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Geometry Worksheet Based on Augmented Reality to Improve Slow Learner Student's Visual-Spatial Ability

[1]Agnes Qhorisa, [1]Andriyani*, [2]Halkano Qalla Bonaya
[1]Universitas Ahmad Dahlan, Jl. Pramuka, Umbulharjo, Yogyakarta, Indonesia
[2]Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya
e-mail: andriyani@mpmat.uad.ac.id

Abstract

The purpose of this study to develop geometry worksheet to improve the visual-spatial abilities of slow-learner students. This study uses the method is Research and Development (R&D) research which in the development process uses the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The subjects in this study were students in the inclusion class of one of the Muhammadiyah high schools in the city of Yogyakarta. Data collection methods are observation, interviews, pretest-posttest tests, and questionnaires. The instruments used in this study were questionnaire instrument validated by media experts and material experts, an instrument for student responses, and pretest-posttest questions. Based on the validity test, the worksheet is included in the good category in terms of material with an average score of 79.67, and very good in terms of media with an average score of 77 so it is valid. Then, based on student responses, the worksheet is included in the good category with an average score of 78 so it is practical. Meanwhile, based on the results of the pretest-posttest achievements there was an increase, so it is included in the effective category to improve students' visual-spatial abilities.

Keywords: slow-learner students, visual-spatial abilities, worksheet

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INTRODUCTION

Currently, the worksheets used by teachers mostly only contain assignments using text instructions in the form of material summaries and collections of questions, but do not contain descriptions of illustrations that include indicators of visual-spatial abilities (Nilamsari & Rejeki, 2021; Wardani & Widiana, 2018). Such worksheet conditions make students less able to conceptualize, imagine, recognize patterns, and solve problems related to visuals. Therefore, this becomes a challenge for professional teachers to improve students' abilities in perceiving, linking concepts, and solving problems from different perspectives so that students' visual-spatial abilities can develop well (Isnaini et al, 2020; Lestari et al, 2023).

Visual-spatial ability is the ability to solve problems related to visual problems and mathematical creativity through the process of thinking (Damayanti et al, 2022). Visual-spatial abilities are often applied to solve spatial problems because of their characteristics which include imagining, conceptualizing, problem-solving, and pattern seeking (Isnaini et al, 2020). Visual-spatial ability is often associated with a person's ability to understand objects and spatial shapes accurately, present ideas visually and spatially, the ability to think in images and construct shapes in the mind, especially in materials related to geometry (Arifin et al, 2020; Hariastuti et al, 2018; Sukiyanto et al, 2023). As an abstract field of mathematics, geometry connects with other mathematical ideas and presents students with a high likelihood of understanding and familiarity (Andriyani & Juniati, 2019).

A geometric object that requires spatial visual abilities is a circle (Estri & Ibrahim, 2021). Furthermore, Estri and Ibrahim (2021) said that students with good spatial visual abilities have sensitivity in solving problems and analyzing elements in a circle such as the central angle and the circumference angle of a circle. According to research by Shofa and Surjono (2018), it is known that students often make mistakes in identifying the central angle and the circumference angle of a circle and linking the concept of the relationship between the central angle and the circumference angle of a circle. To overcome this problem, the role of spatial visual abilities is needed because students can interpret, visualize, and solve problems related to the central angle and the circumference angle through a picture of a circle. Therefore, the importance of spatial visual abilities in learning the central angle and the circumference angle of a circle.

However, field facts show that students' visual-spatial abilities are still in the low category (Hidayat & Wijayanti, 2023; Rizki et al, 2020). This low visual-spatial ability was also found in preliminary research at SMA Muhammadiyah 3 Yogyakarta. SMA Muhammadiyah 3 Yogyakarta is one of the schools that provides inclusive education. In this case, students with special needs are slow learners. Based on observations and interviews with mathematics teachers, it was found that slow learner students experienced obstacles in conceptualizing and solving mathematical problems, especially mathematical problems that relate to geometric concepts such as the circumference and central angles of a circle. In learning the circumference and central angles of a circle, slow learner students also experienced obstacles in imagining the angles of a circle and finding patterns for solving their problems.

Slow learner students are students with special needs characterized by low cognitive abilities so that they are slow in learning, but are not disabled (Firdaus, 2021; Fitri et al, 2019). Based on IQ tests, the intelligence of slow learner students is in the range of 80-90, slower to understand learning materials that are closely related to symbols, abstract, and conceptual (Farisiyah & Budiarti, 2023; Zulfa & Andriyani, 2023). Another characteristic of slow learner students is that they cannot focus for more than 30 minutes, therefore these students often feel bored and do a lot of physical activities (kinesthetic) (Kamala & Minhalina, 2022). Therefore, there is a need for a learning model that accommodates the needs of slow learner students in learning, according to their characteristics. The learning model used by teachers during learning such as the topic of the angle of a circle is by explaining/conventional. Therefore, slow learner students do not have good illustrations or imagination.

With these conditions, it is certainly not easy for slow learner students to learn mathematics that requires visual and spatial concepts. Therefore, to accommodate the needs of slow learner students and minimize behavioral control constraints (difficulty focusing) in slow learner students, a learning approach is needed that activates students' kinesthetics and direct experience (student-centered learning) (Andiwatir et al, 2021). So that slow learner students do not get bored quickly with learning that seems monotonous.

The results of observations and interviews obtained that the conditions that occur in inclusive classes in learning related to visual-spatial abilities, especially in mathematics learning, involve geometric problems (space), realizing objects, diagrams, and graphs. In learning, visual learning media such as videos and teaching aids such as geometry materials using compasses, rulers, arcs, and three-dimensional spatial models are also used. Then, it is also known that the teaching materials owned by slow learner students are the same as those used by other students. However, during the learning process, teachers provide special assistance and guidance to learner students when assigning assignments. To attract students' focus, learning also needs to be linked to everyday events encountered by students and integrated with other materials to accommodate the limited memory of slow learner students.

Based on the description above, the level of urgency of this research lies in the development of teaching materials in the form of worksheets with assignment instructions on the material of central angles and circumference angles of circles so that it can improve students' visual-spatial abilities by providing direct experiences that support real problem-solving practices even though slow learner students have various special characteristics.

RESEARCH METHOD

In this study was conducted at SMA Muhammadiyah 3 Yogyakarta. The subjects of the research were two slow learner students in class XI inclusion. The type of research method is Research and Development (R&D) research which in the development process uses the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). Data collection methods are observation, interviews, pretest-posttest tests, and questionnaires. The research instruments are in the form of questionnaire instruments validated by media experts and material experts, instruments for student responses, and pretest-posttest questions. The results of the validation of media and material experts state that the worksheet is valid or suitable for use. The results of the student questionnaire responses state that the worksheet is practical to use. While the results of the student pretest-posttest are to determine the worksheet is effective to use. The following is a chart of the ADDIE development stages in the worksheet as shown in Figure 1.

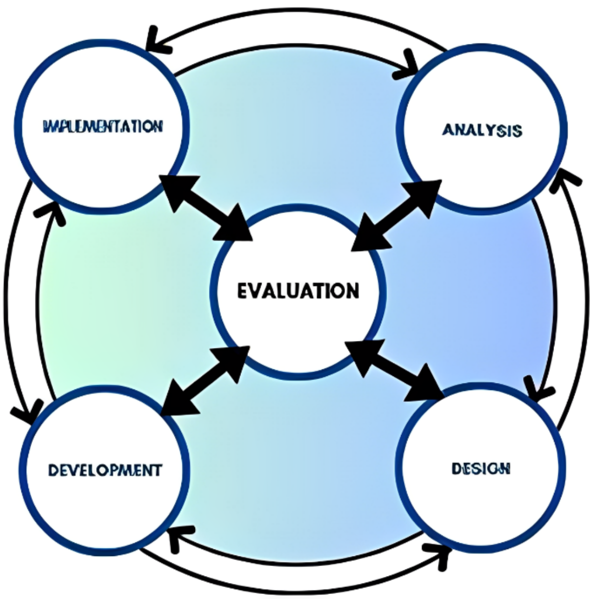


Figure 1. ADDIE Development Stages

Analysis

In the analysis stage, researchers identify information regarding learning outcomes with theories, concepts, or other problems related to learning about central angles and circumferences of circles. This identification is carried out based on the experiences, preferences, and characteristics of slow learner students during the learning process. Researchers also review data sources and information needed for development, including the curriculum used, central angle and circumference material, teacher learning approaches and models, teacher teaching materials, classroom situations and conditions, and characteristics of slow learner students as users of research and development products. To determine the characteristics of slow learner students at the research location, researchers conducted a written test to measure the mathematical abilities of slow learner students in learning about central angles and circumferences of circles presented in the context of real-life problems.

Design

In the design stage, researchers create product designs based on the results of the needs analysis. This process begins with selecting a worksheet as a teaching material that integrates Augmented Reality technology into learning about the central angle and the circumference of a circle. Then, researchers design the initial worksheet by compiling a diagram of the relationship between assignment activities on the worksheet, the syntax of the STEM-Wind Power approach, and four aspects of visual spatial skills (imagination, conceptual, problem solving, and pattern recognition).

Development

In the development stage, the researcher created an initial worksheet prototype. This development includes the development of test instruments, validation questionnaires, and student response questionnaires, which were then validated by evaluation experts. The worksheet prototype was also validated by experts in the fields of learning media and teaching material content. Furthermore, the researcher revised the prototype based on suggestions and input from validators in each field. After the revision, the worksheet can be declared valid and then ready to be implemented.

Implementation

In the implementation stage, the researcher developed concrete procedures needed to implement the learning model and worksheets that had been developed. The researcher tested the worksheets on two slow learner students in grade 11 at one of the Muhammadiyah high schools in Yogyakarta City. The implementation was carried out for five meetings, then continued with the provision of a questionnaire to measure the responses of students as users of the product as a basis for assessing the practicality of the worksheets that had been developed.

Evaluation

Evaluation is done through quantitative and qualitative data analysis. In the early stages of development, a needs analysis is carried out by processing quantitative data from the results of the initial test to identify the characteristics of slow learner students in visual spatial abilities through contextual tests. The validation results at the development stage and implementation stage are also analyzed to improve the product. Then, the results of input, suggestions, and criticisms from experts are analyzed as qualitative data and used as the basis for gradual revisions to improve the quality of the worksheet. In addition, the results of the validation questionnaire and student responses are also subjected to quantitative analysis to assess the feasibility of the worksheet in terms of validity and practicality. The entire evaluation process aims to review the whole and ensure the feasibility of the final product in terms of design, content and ease of use of the product.

The subjects used in this study were two slow learner students in grade 1 of a Muhammadiyah high school in Yogyakarta City. Data collection techniques were carried out using test and non-test methods in the form of questionnaires to validate worksheets and student response questionnaires. Data analysis techniques were carried out using qualitative and quantitative data analysis. Quantitative data analysis was carried out by calculating the average value of students' visual spatial ability test results, calculating the average validation value and the average value of the student response questionnaire results, then continuing by converting the average value into validity and practicality categories that refer to the validity and practicality criteria guidelines on the Linkert scale as represented by Table 1, Table 2, and Table 3 (Widoyoko, 2018).

Table 1. Material expert assessment criteria

No.	Average Score Interval	Criteria
1	$\bar{x} > 79.8$	Very good
2	$64.6 < \bar{x} \leq 79.8$	Good
3	$49.4 < \bar{x} \leq 64.6$	Not enough
4	$34.2 < \bar{x} \leq 49.4$	Less
5	$\bar{x} \leq 34.2$	Very less

Table 2. Media expert assessment criteria

No.	Average Score Interval	Criteria
1	$\bar{x} > 75.6$	Very good
2	$61.2 < \bar{x} \leq 75.6$	Good
3	$46.8 < \bar{x} \leq 61.2$	Not enough
4	$32.4 < \bar{x} \leq 46.8$	Less
5	$\bar{x} \leq 32.4$	Very less

Table 3. Student assessment criteria

No.	Average Score Interval	Criteria
1	$\bar{x} > 79.8$	Very good
2	$64.6 < \bar{x} \leq 79.8$	Good
3	$49.4 < \bar{x} \leq 64.6$	Not enough
4	$34.2 < \bar{x} \leq 49.4$	Less
5	$\bar{x} \leq 34.2$	Very less

A product is said to have achieved validity and practicality standards if it reaches the minimum criteria of "Good".

RESULTS AND DISCUSSION

Analysis

At the stage of curriculum and material analysis, the researcher conducted interviews with teachers and analyzed the curriculum used at SMA Muhammadiyah 3 Yogyakarta. Based on the results of interviews with teachers, it is known that the curriculum used is the Merdeka curriculum which has been adjusted to the characteristics and needs of students. In addition, the results of the interviews also showed that the allocation of time for delivering material per week is 4 x 40 minutes or equivalent to 2 meetings per week. This time allocation causes problems for slow learner students who have limitations in remembering, understanding, and receiving abstract and complex material such as mathematics. In addition to conducting interviews, the researcher also gave initial test questions containing indicators of visual spatial ability to students with the material of central angles and circumference angles of a circle. The test aims to determine the mistakes made by students in solving central angle and circumference angle problems, especially in determining the relationship between central angles and circumference angles of a circle. The test results showed that students were able to solve the problems, but they still made many mistakes in solving them. Students were only able to understand visual concepts in perspectives based on illustrations of central angles and circumference angles of a circle. Meanwhile, students still had difficulty in conceptualizing, creating problem-solving steps, and solving problems with formulas and using patterns.

Based on the results of interviews with mathematics teachers, it was found that the teaching materials used by teachers were textbooks. There was no difference in the use of textbooks by normal students and slow learner students. The textbooks contained long texts, collections of formulas, and collections of questions that had not been adjusted to the characteristics of slow learner students. The textbooks also contained pictures that were less attractive, were still monotonous, and provided less interaction with students so that they did not directly involve students in solving the questions. Thus, slow learner students had difficulty in learning the material about central angles and circumference of circles. Therefore, teaching materials are needed that not only contain long texts, collections of formulas, and collections of questions, but also something interesting such as being equipped with illustrations that can attract students' attention and accommodate the kinesthetics of slow learner students such as worksheets that can involve the student's learning process directly in it.

Another problem related to the results of the analysis of the learning situation and conditions is the problem of the application of the teacher-centered learning model. Learning models such as the expository model that still focus on the teacher tend to cause limitations for students to be actively, critically, and creatively involved in the learning process. In addition, the limitations of teaching materials make slow learner students less familiar with the relationship between learning abstract mathematical concepts and real-life contexts. Thus, it is necessary to apply a learning model that can integrate real problems into the learning process, so that slow learner students who have weak memories gain learning experiences that can accommodate students' memory limitations. In this case, the real problems that students often encounter are geometric problems on the central angle and the circumference of a circle. Geometry problems require the role of visual spatial abilities in interpreting, visualizing and solving problems related to the central angle and the circumference through a picture of a circle.

The results of interviews conducted by researchers with teachers also showed that in the learning process, slow learner students still had difficulty in solving geometric problems such as realizing objects, diagrams and graphs. In addition, slow learner students were also less able to experience obstacles in conceptualizing and solving mathematical problems, especially mathematical problems that relate to geometric concepts such as the circumference and central angles of a circle. Furthermore, researchers gave a written test containing indicators of visual spatial ability to explore these students' abilities. The test results showed that the visual spatial ability of slow learner students was still relatively low. According to the characteristics of slow learner students, students are not used to questions that require imagination, conceptualization, solving problems of the angles of a circle or finding patterns for solving the problem. This condition is reinforced by evidence of the results of the initial test of the achievement of the visual spatial ability aspect obtained from the provision of four test questions illustrated in Table 4 below.

Table 4. Initial test results for achievement of visual spatial ability aspects

Question Items	Visual- Spatial Indicators	Respondents R-1	R-2	Average	Ideal Maximum	Percentage (%)
1.	Imagining	4	7	5,5	7	78,57
2.	Conceptualizing	1	6	3.5	8	43,75
3.	Problem solving	1	0	0.5	5	10
4.	Pattern seeking	1	0	0.5	5	10
	Total Score	7	13		25	
	Result Score	28	52		100	

Based on Table 4, it can be seen that the results of the students' visual spatial ability test are still low or below the learning completion achievement standard (score = 66) with each student's score of 28 and 52. The percentage of each aspect of visual spatial ability also shows the achievement results of only one aspect reaching 55%, namely the imagination aspect of 78.57% and the other three aspects are still less than 55%, namely the conceptual aspect of 15.44%, the problem solving aspect of 4.12%, and the pattern recognition aspect of 7.06%. The low visual spatial ability of slow learner students in learning the central angle and the circumference of a circle and the limited provision of teaching materials that integrate the improvement of visual spatial abilities, thus the need to develop teaching materials that contain assignment guidelines on materials with direct experience in the context of students' daily problems. Therefore, in this study, a worksheet will be developed with the context of the material of the central angle and the circumference of a circle by integrating Augmented Reality technology to improve the visual spatial abilities of slow learner students.

Design

At this stage, the researcher designed a worksheet according to the results obtained in the previous analysis stage. The developed worksheet contains the context The developed worksheet contains material about the central angle and circumference of a circle integrated with Augmented Reality technology. The worksheet also contains the syntax of the STEM-Wind Power approach, each of which is oriented towards achieving aspects of visual spatial abilities. In the worksheet, students will be given procedures to be carried out and complete several tasks. In designing the worksheet, the researcher refers to the worksheet template (the initial part is the cover, foreword, learning objectives, learning outcomes, learning objectives, table of contents), in the content section in the form of a concept map, instructions in the form of general instructions for use and a list of symbols, worksheet activities, assessments, and the closing section in the form of a bibliography, and author profile. The overall design appearance was developed using the help of the Canva application in selecting images, selecting fonts (letters, numbers, and symbols), and selecting colors that attract students' attention.

Development

At this development stage, the worksheet was developed based on the design that had been made. Then, the researcher created a research instrument that included a product validation questionnaire instrument from the media and material aspects, a student response questionnaire, and visual spatial ability test questions. The research instrument will be assessed for its feasibility by expert judgment or grid review with a focus on the suitability of the instrument to the research objectives. Based on the results of the expert judgment, the four instruments have been declared valid as product assessments. Furthermore, the researcher validated the product's feasibility from the material and media aspects using the validation instrument. The results of the material aspect validation are presented in Figure 2 and Table 5.

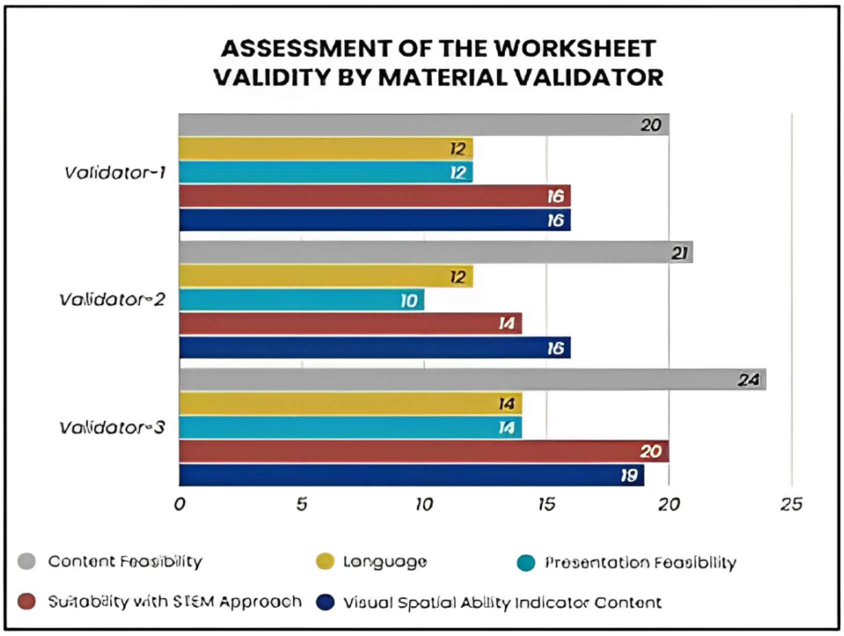


Figure 2. Detail of the assessment results by material validators

Table 5. Assessment score of worksheet validity by material validators

Component	Validator-1	Validator-2	Validator-3
Total Score	76	73	90
Mean Total		**79,67**	

Based on table 5, it can be shown that the validation results by material experts show that the total score of the validator of material-1 is 76 with the criteria of "Good", the total score of the validator of material-2 is 73 with the criteria of "Good", while the total score of the validator of material-3 is 90 with the criteria of "Excellent". The total average of the three material validators is 79.67 with the criteria of "Good". Thus, it can be concluded that the worksheet developed has achieved the validity of a product from the material aspect, so that it can be declared valid for use in learning. Furthermore, the assessment of the validity of the learning media by the validator is presented in Figure 3 and Table 6.

Based on the results of media expert validation, it is known that the total score of media validator-1 is 74 with the criteria of "Very Good", the total score of media validator-2 is 72 with the criteria of "Excellent", while the total score of media validator3 is 85 with the criteria of "Excellent". The average total of the three material validators is 77 with the criteria of "Very Good".

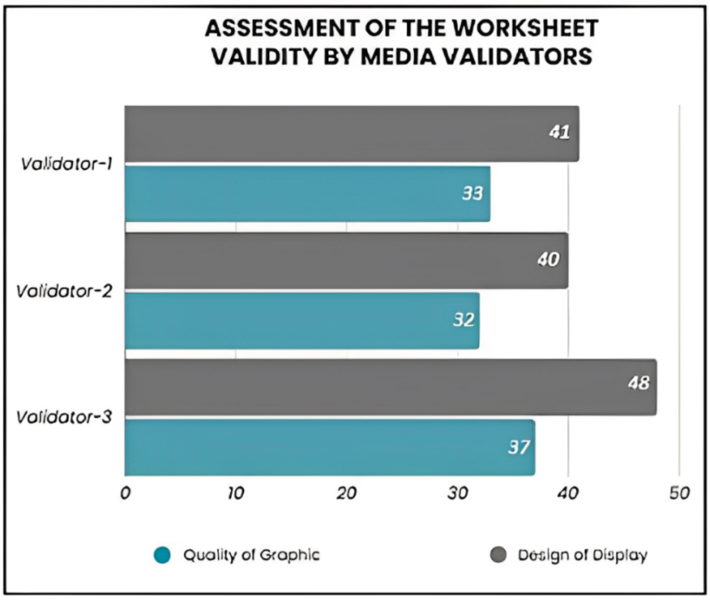


Figure 3. Detail of the assessment results by media validators

Table 6. Assessment score of worksheet validity by media validators

Component	Validator-1	Validator-2	Validator-3
Total Score	74	72	85
Mean Total		**77**	

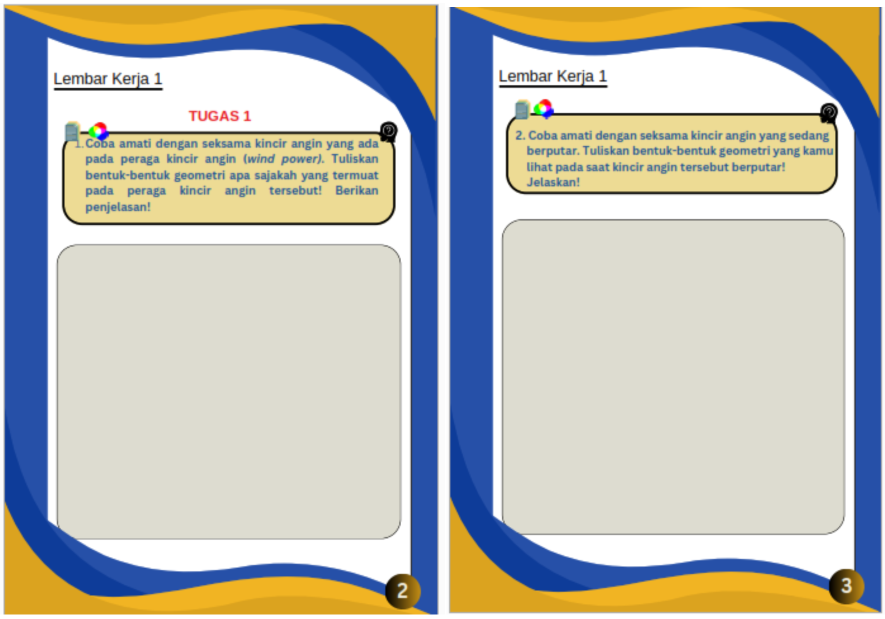
Therefore, it can be concluded that the developed worksheet has achieved the validity category of a product from the media aspect. Based on the material and media aspects, the worksheet integrated with Augmented Reality and containing spatial visual capabilities in this study has achieved the validity criteria of a development product.

Implementation

After the worksheet met the validity criteria and was declared valid for use, the worksheet was then implemented to students for four meetings. Based on the implementation results, the worksheet developed achieved the "Good" criteria with a total average of 78 respondents. Thus, the students' assessment of the worksheet developed has reached the category of practicality of teaching materials. All students gave a positive and very good impression regarding the development and use of worksheet as teaching materials. In using worksheet, students work on the steps and complete several available tasks in groups or independently. The following are some examples of worksheet use activities at the implementation stage.

Preparing tools and materials 1

At the beginning of the lesson, the teacher provides information in the form of materials and tools that need to be prepared. Then, students follow the steps that have been provided. In this case, learning begins by observing the process that occurs in the teaching aids. The results of student observations must be written on worksheet 1. Instructions for giving assignments are included on worksheet 1, such as the example assignment in Figure 4.



(a) Worksheet Activity 1 no 1 (b) Worksheet Activity 1 no 2

Figure 4. Worksheet Activity 1 on Worksheet

Preparing tools and materials 2

In this activity, there is worksheet 2. Worksheet 2 consists of materials and tools that need to be prepared, as well as instructions for the work steps. Furthermore, there are tasks that students must do after doing this activity on the answer sheet that has been prepared in the worksheet. The results of student observations must be written on worksheet 2. Instructions for giving assignments are included on worksheet 2, such as the example assignment in Figure 5.

Figure 5. Worksheet Activity 2 on Worksheet

Conducting assessment

The students' final task is to work on the questions independently as a final assessment for the students.

Evaluation

In the evaluation stage, the researcher analyzes and reviews the overall shortcomings of the process that has been and will be carried out. This is done to produce worksheets that are increasingly valid and good for use in learning. In the process of evaluating the use of worksheets, the researcher provides a posttest to determine students' visual-spatial abilities after using the worksheet. The purpose of the researcher in providing a posttest is to determine the effectiveness of the worksheet containing the central angle and the circumference of a circle in improving students' visual-spatial abilities. The results of the student posttest along with the analysis of answers based on the visual-spatial ability indicators can be seen in Figure 6.

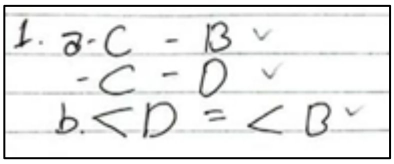


Figure 6. Results of students' post-test to imagining indicators

The answer to the question is that students are able to understand the visual concept of perspective based on the illustration of the central angle and the circumference of the circle. Figure 6 shows that students know the segments of all the radii contained in the circle and can answer the size of the same angle contained in the circle.

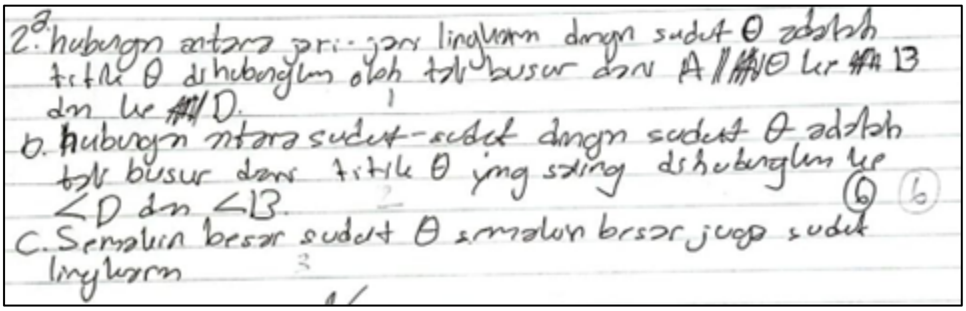


Figure 7. Results of students' post-test to conceptualizing indicators

The answer to the question is that students are able to construct a conceptual framework that correlates real facts/conditions with the problem of central angles and circumference angles of a circle. Figure 7 shows that students are able to provide answers regarding the relationship between the angles asked and the arc of a circle.

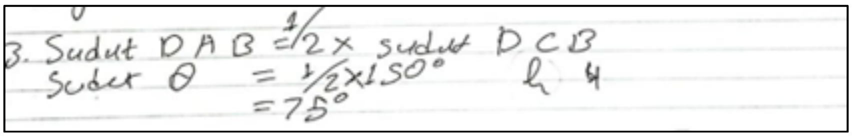


Figure 8. Results of students' post-test to problem-solving indicators

The answer to the question is that students are able to solve problems and find solutions with steps that involve conceptualization and imagination. Figure 9 shows that students do not write down the steps for solving first, but are able to answer the results from the angle asked in the question correctly.

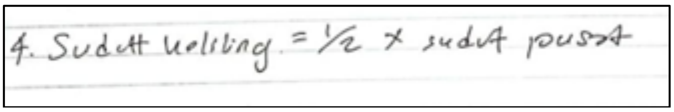


Figure 9. Results of students' post-test to pattern-seeking indicators

The answer to the question is that students are able to solve problems with similar formulas and patterns so that there is always a comparative event. Figure 9 shows that students are able to write a formula that connects the central angle with the circumference of a circle. Several post-test answers that students have worked on show that slow learner students have been able to bring out their visual-spatial abilities. Thus, based on the analysis of student posttests, it is known that students have been able to understand the steps to solve problems related to visual-spatial abilities.
The results of the post-test show that the visual-spatial abilities of slow learner students are presented in Table 7.

Table 7. Posttest results of slow- learner students

Quest. Items	Visual- Spatial Indicators	Respondents		Average	Ideal Maximum	Percentage (%)
		R-1	R-2			
1	Imagining	5	7	6	7	85.71%
2	Conceptualizing	4	6	5	8	62.5%
3	Problem solving	4	4	4	5	80%
4	Pattern seeking	5	5	5	5	100%
	Total Score	18	22		25	
	Result Score	72	88		100	

Table 7 shows the percentage value of the results of students' visual-spatial ability tests on the imagining, problem-solving, and pattern-seeking indicators above 70%, but the conceptualizing indicator is still below 70%. Based on the results of the pretest and posttest of slow learner students, there was an increase in the achievement of each indicator. Figure 10 shows a presentation of the achievement of the increase in the pretest-posttest of students.

Figure 10 shows that there are differences and increases in the achievement of pretest and posttest scores for each indicator of visual-spatial ability. The imagining indicator obtained a pretest score of 78.57% and a posttest score of 85.75%. The conceptualizing indicator obtained a pretest score of 43.75% and a posttest score of 62.50%. The problem-solving indicator obtained a pretest score of 10% and a posttest score of 80%. The pattern-seeking indicator obtained a pretest score of 10% and a posttest score of 100%. This shows that there is a difference in the average achievement of pretest and posttest scores for slow learner students' visual-spatial ability, namely the average posttest score > average pretest score. Thus, the worksheet is declared effective for use in learning.

Based on the results of interviews with teachers, researchers obtained information that when learning to ok place in class, teachers provided specific guidance to slow learner students. In the learning process, the teaching materials used by slow learner students are the same as other students.

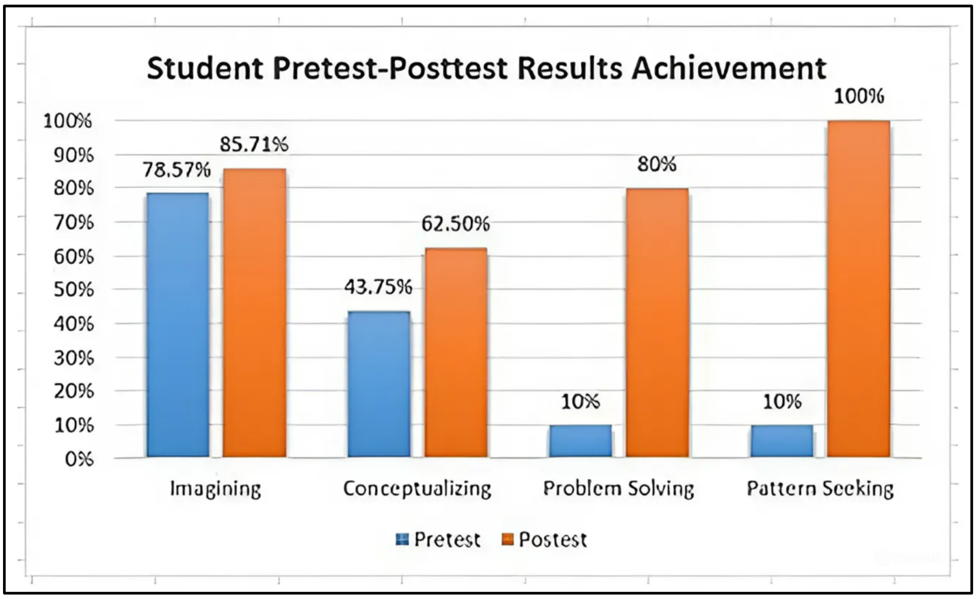


Figure 10. Student pretest-posttest results achievement

The characteristics of slow learner students are special and have limitations in receiving complex information regarding problems of central angles and circumferences of circles, and their solutions. With these special characteristics, it makes the attention of slow learner students easily diverted and their behavior control (difficulty focusing) is difficult to control. This is also emphasized by Kamala & Minhalina, (2022) that slow learner students have a focus time that cannot be more than 30 minutes, so these students often feel bored and do a lot of physical activities (kinesthetic). Therefore, researchers developed a worksheet that could make them focus on learning the material on central angles and circumference angles of circles.

Based on the results of the study, it shows that the worksheets produced meet the criteria for validity or are suitable for use in terms of material and media. This shows that the worksheets produced by researchers have met the aspects of content feasibility, language, presentation feasibility, contain the core/principles of STEM-Wind Power, contain indicators of visual spatial abilities, graphic quality, and display design, and have also been adjusted to the characteristics of slow learner students. The validity of the worksheet containing the material of the central angle and the circumference of a circle with the STEM-Wind Power approach integrated with Augmented Reality is in line with the needs of slow learner students who have low visual spatial abilities. This can be seen in the development of the worksheet with the STEM-Wind Power approach integrated with Augmented Reality which focuses on the indicators of the visual spatial abilities of slow learner students on the material of the central angle and the circumference of a circle. Therefore, in the application of the worksheet, the learning process focuses on students/student center learning (Andiwatir et al., 2021).

The practicality of the resulting worksheet has met the practical criteria as teaching materials in terms of language, interest, content, ease of use, graphics, and benefits. Therefore, the STEM-Wind Power approach integrated with Augmented Reality can be used in learning to improve the visual spatial abilities of slow learners. This can be obtained from the results of the student response questionnaire which shows that the worksheet is included in the good category. During learning using worksheet, students are enthusiastic in participating in learning. This is also in line with the research of Rumasoreng et al. (2023) that worksheet can encourage students' interest in learning mathematics.

In addition to being valid and practical, worksheets containing the material on the central angle and the circumference of a circle integrated with Augmented Reality are also effective for learning. This can be seen in the worksheets that can help students find information contained in the visual spatial problems presented. The worksheets containing the material on the central angle and the circumference of a circle integrated with Augmented Reality have proven effective. This is proven by the achievement of student scores after using worksheets that have exceeded the KKTP (Learning Objective Achievement Criteria) and based on the results of the analysis of pretest and posttest data on the visual spatial abilities of slow learner students which show an increase. Thus, the increase in achievement results is shown in students' written answers when working on the pretest and posttest showing a change after using the worksheet.

The effectiveness of Augmented Reality to improve students' skills in geometry learning is in line with the research results of Garzón et al. (2017) and Buliali et al. (2022), which shows that augmented reality can encourage higher motivation and skill. So, this technology has become indicative of the breadth of augmented reality's role and the magnitude of its potential in education. In particular, the effectiveness of augmented reality-based learning media in geometry learning is also seen through the increase of students' mathematical spatial abilities (Arifin et al, 2020).

CONCLUSION

Based on the results and discussion, it can be concluded that the worksheet to improve visual-spatial abilities in slow learner students meets the valid category. This is based on the assessment results of the material validator with an average score of 79.67 in the category "Good" and the assessment of the media validator with an average score of 77 in the category "Excellent". Then, the worksheet to improve visual-spatial abilities in slow learner students meets the practical category. This is based on the assessment results of the student response questionnaire with an average score of 78 in the category "Good". Furthermore, the worksheet to improve visual-spatial abilities meets the effective category. This is based on the achievement of the pretest-posttest results on each indicator of students' visual-spatial abilities experiencing an increase. This is based on the imagining indicator obtaining a pretest score of 78.57% and a posttest score of 85.75%, the conceptualizing indicator obtaining a pretest score of 43.75% and a posttest score of 62.50%, the problem-solving indicator obtaining a pretest score of 10% and a posttest score of 80%, and the pattern-seeking indicator obtaining a pretest score of 10% and a posttest score of 100%.

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DECLARATION

Author Contribution

All authors contribute in the research process, such as collecting and analyzing the data, and writing the manuscript. All authors approved the final manuscript.

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Conflict of Interest

All authors declare that they have no competing interests.

Ethics Declaration

We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Emerging Mathematics Education (IJEME) in maintaining high standards of personal conduct in all our professional practices and endeavors.

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