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Development of Augmented Reality to Solve Geometry HOTS Problems for Class V SDN 1 Doplang Students

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Abstract

The results of the initial interview were explained by the class teacher that grade V students of SDN 1 Doplang still had difficulty doing high-level questions, especially on geometry material. Then the observations also prove that in general, teachers still use models and learning media only in the form of pictures and videos. The purpose of this study is to develop augmented reality learning media based on geobar applications so that it can facilitate students in the process of understanding geometry material. The type of research used is research and development (RnD) with the Borg and Gall model which is modified into 9 stages. Data collection techniques through observation, interviews, questionnaires, and documentation. Results of the product assessment are in the form of validation of learning media carried out by material, media, and language experts with percentages of 91.6%, 90.6%, and 93.1% with a classification of "very feasible". The effectiveness of media with the T-Test obtained a signification value of 0.000. The result of the N-gain calculation was found to be 0.6904 with the criterion "medium". So the learning media for geobar applications of geometry material can be said to be very feasible and effective to be applied in improving the ability to solve HOTS problems. Researchers recommend the development of *augmented reality* (AR) media so that it can continue to be maximized so that the learning process can take place interesting and fun so that the material delivered can be easily understood by students

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INTRODUCTION

Education plays an important role in human life, education is an effort made by humans to develop better abilities and personalities. Education must be optimal by building good interactions to develop skills, fun, critical thinking, and good character building (I. Isrokatun, 2023; Kadir et al., 2020; Senen et al., 2021; Shafril et al., 2021). These abilities and personalities are resources that can be developed by the targets of countrywide education. Law No. 20 of 2003 governing the national education system states the national education goal. Specifically, to cultivate students' ability to grow to be humans who accept as true with in and are committed to God Almighty, who're noble,

healthy, knowledgeable, capable, creative, independent, and who tackle democratic responsibilities; to mold the character and civilization of a dignified nation; and to educate the nation's life.

To achieve the goals of national education the learning process is the main key that must be done properly and correctly, to support the learning process, learning models and learning media are the main components. However, it needs to be developed to achieve the learning objectives of a learning process. Developing strategies and learning media to overcome student learning difficulties is a small action that needs to be applied by teachers (Pua et al., 2021). (Hasan, 2021) Mentioning that learning media is everything that is used as an middleman or liaison from the informer, namely the teacher to the recipient of statistics or college students who intention to stimulate college students to be stimulated and capable of observe the gaining knowledge of technique as a whole and meaningfully. Then for the types of learning media, namely, image media, video, AR / VR, and so on. So the learning models and media used can help the learning process so that learning objectives are achieved. However, in reality, today many teachers have not used effective learning models and media according to student conditions. This is evidenced by observations, interviews, and tests of students' initial abilities at school directly.

The results of the initial interview explained by the class teacher that grade V students of SDN 1 Doplang still have difficulty doing high-level questions. Furthermore, the observations demonstrate that generally speaking, educators continue to employ media that consists solely of images and videos and learning approaches akin to investigative groups. Furthermore, it is accurate, according to the findings of my study of the test questions I gave the grade V students, that kids are still having trouble answering HOTS questions. Explaining (Saraswati & Agustika, 2020)The ability to synthesize concepts and facts through analysis, evaluation, and creation that is, to offer an appraisal of a fact that has been taught or can be formed from something that has been learned is known as HOTS.

Effective learning models and media are required in the assessment and evaluation process to create something that can be learned, especially when concepts and facts are combined. The problem-based learning model is an effective learning paradigm that may be applied during the learning process. According to (Darwati & Purana, 2021), one of the learning models that may be applied is problem-based learning (PBL), which encourages students to think critically, solve problems adeptly, and apply their understanding of problems to real-world challenges. Real-world challenges will surely result in significant comprehension. The Problem-Based Learning (PBL) Model, according to (Astuti, 2023), exposes students to real-world and meaningful difficulties.

The media's function is crucial to be used in helping pupils comprehend meaningful higher-order thinking skill (HOTS) challenges. As a result, learning will become engaging and effective, and information will be delivered in the form of facts and concepts that can be used to solve problems. demonstrating that educational media can function as a bridge to help students and teachers understand the content in a way that is both efficient and effective (Hasan, 2021).

Solutions to overcome existing obstacles and problems, namely by applying the right methods and using learning media. One of the effective learning media today is many technology-based media. The use of information and communication technology in the field of education is very important. One of them is based on (Ahillon Jr. & Aquino, 2023; Akinoso , 2022; Bolaji &; Jimoh, 2022; Shah, 2022) *Artificial Intelligence*, in which there are *virtual reality* media, *augmented reality* media, and so on. One of the *Artificial Intelligence* technologies that can be utilized in learning mathematics geometry material is *Augmented Reality media*.

According to (Dhani Ariatmanto, 2022) *Augmented Reality* is a bridge that is between the real and virtual worlds, to be able to interact directly and connect between real and virtual world objects. Through *augmented reality* media can provide a unique mathematics learning experience and the explanations given become more concrete. Other research shows that AR can enhance children`s studying cappotential via way of means of making the studying system extra interactive amusing

and easy to understand. (del Cerro Velázquez & Morales Méndez, 2021; Hiranyachattada & Kusirirat, 2020) (Chiang et al., 2022; Joseph, 2020; Rebollo et al., 2022; Soltani & Morice, 2020; Yu et al., 2023). The existence of *Augmented Reality media* can help the process of understanding elementary mathematics learning, especially in geometry mathematics material. In addition, according to research conducted, (İbili et al., 2020) *Augmented Reality* is also able to provide an introduction for students related to building space, namely geometric nets and volume formulas.

Thus, the use of these media can be an effective medium to be applied in the learning process in schools. Especially in this study, which is a mathematics lesson that requires a fairly difficult thinking and understanding process. According to learning, mathematics is one of the instructions with summary standards that require college students to clear up issues contained in math issues, which can not be separated from normal life. Then this encourages researchers to develop augmented reality learning media based on geobar applications which hopefully can facilitate students in the process of understanding geometry material. According to figures geometry is something abstract, such as planes, vectors, coordinates, patterns, and measurements that can be used in everyday life. Learning geometry through the help of geobar applications, of course, can create learning media that is interactive, easy to understand interesting, and easily accessible because it does not require an internet network. In addition, with the interactive learning media, the geobar application can improve the ability to solve (Fitriana, 2021)(Dawkins et al., 2023; Korshunova et al., 2020; Lai et al., 2023). *Higher Order Thinking Skill (HOTS)* geometry mathematics problems for students in class V. But there is also a weakness of this geobar application, namely limitations on the *target image object*.

This research is also strengthened by several relevant previous studies, while the forms of previous research are as follows. The use of *augmented reality* as a learning medium has been carried out by Anggrainy Wulandari, Samijo, and Darsono in 2022 in the Journal of the University of Jember with the title "Development of Augmented Reality-Based Mathematics Learning Media". Based on the results and discussion, this study concludes that augmented reality-based mathematics learning media named GEORANS is very feasible to be used in the learning process in schools. Gladly C Rorimpandey, Christio N Kalalo in 2018 in his Thesis with the journal "Application of Basic Mathematics Learning based on Augmented Reality". Based on the results of the study, it was concluded that this mathematics introduction application can help students who still have difficulty understanding mathematics. In addition, this math introduction application can make children learn while playing. Enang Rusnandi, Harun Sujadi, Eva Fibriyany Noer Fauzyah in 2016 in the UNMA Infotech journal with the title "Implementation of Augmented Reality (AR) in the Development of Learning Media for 3D Space Building Modeling for Elementary School Students". There is also research conducted described in this study, that GeoGebra AR can explain the potential and challenges in learning mathematics in Laos using a type of 4D research. (Kounlaxay et al., 2021)Based on the results of the study, it was concluded that AR can be used as an interactive learning medium and can make a positive contribution to the world of education.

Based on this background, the researcher will discuss three problem formulations, including (1) the design of geobar application learning media, (2) the feasibility of geobar application learning media, and (3) the effectiveness of geobar application learning media in improving the ability to solve geometry mathematics hots problems grade V SDN 1 Doplang.

METHODS

The current study employs research and development models as well as research approaches to create specific items and assess their effectiveness. This research and development follows the modified Borg and Gall model in nine stages: problems and potentials, data collection, product design, product validation, design revision, small-scale trials, product revisions, large-scale trials, and final product revisions. (Sugiyono, 2021b)

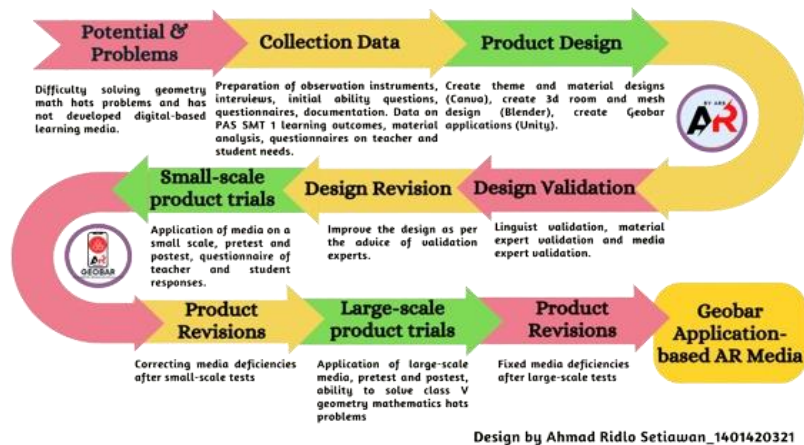


Fig. 1 Development Research Steps

Researchers make products in the form of geobar applications (bringing up two-dimensional objects (building flat) into 3-dimensional objects (building space) with problem-based learning-based material to be used in the learning process.

To construct geobar application learning media, start with the potential and problem stages, then go on to data collecting and product design. Data collection strategies involve both tests and non-tests. The test collecting technique consists of administering an initial test before the media treatment (pretest) and a final test following the media treatment (posttest) to measure the improvement of student learning outcomes in grade V SD Negeri 1 Doplang. There are pretests and posttests to find out more accurate results before treatment and after treatment. Meanwhile, non-test data collection used are interviews, observations, questionnaires, and documentation. Observations were made on November 24, 2023, to observe the learning process that took place in class and found the problem of the need for a better understanding of geometry material and the lack of use of learning media. The researchers' interviews were conducted together with the principal, Mr. Sutiyono, S.Pd.SD and class V teacher, Mr. Purnomo Hadi, S.Pd.SD the distribution of questionnaires given to teachers and students for questionnaires of media needs and responses. As for the validation of media experts, material experts, and linguists, there is also a media, material, and language assessment questionnaire that contains benefits, technical use, aspects of appearance, suitability of the material, and accuracy of teaching modules. At each stage of data collection, there are assessment instruments made by researchers that have previously been validated by the supervisor.

Small-scale trials were carried out to obtain qualitative evaluations of geo bar application media that had been designed by material expert validators, media experts, and linguists and were carried out to see student responses related to the design display test and test functions and buttons running well by the media that had been developed. The subjects of the small-scale trial were 9 grade V students of SD Negeri 1 Doplang. Large-scale trials were conducted to determine the effectiveness of geobar application learning media in improving student learning outcomes. The subjects of the large-scale trial were 21 grade V students of SD Negeri 1 Doplang with all members of the population involved using the saturated sampling technique carried out in this study. Large-scale trials used a *one-group pretest-posttest* design to compare conditions before and after *treatment* (Sugiyono, 2016) Large-scale trial designs are presented in Table 1.

TABLE I
ONE GROUP PRETEST-POSTTEST DESIGN

Before Treatment	Treatment	After Treatment
O1	R	O2

Information:

O1: Value Before Treatment of Geobar Application Learning Media

O2: Value After Treatment of Geobar Application Learning Media

R: Application of geobar application learning media

Characteristics of geobar applications developed with data analysis techniques using descriptive methods. Media feasibility is analyzed according to the results of validation by material experts, media experts, and linguists who use the following percentage formula:

$$NP = \frac{R}{SM} \times 100 \%$$

(Kamila, 2023)

Information:

NP : Percentage value

R : Score obtained

SM : Maximum score

The percentage of data is then converted based on the criteria of very feasible, feasible, feasible enough, and less as follows:

TABLE II

PRODUCT FEASIBILITY ASSESSMENT CRITERIA

Percentage	Criterion
76% - 100%	Very decent
51% - 75%	Proper
26% - 50%	Pretty decent
0% - 25%	Less viable

The impact of employing geobar application media, which was created to enhance student learning outcomes based on data collected before and after installation and computed using the gain index, was evaluated by data analysis (Pratiwi Haryono, 2019)

$$N\text{-gain} = \frac{\text{Skor posttest} - \text{skor pretest}}{\text{skor maks} - \text{pretest}}$$

The computation results are then divided into the following categories based on the N-gain test findings' criteria (Pratiwi Haryono, 2019)

TABLE III

N-GAIN SCORE INTERPRETATION CRITERIA

Average	Criterion
g 0.7>	Tall
0,3 ≤ g ≤ 0,7	Keep
0 ≤ g ≤ 0,3	Low
lesslessg ≤ 0	Fail

The independent variable in this study is the geobar application learning media while the dependent variable is to improve the ability to solve class V hot questions at SD Negeri 1 Doplang.

RESULT AND DISCUSSION

A geobar application is the result of this research and development project. programs for desktop use are accessed using desktop programs developed with Unity. The media design is appealing by the requirements of the pupils and the elementary school geometry mathematics curriculum. You may access the Geobar application learning media by clicking on this link. <https://drive.google.com/drive/folders/1ZmoRZLbdfiOYPkdLqirECAUNnFiDalWt?usp=sharing>

For the display of geobar application learning media can be seen in the following image.



Fig. 2 Geobar Application Logo





Fig. 3 3-dimensional view build cube space



Fig. 4 Learners' use of the app



Fig. 5 Geobar Application Creation View in Unity

Some images and videos in the media support materials such as simulating three-dimensional space building using two-dimensional drawing objects. The language used is also communicative and easily understood by students.

The first step that researchers must take is to collect data or information on the potential problems contained in SD Negeri 1 Doplang. Information collection is carried out by observation, interviews, questionnaire dissemination, and documentation. Based on the information obtained, there are several problems, namely in learning geometry mathematics, teachers have not fully developed and applied learning media, and teachers refer more to teacher and student books that are already

available so that the impact on student mathematics learning outcomes tends to be low. At the data collection stage, researchers collect various information related to product development, so that the resulting products can overcome problems that exist in SD Negeri 1 Doplang and accordance with the needs of teachers and students.

Product design is carried out based on analyzing media needs questionnaires to teachers and students. At this stage, researchers design learning media products that contain interesting geometry materials by being able to display 3-dimensional space buildings in reality. There is a suitable color combination equipped with a display menu that can be selected by users in the form of games, profiles, learning outcomes, learning objectives, materials, sample questions, and quizzes that can be accessed easily. So this geobar application with the basis of *augmented reality* is an attraction for students.

At the product validation stage, researchers test the geobar application media that has been made, to media experts and material experts. Based on the assessment of media experts and material experts, the following results were obtained.

TABLE IV
PRODUCT VALIDATION RESULTS

Validators	Score	Criterion
Material	91,6	Very decent
Media	90,6	Very decent
Average	93,1	Very decent

After assessment and validation from experts, media results were obtained that were said to be "very feasible" to be used in the learning process. Several weaknesses were found in the product related to the order of the material from building flat first and then building space and location plans of the system plotted according to the material so that the material on the product can be systematic. There is also related to adjusting the question material which should be a problem that is by real life with the right syntax and learning objectives. The weaknesses of the product are corrected to produce a product that is suitable for use.

Small-scale product trials were carried out on several grade V students of SD Negeri 1 Doplang to prove the developed products' effectiveness. Product effectiveness tests are carried out using testing instruments so that complete data related to the application of the product is obtained and used as material for improving geobar application media to meet applicable standards effectively. At this stage, there are 9 students drawn from the top 3 ranks, the middle 3 ranks, and the last 3 ranks, with the aim that the implementation of small-scale trials can run evenly and balanced. Small-scale results obtained a value of 100% showing that the geobar application media is very good and there are no criticism and suggestions, so it can be used for large-scale trials.

The eight large-scale usage trials on grade V students of SD Negeri 1 Doplang totaled 21 people to test the feasibility and effectiveness of augmented reality media learning media products based on geobar applications that have been made. The results obtained by 1 in 21 or 5% of students said there were still designs considered less attractive. Here are the normality test results on small-scale and large-scale trials.

TABLE V
RESULTS OF SMALL SCALE NORMALITY TEST

Tests of Normality					
Kolmogorov-Smirnova			Shapiro-Wilk		
Statistics	Df	Sig.	Statistics	Df	Sig.

Pretest	.135	9	.200*	.976	9	.941
Posttest	.179	9	.200*	.937	9	.550

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

TABLE VI
RESULTS OF THE LARGE-SCALE NORMALITY TEST

	Tests of Normality					
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	Df	Sig.	Statistics	Df	Sig.
Pretest	.186	12	.200*	.907	12	.196
Posttest	.139	12	.200*	.945	12	.559

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The table above shows the results of the pretest and posttest value normality test with the Kolmogorov-Smirnova and Shapiro-Wilk tests assisted by the SPSS 25 application. The normality test criteria are said to be normal if the significance value is >0.05 so that the data is normally distributed. The normality test results above showed a significance of >0.05 , namely in the Kolmogorov-Smirnova pretest significance reached 0.200 and the normality test posttest value showed a significance of 0.200. Then using Shapiro-Wilk obtained significant results of 0.941 and 0.550 in small classes and significance of 0.196 and 0.559 in large classes so that the data is normally distributed. Then test the effectiveness of the media with a t-test. The paired sample t-test test criterion indicates a significant difference in learning outcomes between pretest and posttest data with a sig value (2-tailed) < 0.05 . However, if the sig. (2-tailed) value is greater than 0.05, there is no significant difference between the learning outcomes in the pretest and posttest data. The SPSS 25 program was used to help achieve the following t-test results.

TABLE VII
SMALL SCALE T-TEST RESULTS

SMALL SCALE 1 TEST RESULTS									
		Paired Samples Test							
		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	Df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pretest - Posttest	-92.55556	15.22425	5.07475	-104.25795	-80.85316	-18.238	8	.000

TABLE VIII
LARGE-SCALE T-TEST TEST RESULTS

SPSS Output - Paired Samples Test									
		Paired Samples Test							
		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	Df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pretest - Posttest	-86.75000	19.11746	5.51874	-98.89665	-74.60335	-15.719	11	.000

The results of the pretest and posttest in small and big groups differ significantly, as can be seen in the table when sig (2-tailed) $0.000 < 0.05$. Next, compare the increase in the pretest value results with the posttest value, which was determined using the gain index analysis, to test the increase in the average value (N-gain). The outcomes are as follows.

TABLE IX
SMALL AND LARGE SCALE N-GAIN TEST RESULTS

		N	Min	Max	Mean	Std. Deviation
NGain		9	-.48	1.00	.7695	.14768
Valid	N	9				
(listwise)						
NGain		12	.50	1.00	.6904	.14126
Valid	N	12				
(listwise)						

The aforementioned data suggests that using the geobar application learning material has raised students' average scores in both small- and large-scale trials using moderate criteria. With no changes and recommendations from the relevant class teacher, the teacher response questionnaire received 100% of the possible points.

After undergoing both small- and large-scale trials, the geobar application learning medium was found to be effective. To assess the effectiveness of the produced media, it is evaluated not only following student learning objectives but also following the answers to questionnaires sent to both teachers and students. This demonstrates that the geobar application's ability to aid pupils in understanding geometry-related mathematical content has been successful.

CONCLUSIONS

The study's findings demonstrate that augmented reality learning materials based on the geo bar application have been created to help SDN Doplang 1's grade V pupils do better when it comes to solving geometry math hotspot issues. The findings are very viable to be used to enhance the teaching and learning process, according to the validation results of lecturers, media specialists, material experts, and linguists. Large-scale experiments' findings demonstrate the effectiveness of geo-spatial application learning medium in raising student learning outcomes.

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CONFLICTS OF INTEREST STATEMENT

The author declares that the data published in the manuscript has no conflict of interest to any party. If in the future such a thing is found, full responsibility for it lies with the author.

AUTHOR CONTRIBUTIONS

The contributions of the authors involved in the preparation of this scientific article consist of Ahmad Ridlo Setiawan (Author 1), who acted as a researcher who played a role in conducting observations at one of the schools that was the subject of the research and writing this scientific

article. Mrs. Nursiwi Nugraheni (Author 2) is a supervising lecturer who has guided, evaluated, and directed the author in the preparation of this scientific article.

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