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Integration of the POE Model and Metaphoral Thinking in Student Worksheets: Improving Mathematical Reasoning Abilities in the Modern Education Era

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ABSTRACT

Purpose of the study: This research aims to develop and evaluate the effectiveness of POE-based (Predict, Observe, Explain) student worksheets using a metaphorical thinking approach to enhance the mathematical reasoning abilities of class 9 students at Public Middle School.

Methodology: This research aims to find out how to develop student worksheets based on POE (Predict, Observe, Explain) through a metaphoral thinking approach oriented towards the mathematical reasoning abilities of junior high school students in class 9 and find out the effectiveness of student worksheet products based on POE (Predict, Observe, Explain) through Metaphoral Thinking approach to the mathematical reasoning abilities of Public Middle School 7 Banjit students in class 9.

Main Findings: Validation results showed material experts rated the worksheets at 89.4%, media experts at 94.9%, and language experts at 75%, all with high appropriateness. Small group trials averaged 86%, field trials 87%, and educator trials 97.2%, all with very good criteria. The paired t-test ($t_{hitung} = 12.7 > t_{tabel} = 2.02$) confirmed the effectiveness of the POE-based worksheets using the Metaphorical Thinking approach in enhancing mathematical reasoning abilities..

Novelty/Originality of this study: The novelty of this study lies in developing and validating POE-based student worksheets integrated with a metaphorical thinking approach to enhance junior high students' mathematical reasoning. This innovative strategy combines cognitive and imaginative techniques, fostering deeper comprehension and problem-solving skills.

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1. INTRODUCTION

Schools are formal educational institutions designed to provide teaching and learning to students in a structured environment. The meaning of school is to provide formal education to individuals from an early age to a higher level of education [1], [2]. The function of school is as a forum for education, socialization, character formation, skill development, preparation for the next life [3], [4]. Schools can be formal institutions such as elementary schools, middle schools and high schools, or they can also be non-formal institutions such as courses or professional training institutions [5]., basically, the aim of school is to provide education and help in the holistic development of the individual.

Education is very important for humans in general. Without education, humans are like people who walk in a dark place without the slightest light and will groped in the dark. Through education, human life will progress because they are able to use their minds to make use of them in their lives [6], [7]. Education makes humans try to develop themselves so that they are able to face every change that occurs due to advances in science and technology [8-10]. Mathematics is a universal science that underlies the development of modern technology, has an important role in various sciences and advances human thinking [11], [12]. Mathematics makes people think logically, rationally and confidently [13], [14]. One of the subjects that must be implemented at every level of education from elementary school to college is mathematics.

Learning mathematics has become a necessity for the full development of individuals in today's complex Indonesian society [15-17]. Technological advances and the increasing importance of means of communication mean that people need to adapt to new situations that arise from social change [18-20]. Mathematics subjects need to be given to all students starting from elementary school to equip students to learn how to reason critically, creatively and actively [21-23]. Mathematics is a means of thinking to develop the power of reason as well as a way of thinking logically, systematically and critically [24-26]. In reality mathematics is often considered a difficult subject to understand. This is because mathematics is abstract and requires an understanding of mathematical concepts.

Mathematics was formed as a result of human thinking related to ideas, processes and reasoning. Mathematics is the study of patterns and relationships, ways of thinking with organizational strategies, analysis and synthesis, art, language and tools for solving abstract and practical problems, and mathematics is formed from human experiences in their world empirically and then these experiences are processed in ratios, processed analytically with reasoning in cognitive structures so that mathematical concepts are formed so that the mathematical concepts formed are easily understood by other people and can be manipulated appropriately, then a mathematical language or mathematical notation that has global value is used [27], [28]. Based on this explanation, it follows that It can be concluded that mastery of mathematical material cannot be separated from the organization of one's reasoning.

Within mathematics, there are various branches and subdisciplines, including algebra, geometry, calculus, number theory, statistics, and many more. Each branch of mathematics has unique applications and contributions in solving problems and understanding real-world phenomena [29], [30]. Apart from that, mathematics is also the foundation for the development of modern technology, such as computing, data security and artificial intelligence. Mathematics not only serves as a tool for calculating, but also as a tool for solving problems, predicting the behavior of complex systems, and investigating quantitative aspects of the world around us [31], [32].

The ability of reasoning is very necessary in mathematics because people who have high reasoning abilities and the abilities to communicate mathematical ideas or thoughts well tend to have a good understanding of the concept of studied, and are able to solve problems related to the concept study. Student Learning Outcomes. Reasoning and mathematical abilities are an interrelated unity, therefor reasoning abilities in learning mathematics is one of the thinking abilities that must be developed [33].

Based on the results of observations, it is known that students still have difficulty understanding mathematics material, because the average students' mathematical reasoning abilities are still low. Students' low mathematical reasoning abilities can be seen when students solve problems [34], [35]. Students are still unable to come up with ideas to estimate answers and solutions, so it can be said that students cannot make guesses to find the right answer. Students can complete calculations but cannot explain why they wrote down the answer, meaning students cannot provide reasons or evidence for the correctness of the solution.

There are still many students who are not careful in calculations so that the final results of the answers are still wrong, meaning students cannot check the correctness of an answer. This includes indicators of mathematical reasoning ability.Student worksheets currently occupy a very important position in learning, especially after the increasing popularity of student-centered learning. Therefore, creativity is needed for a teacher to be able to develop student worksheets according to student needs, because by developing student worksheets themselves it can make it easier for teachers to achieve the learning that has been determined previously [36], [37]. New innovations in developing student worksheets as a learning resource are very necessary, so that student worksheets become more meaningful in the learning process.

The development of student worksheets must contain activities that can construct student knowledge and also be linked to student-centered learning. One model that can meet these demands is POE (Predict-Observe-Explain). The POE model is based on constructivist learning theory which assumes that through prediction, observation and explaining the results of observations, the cognitive structure will be well formed [38-40]. The POE model provides opportunities for students to construct their own knowledge, carry out knowledge of phenomena that occur, communicate their thoughts and discussion results, and train students to develop both cognitively, effectively and psychomotorically [41].

POE-based student worksheets are an alternative learning media that can train students' reasoning and understanding of concepts. Using POE-based student worksheets can implement an active learning system for teachers because by using POE-based student worksheets, students are guided to predict first, then make

observations and finally students will explain whether the initial predictions they made or made were true or false [42-44]. Apart from that, one approach that can influence a level of mathematical reasoning ability is Metaphoral Thinking.

Metaphoral Thinking is a thinking process using metaphors or analogies to make it easier for students to understand and absorb certain material or information [45], [46]. The metaphorical thinking approach is a form of approach that bridges abstract concepts into more concrete things [47], [48]. Metaphoral Thinking is a bridge between models and interpretation, providing great opportunities for students to exploit their knowledge in learning mathematics [49]. Through Metaphoral Thinking, the student learning process becomes meaningful because students can see the relationship between the concepts they are studying and the concepts they already know [50]. The development of POE-based student worksheets (Predict, Observe, Explain) can influence the learning process and has very appropriate criteria to be used as a tool in teaching and learning activities in mathematics lessons.

Previous research is of the view that mathematical reasoning plays an important role, both in solving problems and in conveying ideas when learning mathematics [51], [52]. The results of previous research found that mathematics self-efficacy and task-specific self-efficacy beliefs collectively and significantly mediate the influence of learning approaches on students' mathematical reasoning [34]. Previous research has emphasized the importance of mathematical reasoning in problem solving and conveying ideas when learning mathematics, and found that mathematics self-efficacy and task-specific self-efficacy beliefs have a significant role in mediating the influence of learning approaches on students' mathematical reasoning. However, this research has not specifically explored the approach that uses student worksheets based on POE (Predict, Observe, Explain) with a Metaphorical Thinking approach in improving students' mathematical reasoning abilities.

This research offers an innovative approach in developing Student Worksheets by integrating the POE (Predict, Observe, Explain) model and the Metaphoral Thinking approach. This combination has not been widely explored in the context of mathematics learning, especially in Indonesia, and is expected to provide a new perspective in improving students' mathematical reasoning abilities. By using POE, students are encouraged to predict, observe, and explain the results of their observations, while the Metaphoral Thinking approach helps bridge abstract concepts into more concrete ones through the use of metaphors.

The development of student worksheets based on POE and Metaphoral Thinking has great potential forincrease the effectiveness of mathematics learning. This model not only encourages students to be more active and critical in learning, but also helps them develop a deeper understanding of mathematical concepts through logical and creative reasoning. The practical implication is that teachers will have more effective tools in the learning process, so that they can achieve more optimal and comprehensive learning outcomes, including cognitive, affective and psychomotor aspects.

Considering the low level of students' mathematical reasoning abilities which were revealed from the results of observations, the development and application of POE-based student worksheets using the Metaphoral Thinking approach is very urgent. The urgency of this research lies in the need to improve the overall quality of mathematics education, which in turn will better prepare students to face real-life challenges and rapid social change. It is hoped that this student worksheet product can be an effective solution in overcoming students' difficulties in understanding abstract mathematical concepts, as well as equipping them with the critical and analytical thinking skills needed in the era of modern technology. So this research aims to find out how to develop Student Worksheets based on POE (Predict, Observe, Explain) through a Metaphoral Thinking approach oriented towards mathematical reasoning abilities. And to find out how effective the POE (Predict, Observe, Explain) based Student Worksheet product is through a Metaphoral Thinking approach oriented towards mathematical reasoning abilities.

2. RESEARCH METHOD

This research uses research and development methods. Research and Development is a research method used to produce certain products and test the effectiveness of these products [53], [54]. Research and Development is a process or steps to develop a new product or improve an existing product, which can be accounted for. To produce certain products, research is used in the nature of needs analysis and to test the effectiveness of the product so that it can function in the wider community, research is needed to test the effectiveness of the product.

This type of research is development research which aims to produce innovative teaching material products in the form of student worksheets for mathematics learning to improve student reasoning. The test subjects in this research were class 9 students at Public Middle School 7 Banjit. The development was carried out in mathematics subjects, for the 2023/2024 academic year of Public Middle School 7 Banjit class 9. This research method uses a model developed by Robert Maribe Brach using the ADDIE cycle, namely an instructional design model in the form of a general process traditionally used by instructional designers or training developers. The ADDIE model is divided into 5 phases, namely: (1) Analysis, (2) Design, (3) Development, (4) Implementation, (5) evaluation[55].

An instrument is a tool that functions to facilitate the implementation of something. Apart from compiling POE-based student worksheets using the Metaphoral Thinking approach, research instruments were also prepared to be used to assess the student worksheets that were developed. Data collection instruments include a preliminary study instrument which is used as a needs analysis stage to obtain initial information about teaching materials. This instrument is in the form of interviews with teachers and students which are designed to find out what kind of worksheets suit students' needs and serve to provide input in developing POE-based worksheets using a Metaphoral Thinking approach oriented to reasoning abilities.

Furthermore, the material expert validation instrument. This instrument is in the form of a validation questionnaire regarding the suitability of the content and suitability of POE-based worksheets using the Metaphoral thinking approach, and functions to provide input in the development of POE-based student worksheets using the Metaphoral thinking approach. The validators who are material experts consist of 2 Mathematics lecturers from UIN Raden Intan Lampung and 1 Mathematics teacher at Public Middle School 7 Banjit with active qualifications in their fields. The aspects validated were content appropriateness, language, POE-based student worksheets using the Metaphoral Thinking approach and mathematical reasoning questions.

This instrument takes the form of a validation questionnaire related to graphics, language, and the presentation of POE-based worksheets using a Metaphoral Thinking approach with mathematical reasoning questions. The validators who are media experts consist of 2 Mathematics Lecturers from UIN Raden Intan Lampung and 1 Teacher from Public Middle School 7 Banji twith active qualifications in their fields. The aspects validated are graphics and presentation. The mathematical reasoning ability test was given to determine the effect of POE-based Student Worksheets through a metaphorical thinking approach on students' mathematical reasoning abilities. The test given is an essay test related to indicators of mathematical reasoning ability. This test is intended to determine students' mathematical reasoning abilities in learning mathematics. The value of students' mathematical reasoning abilities is obtained from scoring the students' answers to each question item. The test instrument data processing carried out includes validity, difficulty index, distinguishing power and reliability. The data obtained will be analyzed using a paired difference test of two means (t test). Data processing and data analysis in this research were carried out on students' pretest and posttest scores.

3. RESULTS AND DISCUSSION

The main result of the development research carried out at Public Middle School 7 Banjitis a student worksheet based on POE (Predict, Observe, Explain) using a Metaphoral Thinking approach oriented towards students' mathematical reasoning abilities. This research uses development procedures with the ADDIE method according to Dick and Carry. The results of each stage of the development procedure carried out are as follows.

3.1. Analysis Stage

Analysis here is collecting information about students' learning needs and learning resources related to facilities and infrastructure that support the learning process. This information gathering stage was carried out at the Public Middle School 7 Banjitby conducting interviews and observations. Based on interviews, information was obtained that the learning resources used were student textbooks and worksheets which did not contain learning activities that directly involved students, and did not facilitate students to construct their own knowledge. Apart from that, students still have difficulty understanding mathematical material, because the average student's mathematical reasoning abilities are still low.

Students' low mathematical reasoning abilities can be seen when students solve problems. Students are still unable to come up with ideas to estimate answers and solutions, so it can be said that students cannot make guesses to find the right answer. There are still many students who are not careful in calculations so that the final results of the answers are still wrong, meaning students cannot check the correctness of an answer. This includes indicators of mathematical reasoning ability. Students actually have an interest in learning, are able to adapt, interact and communicate in teaching and learning activities.

Teachers have never developed student worksheets themselves. Therefore, creativity is needed to develop worksheets that can make students active, contain learning activities that involve students directly, can train students' mathematical reasoning abilities by constructing their own knowledge, and can motivate students to study mathematics. For this reason, it is necessary to develop student mathematics learning worksheets designed to be based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach to train students' mathematical reasoning abilities. After carrying out the analysis stage, before proceeding to the next stage the researcher carried out an evaluation at the analysis stage. Judging from the needs analysis, to raise student enthusiasm and so that students are motivated in learning mathematics in class, teaching materials are needed to overcome these problems. Therefore, researchers will develop teaching materials in the form of student worksheets based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach to train students' mathematical reasoning abilities.

3.2. Design Stage

After the needs analysis is carried out, the next step is the design stage. The activities carried out in the product design stage of student worksheet development are as follows. a. Selection of Teaching Materials, Materials and Learning Methods The teaching materials chosen are teaching materials in the form of student worksheets that are oriented towards mathematical reasoning abilities. The learning material chosen is the material of curved sided space shapes because apart from being considered difficult in this material, students must also be able to imagine a theory in everyday life. With the metaphorical thinking approach, it will help students to see in everyday life what is related to this material.

The method used in this student worksheet is POE (Predict, Observe, Explain). This method not only makes students able to master the material but also makes students active and can make students remember more of the material. The following are the core competencies, basic competencies and indicators in curved side building materials. Core Competency 1: Appreciate and appreciate the teachings of the religion one adheres to. Core Competency 2: Appreciate and appreciate honest behavior, discipline, responsibility, caring (tolerance, mutual cooperation), politeness, self-confidence, in interacting effectively with the social and natural environment within the reach of one's interactions and existence. Core Competency 3: Understand and apply knowledge, factual, conceptual, procedural, and based on curiosity about science, technology, arts and culture, visible phenomena and events. Core Competency 4: Process, present and reason in the concrete realm (using, parsing, assembling, modifying, and creating) and the abstract domain (writing, reading, calculating, drawing, and composing) in accordance with what is learned at school and other sources with the same point of view/theory. The following is table 1 of basic competencies and indicators in curved side building material.

Table 1. Basic competencies and indicators in curved side building material

Basic competencies	Indicator
1. Identify the elements and nets of tubes, cones and spheres.	- Mention the elements of a cylinder, cone and sphere. - Name the nets of tubes, cones and balls.
2. Calculate the area of the blanket and the volume of the cylinder, cone and sphere	- Calculate the blanket area of cylinders, cones and spheres. - Calculate the volume of cylinders, cones and spheres.
3. Solve problems related to cylinders, cones and spheres.	- Resolving contextual problems related to curved sided space shapes.

The learning objectives that will be achieved in the teaching materials that will be developed are as follows.

Table 2. Learning Objectives on Curved Side Building Material

No	Indicator	Learning objectives
1	Name the elements of a cylinder, cone and sphere.	Students can name the elements of a cylinder, cone and sphere
2	Mention the nets of tubes, cones and balls.	Students can name the nets of tubes, cones and balls.
3	Calculate the area of a cylinder, cone, and sphere.	Students can calculate the area of a cylinder, cone and sphere
4	Calculate the volume of cylinders, cones, and spheres.	Students can calculate the volume of cylinders, cones, and spheres.
5	Resolving contextual problems related to curved sided space shapes	Students can solve contextual problems related to curved geometric shapes.

The development of this student worksheet started by adapting the core and basic competencies as well as the syllabus based on the 2013 curriculum. The student worksheet uses B5 paper, 1 spaced scale, Cambria and Snap ITC fonts.The initial design of this student worksheet development product was the initial part consisting of the front page (outer cover), table of contents, foreword, core competencies and basic competencies. The content section consists of material descriptions and practice questions. The closing section consists of a bibliography and back cover.

After carrying out the design stage, before proceeding to the next stage the researcher carried out an evaluation at the design stage. The researcher added and modified the questionnaire according to needs, namely by adding the POE (Predict, Observe, Explain) aspect to the suitability of the content because the student worksheets that will be developed in this research are based on POE (Predict, Observe, Explain).Apart from that, there is also a questionnaire for students and teachers which includes assessment items that are adapted to the requirements of a good student worksheet to determine the response to the attractiveness of the teaching materials that have been developed.

3.3. Development Stage

This stage is the stage of preparing student worksheets based on POE (Predict, Observe, Explain) using a Metaphoral Thinking approach oriented towards students' mathematical reasoning abilities. After the product has been successfully developed, the next step is to carry out a product feasibility test by means of product validation. This validation is carried out after product manufacture. Validation is carried out in three types, namely material expert validation, media expert validation, language expert validation.

Researchers asked for assessments from three material experts, namely Mr. Dr. Nanang Supriadi, S.Si., M.Sc and Mr. Suherman, M.Pd as mathematics lecturer at UIN Raden Intan Lampung and Mr. Silas Sukirno, S.Pd as mathematics teacher at Public Middle School 7 Banjit. Aspects assessed by material experts are appropriateness of content, appropriateness of presentation, appropriateness of language, and POE (Predict, Observe, Explain) assessment.

In the feasibility aspect, the content of the assessment obtained an average percentage result of 74.3 with the "Worthy" criteria. In the feasibility aspect, the assessment presentation obtained an average percentage result of 70 with the "Worthy" criteria. In the language feasibility aspect, the assessment obtained an average percentage result of 81.5 with the criteria "Very Eligible". In the POE (Predict, Observe, Explain) assessment aspect, the average percentage result was 75 with the "Decent" criteria. The assessment has met the appropriate criteria for student worksheets that have been validated, but revisions still need to be made to student worksheets that have been validated. Revisions are made according to suggestions from the validator. The following are recommendations for improvement provided by material expert validation.

Table 3. Suggestions for improving material expert validation

Suggestions	Improvement Results
a. Lack of discussion of material, no net material according to the concept map. b. When the practice questions are still too easy, more reasoning questions should be added.	a. Add net material according to the concept map. b. Add reasoning questions to practice.
a. Image accuracy and definition have not been shown. b. More questions added. c. The answer key to the question is not yet available.	a. Describes the accuracy of the image displaying the source. b. Add questions c. Includes answer key to the questions.

The second stage of validation was carried out after revising the student worksheets. The second stage of validation was carried out by researchers to see the quality of the revised student worksheets. The validator assessment after revisions were made to the feasibility aspect of the content obtained an average percentage of 89.6% with the criteria "Very Eligible". In the feasibility aspect of presenting the assessment, the average percentage result was 89.2 with the criteria "Very Eligible". In the language feasibility aspect, the assessment obtained an average percentage result of 88.9 with the criteria "Very Eligible". In the POE (Predict, Observe, Explain) assessment aspect, the average percentage result was 89.8 with the criteria "Very Eligible".

Media expert validation aims to test the graphics and presentation of POE-based junior high schools (Predict, Observe, Explain) through a Metaphoral Thinking approach oriented towards students' mathematical reasoning abilities. The aspects assessed by media experts are the size of junior high schools, the cover design of junior high schools, and the design of the contents of student worksheets. Media experts are Mr. Iip Sugiharta, M.Si and Mrs. Wita Kurnia, M.Pd as lecturers at UIN Raden Intan Lampung and Mrs. Puput Purna Evayanti S.Pd as teacher at Public Middle School 7 Banjit.

The validator's assessment of the size aspect of student worksheets obtained an average percentage of 75% with the criteria "Appropriate". In the aspect of student worksheet cover design, the validator assessment obtained an average percentage result of 73.8% with the "Decent" criteria. In the design aspect of the contents of student worksheets, validator assessments obtained an average percentage of 77.3% with the criteria "Very Eligible". The validation results have entered the appropriate criteria for student worksheets that have been validated, but revisions still need to be made to student worksheets that have been validated. Revisions are made according to the validator's suggestions. The following are recommendations for improvement provided by media expert validation.

Table 4. Suggestions for improving media expert validation

Suggestions	Improvement Results
a. The title on the cover is still simple. b. The writing design on the cover overwrites and covers the image of the cone shape. c. Big title material doesn't need too much design, just draw the text directly.	a. Changed the cover to be even better. b. Move the spatial image so that the writing is clear. c. Reduced design on large material titles. d. Just give color to the page text.

d. Only the written part of the page is colored.	
a. There is still a discontinuity in the layout of the title on the cover, the design of the text on the cover overlaps the image.	a. Change the cover to ensure continuity in the layout.
b. Writing must be checked again, avoiding mistakes in writing.	b. Correcting errors in writing.

The second stage of validation was carried out after revising the student worksheets. The second stage of validation was carried out by researchers to see the quality of the revised modules. The aspects assessed in this validation remain the same as the first validation. The validator assessment after revisions were made to the size aspect of student worksheets obtained an average percentage of 95.8% with the criteria "Very Eligible". In the worksheet cover design aspect, students obtained an average percentage of 95.2 with the criteria "Very Eligible". In the aspect of worksheet content design, students obtained an average percentage of 94.4 with the criteria "Very Eligible".

The aspects assessed by linguists are straightforward, communicative, dialogic and interactive aspects, suitability for students, and conformity with language rules. The language expert validator is Mr Untung Nopriansyah, M.Pd. The validator's assessment on the straightforward aspect obtained results with a percentage of 75% with the "Decent" criteria. In the communicative aspect of the validator assessment, results were obtained with a percentage of 75% with the criteria "feasible". In the aspect of suitability with students, the validator's assessment obtained results with a percentage of 75% with the "Decent" criteria. In the aspect of conformity with the language rules of the validator assessment, results were obtained with a percentage of 50% with the "Decent" criteria. The assessment has met the appropriate criteria for student worksheets that have been validated, but revisions still need to be made to student worksheets that have been validated. Revisions are made according to suggestions from the validator. The following are suggestions for improvement provided by validation language experts.

Table 5. Suggestions for improving linguist validation

Suggestions	Improvement Results
a. Distinguish between interrogative and command sentences and the use of punctuation marks.	a. Distinguish between interrogative sentences and command sentences, give punctuation in the form of an exclamation mark for command sentences and a question mark for interrogative sentences.
b. Pay more attention to the effectiveness of sentences.	b. Change sentences that are less effective.

The second stage of validation was carried out by researchers after the student worksheets were revised to see the quality of the revised student learning worksheets. The aspects assessed at this stage are the same as the first stage of validation. The validator's assessment on the straightforward aspect obtained results with a percentage of 75% with the criteria "Feasible". In the communicative aspect of the validator assessment, results were obtained with a percentage of 75% with the "Decent" criteria. In the aspect of suitability with students, the validator's assessment obtained results with a percentage of 75% with the "Decent" criteria. In the aspect of conformity with the language rules of the validator assessment, results were obtained with a percentage of 75% with the "Decent" criteria.

Based on the validation instrument sheet that was given by the researcher to the material expert validator, the results obtained were improvements with input from media expert validation, namely that the title on the cover was still simple, the design of the writing on the cover overlapped and covered the image of a cone shape, the material title didn't need too much design, just a picture. write directly, only the written part of the page is colored. Improvements made include changing the cover to a better one, moving the spatial image so it doesn't overlap the writing on the cover and clarifying the writing, reducing the design on the big title of the material, and adding color to the page text..

3.3. Trials

This trial was carried out in small groups, involving 10 students of Negeri 7 Banjit Middle School class IX who were selected heterogeneously based on class ability and gender. Students in this small group test look at the student worksheets provided, then students are given a questionnaire to assess the effectiveness of the student worksheet product. The results of student responses to student worksheet products based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach oriented towards mathematical reasoning abilities obtained an average of 86% with the criteria "very good". This means that student worksheet products based on POE (Predict, Observe, Explain) using a Metaphoral Thinking approach oriented towards mathematical reasoning abilities developed by researchers are effective as tools in teaching and learning activities on curved sided

geometric shapes for class IX junior high school. The small group trial has obtained very good criteria so there is no revision. After small group trials, the product is then tested again with field trials.

After a small group trial was carried out, the product was then tested again with a field trial involving 38 students from the Public Middle School 7 Banjit class IX. This field trial was carried out to confirm the data that had been obtained by giving a questionnaire. The results of student responses to student worksheets based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach oriented towards mathematical reasoning abilities obtained an average of 88% with the criteria achieved being "very good".

This means that student worksheet products based on POE (Predict, Observe, Explain) using a Metaphoral Thinking approach oriented towards mathematical reasoning abilities developed by researchers are effective as tools in teaching and learning activities on curved sided geometric figures for class 9 junior high school. The results of trials related to attractiveness were carried out in two stages, namely small group trials and field trials, which experienced an increase in the average percentage in each aspect. The results of the small group trial obtained a score of 86% with the "Very Good" criteria and the field trial obtained a score of 88% with the "Very Good" criteria. This means that the student worksheets developed by researchers are suitable for use.

After small group trials and field trials are carried out, the product is then tested again for educator trials. This educator trial was carried out to confirm the data. The number of respondents in this teacher test was 1 teacher at State 7 Banjit Middle School class 9 by giving a questionnaire to determine the teacher's response to the effectiveness of teaching materials. This educator trial was carried out at Banjit 7 State Junior High School. The trial results obtained an average percentage of 97.2% with the criteria achieved being "Very Good".

This means that student worksheet products based on POE (Predict, Observe, Explain) using a Metaphoral Thinking approach oriented towards mathematical reasoning abilities developed by researchers are effective as tools in teaching and learning activities on curved sided geometric figures for class 9 junior high school. After testing the product with the aim of determining the suitability of teaching materials in the form of student worksheets, the weaknesses of the student worksheet product can be identified. These weaknesses are then evaluated to produce even better products. Based on responses from teachers and students who said that this product was good and interesting, it can be said that the student worksheets based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach oriented towards mathematical reasoning abilities have been developed and are ready to be used.

3.3. Implementation Stage

After the student worksheet based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach oriented towards mathematical reasoning abilities on curved sided geometric material has been developed, then a trial of the student worksheet is carried out. The student worksheet trial was carried out on class IX students at Negeri 7 Banjit Middle School. Before the students' worksheets were tested, the researcher first tested the test instruments on the pretest and posttest questions. After the student worksheet based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach oriented towards mathematical reasoning abilities on curved sided geometric material was tested, then a paired t test analysis was carried out to see the effectiveness of the product on students' mathematical reasoning abilities.

Data from the trial of the mathematical reasoning ability test were obtained by testing 12 essay questions, namely pretest and posttest questions for curved sided space figures on students outside the research sample, namely on class Analysis of trial data includes validity tests, reliability tests, discrimination tests, and difficulty level tests. Validity tests are carried out to measure the extent of accuracy or validity of the question items to be measured. The results of these calculations show that in the pretest questions there were 10 valid questions because and 2 questions were invalid, namely numbers 9 and 11, because.

In the posttest questions there are 10 valid questions and 2 invalid questions, namely numbers 3 and 10. The reliability test is used to determine the level of consistency of a test instrument. This means that whenever this assessment tool is used it will produce relatively the same results. The test instrument is said to be reliable if it is 0.70. The calculation results on the pretest questions obtained r11 = 0.71 with a limit of r11 = 0.70, so that the 12 questions were reliable. In the posttest questions, r11 = 0.73 with a limit of 0.70, so the 12 questions are reliable.

The discriminating power test is used to determine how far the ability of the items to differentiate between students who answered correctly in the upper group and the lower group. The results of these calculations show that in the pretest test questions there were 10 questions that were categorized as adequate based on the classification $0.20 < DP \leq 0.40$ and 2 questions that were categorized as poor based on the classification $0.20 < DP \leq 0.40$. In the posttest questions there were 10 items that were categorized as fair, 1 item that was categorized as bad, and 1 item that was categorized as very bad. The difficulty level test is carried out to show how difficult and easy a question is. The calculation results show that in the pretest and posttest questions, the 12 questions were categorized as moderate based on the classification $0.30 \leq P \leq 0.70$. A brief description of the data on students' mathematical reasoning abilities is presented in the table 6.

Table 6. Mathematical reasoning ability data

Data	N	Xmax	Xmin	Measures of Central Tendency			Group Variance Measures
				Mean	Med	Mod	R
Pretest	38	74	14	54	55	55	60
Posttest	38	98	51	72	71.5	60	40

Based on data on mathematical reasoning abilities, it is known that the average score of students' posttest mathematical reasoning abilities is better than the pretest score. Next, research data analysis was carried out using a paired t test which aimed to determine the influence of the developed teaching materials on students' mathematical reasoning abilities. As a prerequisite for the paired t test, the researcher previously carried out a normality test.

This normality test was carried out on students' mathematical reasoning abilities. The results of the normality test calculation for the data group can be seen in the attachment and a summary of the normality test is presented in Table 7.

Table 7. Normality test results for mathematical reasoning ability data

Data	N	Sig.
Pretest	38	.230
Posttest	38	.137

Based on the results of the data normality test, students' mathematical reasoning abilities show that the Sig. more than 0.05 then Ho is accepted so it can be concluded that the data comes from a normally distributed population.

Data on students' mathematical reasoning abilities after meeting normal requirements, the next stage is testing using the paired t test. The use of teaching materials influences students' mathematical reasoning abilities, which is the hypothesis of this research. The calculation results are presented in Table 8.

Table 8. Paired t test results for Mathematical Reasoning Ability Data

t_{table}	T_{count}	Average score value	
		Pretest	Posttest
74	14	54	72

Based on the results of the paired t test, students' mathematical reasoning abilities can be seen to be tcount more than ttable, with a level that means the average student's mathematical reasoning ability after using teaching materials is greater than the average before using teaching materials so it is rejected. So it can be concluded that there is an increase in students' mathematical reasoning abilities after using POE (Predict, Observe, Explain) based student worksheets through the Metaphoral Thinking approach oriented towards mathematical reasoning abilities.

The ability or ability to use reasoning or mental processes in developing thoughts about mathematical objects is called mathematical reasoning ability. Based on the data analysis that has been carried out, it is known that the average score for the mathematical reasoning ability test on curved-sided geometric shapes has increased after using the POE (Predict, Observe, Explain) based student worksheet product using the Metaphoral Thinking approach. The average data on the results of students' mathematical reasoning ability test results before using student worksheet teaching materials is 54 with a maximum score of 74 and a minimum score of 14, whereas after using student worksheet teaching materials the average result of students' mathematical reasoning ability test results is 72 with a maximum score 98 and a minimum score of 51. It can be concluded that the use of student worksheet products has an effect on students' mathematical reasoning abilities.

In line with previous research, it was found that POE (Predict Observe Explain) based student worksheets were valid, practical and effective for improving students' mathematical problem solving abilities [56]. Then previous research produced a student worksheet based on POE (Predict Observe Explain) on flat-sided geometric material to improve students' creative mathematical thinking skills that met very valid and practical standards, so that the student worksheet could be used in learning activities [57]. The gap in previous research is that previous research focused on flat-sided spatial shapes, while current research focuses on curved-sided geometric material. Previous research did not include the use of the Metaphorical Thinking approach in POE-based student worksheets, while the current research integrates this approach to improve mathematical reasoning.

POE-based student worksheets (Predict, Observe, Explain) using a Metaphoral Thinking approach oriented towards students' mathematical reasoning abilities are teaching materials which include questions and problems containing instructions and steps that students will take to solve problems. In this student worksheet, students predict first, then make observations or experiments, and finally students will explain. Students are required to think with metaphors or analogies where the problem is based on mathematical reasoning abilities. Mathematical reasoning ability is the ability of students to carry out logical thinking based on existing

mathematical facts or statements to draw conclusions. When in the field, before learning is carried out using student worksheets based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach, students first work on pretest questions. During the work process, students looked confused because they did not understand the material.

After completing the work the teacher divides the students into several groups. The division into groups went well, students sat according to their groups. After that, the teacher provides direction regarding the learning process using student worksheets based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach. During the learning process, students seemed eager and enthusiastic about working on student worksheets. Students seem to find it easier to divide the tasks of carrying out experiments because they are in groups. When discussing between students there is still minimal interaction, students seem embarrassed to ask questions between students or the teacher. To anticipate this problem the teacher tries to explain and give direction to each group.

Progress in learning activity began to be seen after students discussed understanding student worksheets [58], [59]. Students start to carry out experiments and try to understand the material. If they don't understand the experiment being carried out and are not able to understand the material, students start trying to ask their group friends or ask the teacher for directions. The teacher asks students to work together to carry out experiments and solve problems on the students' worksheets. Before the group presentation, the teacher checks and ensures that all group members have understood the material. During the group presentation, the designated students were able to explain the problem well in their own language and had little difficulty in explaining. To anticipate these difficulties the teacher helps complete the explanation given by the student. When one of the students gave a presentation, the other groups looked enthusiastic to understand and listen to the material that had been presented.

During the experiment, students carried out the three stages on the student worksheet, namely predict, observe, and explain. The predict stage is where students provide a hypothesis based on problems taken from student experience or a guidebook that contains a phenomenon related to the material being discussed. The observe stage is where students observe by carrying out experiments or demonstrations based on the problem being studied and recording the results of observations to reflect on each other.

The explain stage is to explain by concluding the results of the assumptions and observations. At the predict stage, students are seen working together to think about answers to answer questions, after finding predictions, students then start to carry out experiments and answer questions at the observation stage based on the experiments carried out, then students try to conclude and answer questions at the explain stage in accordance with the predictions and experiments that have been carried out. Initially the students still looked confused, but after trying to understand and discussing between their respective groups and the teacher giving directions, the students finally started to feel comfortable and enjoy the learning process. At the last meeting, after learning using student worksheets based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach, students worked on posttest questions. When working on posttest questions, students seemed to understand and work better than when working on pretest questions. When working on posttest questions, students did not complain of confusion because they already understood the material.

The novelty of this research introduces the use of student worksheets based on POE (Predict, Observe, Explain) with a Metaphorical Thinking approach to improve mathematical reasoning abilities, especially in curved side geometry material. This approach has not been explored much in previous research, which generally focuses on flat-sided spatial material and without the integration of Metaphorical Thinking. The implication of this research is that the results of this research can be used as a basis for developing teaching materials that are more effective in improving students' mathematical reasoning abilities. Teachers can adopt this approach to help students understand mathematical concepts in a more in-depth and interactive way. The limitation of this research is that the focus is only on curved side geometry, the results may not apply to other mathematical materials.

4. CONCLUSION

The conclusions obtained from this research and development are: Student Worksheets based on POE (Predict, Observe, Expain) through a Metaphoral Thinking approach oriented towards mathematical reasoning abilities, curved sided geometric material which has been developed using the ADDIE (Analysis, Design, Development, Implementation) stage model , Evaluation) through the validation stage of material experts, media experts, and language experts have reached feasibility standards and are suitable for use. Student responses to student worksheets for small group trials obtained an average score of 86% with "very good" criteria and field trials obtained an average of 87% with "very good" criteria. The teacher's response to the student worksheet that was developed obtained an average score of 97.2% with the criteria "very good". So, student worksheets based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach are ready to be used as teaching materials. Based on the results of the paired t test, it can be seen that student worksheets based on POE (Predict, Observe, Explain) using the Metaphoral Thinking approach are effective on students' mathematical reasoning abilities. The researcher recommends that further research explore other learning methods that can be combined

with the Metaphorical Thinking approach, such as project-based learning models or problem-based learning, to further improve students' mathematical reasoning abilities.

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