information about the actual situation on the ground. Researchers who observed the mathematics learning process of class VIII students through field observations observed students who had the ability to solve mathematical problems that they faced during the learning process of line pattern teaching materials. It was a math problem (math problem), and I was trying to solve the problem using all the schematics.

Description of students observing how to learn mathematics in Grade VIII. Students stated that they had learning difficulties and understood well when given questions with descriptive question types. This is because students do not know where and how to start answering questions (steps in doing the type of problem description) so that students tend to immediately want to solve or solve problems but students often experience problems where after working for a long time. when the answer was not found, after being corrected again it turned out that students were aware that the method chosen or the formula chosen in solving the problem was wrong, as a result students repeated it again and some even chose to let it go. This is because students do not know the correct steps in solving math problems. Therefore, to solve mathematical problems, systematic methods or steps are needed so that the completion process becomes easy and directed, namely by using the Polya step.

Assessment in carrying out assessments the teacher only carries out conventional assessments, so an instrument is needed to detect students who have mathematical problem-solving abilities. Interviews with teachers revealed that they had not developed a rubric-based performance assessment tool for their students' mathematical problem-solving skills in solving math problems. Teachers only use

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written tests, which are global for all subjects, and don't even have math test kits. The test instrument is still conventional in terms of test results.

Based on the facts above, the researcher plans to develop a Polya theory-based math problem-solving skills rubric to solve math problems related to class VIII SMP, especially sequence patterns.

Prototyping Phase

The next stage that must be carried out by researchers is the prototyping stage. This stage consists of establishing an instrument design schedule, development team, and specifications. Device design specifications are the stage of product creation by researchers, and products made by researchers are a form of device for evaluating mathematical problem-solving abilities, namely the form of an assessment rubric format sheet. Researchers compiled and designed a rubric for assessing essay tests of mathematical problem solving abilities based on Polya's problem solving theory. The essay test assessment rubric of mathematical problem solving skills is designed to assess the stages and criteria for students' answers to a given problem. There are four columns each containing aspects or indicators, criteria for student answers, interpretation of problem solving skills, and scores.

The aspect column contains the stages of problem solving based on Polya's theory, namely identifying problems, planning strategies, implementing strategies, and re-examining. Each aspect has four criteria for possible answers given by students, except for the re-examination aspect which only has two criteria. Each criterion is then interpreted into problem solving ability. In this column it will be illustrated how the abilities and attitudes of students' problem solving. Based on the criteria and interpretation, a score is given on a scale of 0-3 from the lowest criterion to the highest criterion. Specifically for the re-examining aspect, the researcher only sets two criteria because in this aspect there are only two possibilities, namely students re-examining their work or not . Students who check again are given a score of 1 and if not, given a score of 0. So that the maximum score that will be obtained by students is 10 points.

One of the things that researchers can excel in developing this rubric is that rubrics are arranged and designed systematically to be able to assess students' problem solving abilities based on the stages of problem solving. So that if an error or mistake has occurred at the initial stage, it will affect the next stage and it is likely that there will be a failure in solving the problem. In addition, this rubric can also be used in both qualitative and quantitative research because it contains qualitative descriptions and scores that are quantitative in nature.

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Assessment Phase

This stage starts with the product being verified by experts during the development stage. The researcher's design specification for the problem-solving ability assessment instrument consists of three criteria with a rating scale of 1 to 4 for each aspect of the assessment. Design Verification and Product Revision. In the design validation stage, a team of experts validates the device design (Plan 1) through expert assessment of the results of the device design and assessing problem solving abilities.

It has been validated five times by experts as a tool to assess problem solving abilities. Many opinions and suggestions from experts were obtained from the verification. Input and suggestions were given orally by experts through discussions with researchers and in writing through validation forms filled in by researchers. Based on the opinions and suggestions of these experts, the product has been revised. The first product revision is for the results of the first validation (draft 2) and the second product revision is for the results of the second validation (draft 3). After product revisions, we received positive verbal and written feedback from our experts. These expert comments indicate that the product is theoretically tested and ready to use. The following validation was carried out by two trainers and one teacher on the content, presentation and language aspects of the second revision (Draft 3). The second test is an empirical test. Researchers conducted empirical testing using three assessors, each group consisting of three assessors. Assessors are math teachers who are asked to review the results of a written test on their students' math problem solving abilities. The first group of raters checked the test without a rubric. Second and third raters, on the other hand, use rubrics to explore the test. Verification is carried out by filling out a side verification form in the form of questions about how to use the product.

In general, based on the data obtained from the validation sheet, the teacher states that the product is good enough and can be used under certain conditions. There are also suggestions from teachers on how to use the product, and these suggestions are used by researchers. as input for further research. To develop a tool for assessing problem-solving abilities, a tool-limited test was administered to 30 Grade VIII students. This research was conducted to obtain the validity and reliability of the data. The following is the result of measuring the math problem solving abilities of junior high school students.

Table 3. Results of the TEPMMP Assessment Rubric

Aspect	Score	Category
Identification of problems Plan Strategy Execute Strategy Check again	3.40	Valid

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Table 3 shows the results of the expert validation after going through suggestions and revising, the rubric of the assessment of the essay test for mathematical problem solving abilities obtained a score of 3.40 on a scale of 1-4. The expert validation value shows that the essay test assessment rubric of the Polya theory-based mathematical problem solving ability is declared valid and feasible to use.

After the rubric has been declared valid by the validator, the next step is to test its effectiveness. The rubric of the validation results was implicated in the assessment of the essay tests given to 30 students. The implication of the rubric is as well as an empirical test of the effectiveness of the rubric. The results of the empirical test correlation analysis for the rater group are presented in the following table.

Table 4 . Rater Group Correlation Data

	Rater kel. 1	Rater kel. 2	Rater kel. 3	Cor 1-2	Cor 1-3	Cor 2-3
Koef.	0.3659	0.9591	0.9376	0.5324	0.5012	0.9290

Based on table 4, the results of the correlation analysis from table 4 shows a score with a coefficient of 0.9290. So it can be concluded that the use of rubrics in the assessment will provide results that are more consistent and tend to be homogeneous.

An assessment rubric that has been designed to help teachers correct their students' work has been developed. The value generated from this rubric is 3.40 for the valid category of the validated test. In other words, this rubric can be used as a tool to help students solve problems by using their math problem solving skills. This is because the rubric developed teaches students to think systematically. This is consistent with (Güner & Erbay, 2021; Pathuddin & Bennu, 2021; Sekaryanti et al., 2022; Widodo, 2018) that solving mathematical problems requires systematic thinking. Rubric is a tool for evaluating the teaching and learning process. (Silvia et al., 2015), rubrics are an important source of information for improving teaching, providing feedback to students, contributing to better research, and improving performance by improving the quality of learning.

Furthermore, the empirical test results on the rubric using three groups of assessors showed a correlation coefficient of 0.9290 and a correlation coefficient of 0.9290. Accounting for student ability yields very high correlation results. In line with this, (Dodd et al., 2022; Kao et al., 2018; Nichols-Barrer et al., 2016; Srirahayu & Arty, 2018) states that a scale is said to be good if it is valid and reliable both in terms of content validity, construct validity, empirical validity, response consistency confidence, and item consistency trust.

Conclusion

Based on the description above, the essay test rubric that evaluates the ability to solve mathematical problems in array pattern material based on Polya theory has an overall score of 3.40 which is valid for material professionals. For grade 8 test scores, a correlation coefficient of 0.9290 was found in empirical tests by the three rating groups. Based on Polya's theory, this math problem solving essay helps teachers simplify assessments. The Essay Test Assessment Rubric provides teachers with an assessment to develop mathematical problem-solving skills based on Polya's line pattern material theory and can be used as a substitute for this assessment rubric in other teaching materials. increase. to secure it.

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