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THE USE OF AUGMENTED REALITY TO IMPROVE STUDENTS' GEOMETRY CONCEPT PROBLEM-SOLVING SKILLS THROUGH THE STEAM APPROACH

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ABSTRACT

This research develops learning media with a Science, Technology, Engineering, Art, Mathematics (STEAM) approach based on Augmented Reality (AR) to improve students' mathematical problem-solving abilities on geometric concepts. This method uses design-based research (DBR). The development stages consist of needs assessment and literature review, design and development, user testing to analyze user responses and evaluation and examination of the media devices being developed. The research subjects for expert tests included media experts and education experts, practicality tests for teachers, response tests for ten high school students, and examination stage tests for 30 high schools in Indonesia. The instruments used were media expert questionnaires, education expert questionnaires, practicality questionnaires, and tests. The media developed is called Augmented Reality Mathematics (ARM). The results of this research are 1) ARM media expert test in the very good category, 2) ARM educational media expert test in the very good category, 3) ARM media practicality test in the good category, 4) responses from students who use ARM media in the very good category, and 5) ARM media can improve mathematical problem-solving abilities in the moderate category. The findings of this research are that AR media is effectively used to improve students' problem-solving abilities in medium-category geometry concepts using the STEAM approach. This research concludes that using ARM media with STEAM learning can improve problem-solving abilities in geometric concepts.

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1. INTRODUCTION

The ability demanded in dealing with 21st century skills is the ability to solve mathematical problems (Primayana, 2020). Critical thinking skills can be developed by students through problem-solving activities in school, society, and daily life (Rahmawati et al., 2020). Thus, it is very important that problem-solving skills are introduced to students to develop critical thinking skills (Nuriyah et al., 2020; Sutama et al., 2022).

Students in mathematical problem-solving abilities still have many difficulties (Özreçberoğlu & Çağanağa, 2018; Syamsuddin et al., 2020). Mathematical problem-solving ability is the ability to understand problems, strategize, strategize, and reflect (Siskawati et al., 2022). Geometry is one branch of mathematics, this field still many students misunderstand geometry concepts, especially in solving problems, such as calculating the area and perimeter of rectangles and parallelograms (Aisyah et al., 2023; Puig et al., 2022; Siskawati et al., 2022). The field of geometry is considered difficult, especially related to the third dimension, because of its abstract nature and the student must be able to visualize shapes from the third dimension (Bedewy et al., 2021). Geometry material is also difficult at the school level, including in the South African area of Naidoo and Kapofu (2020). Students' ability in geometry will affect the ability to understand other mathematics (Meryansumayeka et al., 2022; Pertiwi et al., 2021). Thus, geometry skills are very important and urgently need to be addressed.

The ability to solve problems in the field of geometry needs to be overcome immediately, namely by applying learning media. Learning media as a bridge to learning communication (Sukirman & Setiawan, 2022). Learning media today is very developed. Learning media that were previously still classic, are now digital and look more real like learning media using augmented reality which is more popular with students.

Augmented Reality (AR) is a technology-based learning medium that can visualize geometry field material, thus helping students in understanding concepts. Technology-based media is very urgent to be applied in the world of education (Elsayed & Al-Najrani, 2021). AR technology has been widely implemented in the world of education and is able to improve academic and non-academic abilities for students at various levels of education and their different and diverse needs (Castaño-Calle et al., 2022). AR media can enrich teaching and learning activities and improve educational facilities (Lampropoulos et al., 2022).

The use of media with AR has advantages in improving academic and non-academic abilities, including fostering the achievement of learning achievement, attitudes, motivation (Cevahir, 2022). AR can develop critical thinking skills, problem solving and geometry skills (Bedewy et al., 2021). AR media can activate students in learning (Jesionkowska et al., 2020). AR media can have a positive effect on computational thinking skills and thinking skills visualization in geometry topics (Hanid et al., 2022). AR media can improve mathematical representation capabilities (Li et al., 2022).

This AR media can facilitate students in achieving 21st century skills. Abilities in the 21st century, 4C skills are required, namely the ability of critical thingking, Communication, Collaboration, Creativty, so that in learning mathematics it is necessary to include these elements (Fox & Cavner, 2015; Setyarto et al., 2020) and mastery of technology (Körtesi et al., 2022). AR media can facilitate students in mastering technology, critical thinking skills, and solving problems. and anything else that supports 21st century skills.

Augmented reality can display a visualization of objects with the help of a real camera. According to Fransiska and Akhriza (2017) augmented reality is an interactive and informative learning medium and can improve students' ability to solve a problem. In addition, AR media is an interactive media that can improve problem solving, especially with learning Science, Technology, Engineering, art, and mathematics (STEAM), can develop critical, creative, and collaborative thinking skills in completing tasks (Jantassova et al., 2022). AR media based on several study results, many are integrated with learning approaches, including STEAM learning (Bedewy et al., 2021; Bedewy et al., 2022).

Learning with the STEAM approach or Science, Technology, Engineering, Art, and Mathematics can facilitate students to understand the subject matter and is in line with the demands of 21st century competencies (Sigit et al., 2022). It prepares students for the digital age career opportunities (Rahman et al., 2022). According to Katz-Buonincontro (2018), STEAM learning integrates science, technology, engineering, art, and mathematics. STEAM learning is also said to be a curriculum reform and sub-construction of STEAM education as a pedagogical process and assessment of STEAM education. Sub – The construction of problems in STEAM education is a criticism of its challenges (Belbase et al., 2022).

Many efforts have been made for STEAM learning, including STEAM learning integrated with project-based learning (Sigit et al., 2022), integrating STEAM with problem-based learning (Diego-Mantecon et al., 2021), STEAM learning integrated with local culture and problem-solving skills (Bedewy et al., 2022). The STEAM learning model integrated with flipped clasroom can improve material mastery, namely mathematical understanding (Sutama et al., 2020). The results showed that looking at the application of STEAM learning integrated with other learning, showed effectiveness in mastery and understanding of mathematics and problem solving.

AR is a medium that facilitates the learning environment by consisting of contemporary technology and virtual technology that combines reality and digital interaction (Jesionkowska et al., 2020). In addition, AR technology can be used directly or indirectly in teaching and learning environments to help and retain learners in dealing with knowledge and interacting visually and auditorily in an easier way that is useful for representing, storing, and testing knowledge (Sun et al., 2018). AR technology facilitates computer-generated writing as information, images, virtual 3D designs, videos, or scenes such as the actual state perceived by the user in real-time and accurately (Zhou et al., 2022). Thus, AR has a lot of sense showing hope, particularly for STEAM education (Ibáñez & Delgado-Kloos, 2018). Research results related to the need to facilitate technology in the 21st century era, namely with AR with the STEAM Approach (Rukayah et al., 2022).

As for STEAM learning using AR media integrated with architecture, culture in problem-solving abilities in modeling using the geogebra platform on AR, as well as 3-dimensional printing, the results show students use mathematical knowledge to be able to reflect on history, architecture and modeling tasks (Bedewy et al., 2021), application by teachers to mathematics learning through STEAM which is associated with various cultures for solving Mathematical modeling implemented with the GeoGebra platform, as a result teachers get the opportunity to get various kinds of modeling (Bedewy et al., 2022). Thus, based on the results of studies related to learning media with a STEAM approach with AR, no one has developed learning media products with an AR-based STEAM approach for three-dimensional geometry for school students in improving mathematical problem-solving skills. In addition, AR is suitable for overcoming problems that demand high visual loads (del Cerro Velázquez & Morales Méndez, 2021) as in the field of geometry. Thus, the formulation of the problem proposed is: How to develop AR learning media with STEAM learning for 3rd dimensional material in geometry in school students in improving mathematical problem-solving skills in geometry?

2. METHOD

2.1. Research Design

The research method applied by Design-Based Research (DBR), DBR stages carried out with development and Examination stages (Chiu & Churchill, 2015). The development stages consist of: needs assessment and literature review, design and development, tests on users to analyze user responses, and evaluating and examining sets testing developed media (Chiu & Churchill, 2015; Lavicza et al., 2022).

The results of learning media are AR education media with a STEAM approach for solving mathematical problems in three-dimensional geometry materials for high school students. Need assessment activities are carried out by conducting a Forum Group Discussion (FGD) for mathematics teachers and reviewing literature by analyzing various scientific sources. In the design stage, three designs, namely the design of the augmented reality learning media application, the design of the augmented reality marker as a support for the application of learning media, and the design of a guidebook as a guide in using media applications. Develop stage, conducting media tests to experts and, among them, testing the media to media and education experts while to teachers to get information about the practicality of the developed media. Then, conduct FGDs from the study subjects, namely experts and teachers. After that, conducted field trials were limited to 10 students of class XII (High School level in Jakarta. This little trial is to get feedback from real users.

We are examining stage, testing AR learning media with the STEAM approach for mathematical problem-solving skills. The study subjects were 30 students of class XII of Senior High School in Jakarta Indonesia. This activity also shows the application of learning media to the ability to solve mathematical problems in geometry in the classroom.

2.2. Research Subject

The subjects of the study are experts, namely educational experts, media experts, and teachers. In addition, it is high school seniors who are getting three-dimensional geometry materials. The instrument used, a questionnaire to get validation from experts, is a k test in the form of solving problems in the geometry concepts. This study used descriptive statistical data analysis.

2.3. Data analysis technique

Qualitative data analysis in the form of responses, comments, and suggestions is the basis for improving learning media. The use of quantitative data in the form of validation of media expert tests, educational expert tests, and teacher practicality tests through questionnaires as Likert-scale (4 scale; 1, 2, 3, 4) answer criteria and product assessments from the theory of Rezapour Nasrabad (2017), namely in Table 1.

Table 1. Validity criteria

Percentage Score (in %)	Category Validity
91-100	Excellent
81-90	Good
71-80	Enough
61-70	Less
0-60	Very bad

The formula for processing the problem-solving ability test of the geometry concepts, namely the n-gain formula from Hake's (2002), is as follows:

$$g = \frac{S_1 - S_0}{S_{max} - S_0} \quad (1)$$

With S_0 = Initial score; S_1 = Final score; S_{max} = Maximum score.

Furthermore, the interpretation of the score according to the criteria of Hake's (2002) is in Table 2.

Table 2. Interpretation of n-gain

N-gain score	Category Upgrade
- 1.00 < g < 0.00	Decreased
g = 0.00	Stable
0.00 < g < 0.30	Low
0.30 < g < 0.70	Keep
0.70 < g < 1.30	Tall

3. RESULT AND DISCUSSION

3.1. Results

3.1.1. Need Assessment and Literature Review Stage

At the need assessment stage, applying FGD and providing questionnaires to mathematics teachers. The results found that an effective and efficient learning medium for three-dimensional material is needed. In addition, students already have smartphones and are proficient in using them. Then the researcher made an application consisting of three components: the ARM application, the ARM marker, and the application usage guidebook. Researchers obtained several resources on STEAM learning and AR learning media from a literature review.

3.1.2. Design Stage

As research has been done by Arifin et al. (2020) and Putra et al. (2020), the design stage is a crucial stage to do so that it can make it easier to develop learning media. There are three designs: the design of the augmented reality education media application, the augmented reality marker as a support for learning media applications, and the design of a guidebook as a guide in using learning media applications.

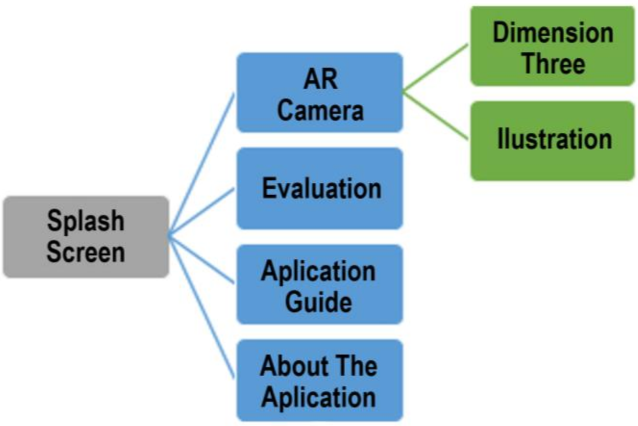


Figure 1. Augmented reality media systematics

Figure 1 is the systematics of AR media compiled, Starting from Splash Screen. It consists of AR cameras, evaluations, application guides, and about applications. The AR camera consists of three-dimensional illustrations.

3.1.3. The Development Stage

The development of the resulting learning media is named "ARM Augmented Reality Mathematics." ARM application development uses the Unity application as the basis for creating augmented reality applications using the Vuforia plugin and making space-building models using the Blender application. Users can install ARM applications on smartphones with a minimum of the Lollipop version of the Android operating system. The ARM application displays three-dimensional construct shapes with the material of the distance between spaces on the cube and beam space constructs. There is each one example of the distance between areas in the cube and beam space, namely the distance between point to point, between points to lines, and between points to planes. The display of the ARM application is in Figure 2.

In making augmented reality mathematics applications, there are several manufacturing processes. The first is to design the basic shape of the application display by using Inkscape. Inkscape is a free application to use for individual purposes. The design is in the form of a basic appearance, application icons, and logos. The second stage is to create a 3-dimensional model using a blender application. The 3-dimensional models created include cube models, beams, and illustration models. The following process is to create a marker. Make markers through the https://www.unitag.io/qrcode website by selecting the marker display and entering the application logo.

After finishing designing, the researchers combined all the designs into the application to create an Augmented Reality Mathematics application using the Unity application. In addition, creating Augmented reality-based applications uses the Vuforia Engine as a tool to incorporate into Unity programs.

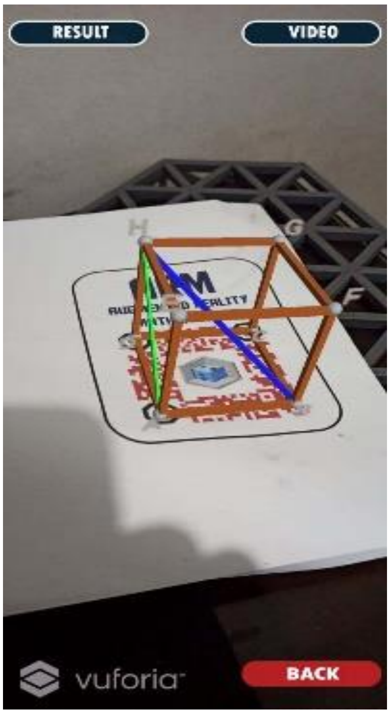


Figure 2. ARM object view

The ARM application has an evaluation menu using the Quizizz platform to increase students' understanding of three-dimensional material. Implementation of evaluation through Quizizz as a student's assignment at school and as homework. The selection of Quizizz as an evaluation tool is based on Noor's research (2020) that there is an increase in learning outcomes through the application of Quizizz because it is exciting and fun to motivate students to learn.

The second component of ARM application development is the ARM marker. The ARM marker serves as a QR code to display the object you want to say. There are three, namely cube markers, block markers, and STEAM illustration markers (see Figure 3). Users can print ARM Markers using A4 size paper to make it easier to use ARM applications.

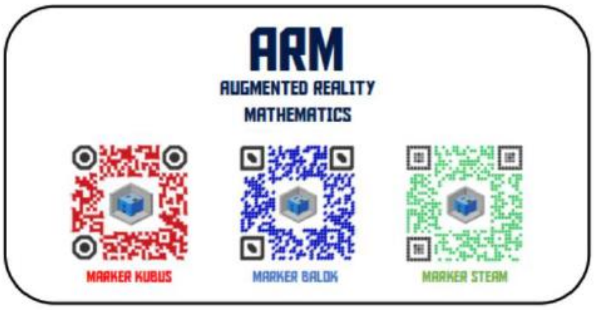


Figure 3. Marker ARM

The last component in learning media development is the application usage guidebook. The creation of this guidebook serves to make it easier for users to use ARM applications, download ARM applications, and markers, and carry out evaluations. Users can print guidebooks using A4 size paper to make it easier to read the guidebook.

3.1.4. Tests on Users to Analyze User Responses

Furthermore, researchers conduct validation tests by learning media experts, validation tests by education experts, and practicality tests by teachers. The validation instrument uses a questionnaire instrument with a Likert scale. Three expert validators consist of lecturers and teachers who are experts in their respective fields. The indicators of the validated visual display are the attractiveness of the image display, the suitability of the content/icon layout, the clarity of the shape of the three-dimensional build model, the clarity of the instructions for use, the clarity of typeface selection, the suitability of colours and elements of the three-dimensional build, and the attractiveness of the image display. Meanwhile, indicators in the software assessment aspect are ease of installation, ease of use, and suitability of button functions. The validation results of the media experts are in Table 3.

Table 3. Media expert validation results

No	Aspects	Number of scores	Maximum score	Percentage (%)	Category
1.	Visual appearance	31	35	89	Excellent
2.	Software	14	15	93	Excellent
	Overall	45	50	90	Excellent

The result of media expert validation is that the visual display aspect gets a percentage of 89% with an excellent category. Meanwhile, the software aspect receives a percentage of 93% with an excellent category. So overall, it gets a percentage of 90% with excellent categories. Indicators of each aspect of validation of educational experts, namely for the content part, the indicators are the accuracy of concepts and definitions, the accuracy of the three-dimensional subject matter with the indicators in the subject matter, the suitability of the STEAM approach used in the guidebook, the suitability of the questions to the three-dimensional material in the learning media, and the diversity of three-dimensional forms. Aspects of material presentation include sentence clarity, diction conformity, the accuracy of letter size, colour conformity of three-dimensional, three-dimensional model suitability, suitability of three-dimensional elements, and three-dimensional model size conformity (proportional). Furthermore, the results of the validation of education experts are in Table 4.

Table 4. Education expert validation results

No	Aspects	Number of scores	Maximum score	Percentage (%)	Category
1.	Fill	20	25	80	Excellent
2.	Presentation of the material	30	35	86	Excellent
	Overall	50	60	83	Excellent

Based on Table 4, the validation results of education experts get a total percentage of 83% with excellent categories. This result was obtained based on the content aspect of 80% and material presentation aspect of 86%, with an excellent category. The content part of the technical expert test has indicators, namely the use of AR media to understand the material well, easy-to-use AR media, and the suitability of naming angular points. Indicators from the interactive aspect are that the buttons on AR media can function properly, users can adjust the size of the three-dimensional model, the suitability of the letter display, and the font display is easy for the user to read. The efficiency aspect is that users can easily use AR media, create AR media markers, reprint AR media markers, and carry AR media. Indicators from the creative aspect are that AR media can help students be active in learning. The following validation is the validation of the practicality test by the teacher. The results of the validation of the practicality test by the teacher are in Table 5.

Table 5. Practicality test validation

No	Aspects	Number of scores	Maximum score	Percentage (%)	Category
1.	Fill	10	15	67	Good
2.	Presentation of the material	11	15	73	Good
3.	Efficient	11	15	73	Good
4.	Creative	3	5	60	Enough
	Overall	35	50	70	Good

The practicality test results in several scores of 35 and a maximum score of 50, so get a percentage of 70% in the good category. The next stage is a Forum Group Discussion (FGD) with validators. FGD aims to unify perceptions among validators to get a common conclusion for learning media development.

Suggestions from validators during validation and FGD include adding background animations to increase students' interest in using the learning media created. In addition, it is necessary to add discussions using videos in learning media so that students better understand the material. Based on the assessment and validator suggestions, the learning media is valid so that users can use the learning media well.

The next stage is limited field trials. Researchers tested ten students of class XII (high school level) to look at the initial quality of learning media from the student's point of view. Furthermore, students direct use augmented reality learning media. After that, the researcher ran the students to fill out the questionnaire. Questionnaire of student responses from content aspect indicators, namely users understanding language quickly, the display of matching learning media. As for the technical aspect indicators, users are easy to use learning media, users are easy to operate the location of navigation buttons, and users are easy to rotate and change the scale of the three-dimensional dimension build model. Then the indicators of the instructional aspect of AR media can attract students' attention, efficiently use media, help with independent learning, assist in visualizing the third dimension, and help understand subjects other than mathematics. The results of student responses to the limited trial are in Table 6.

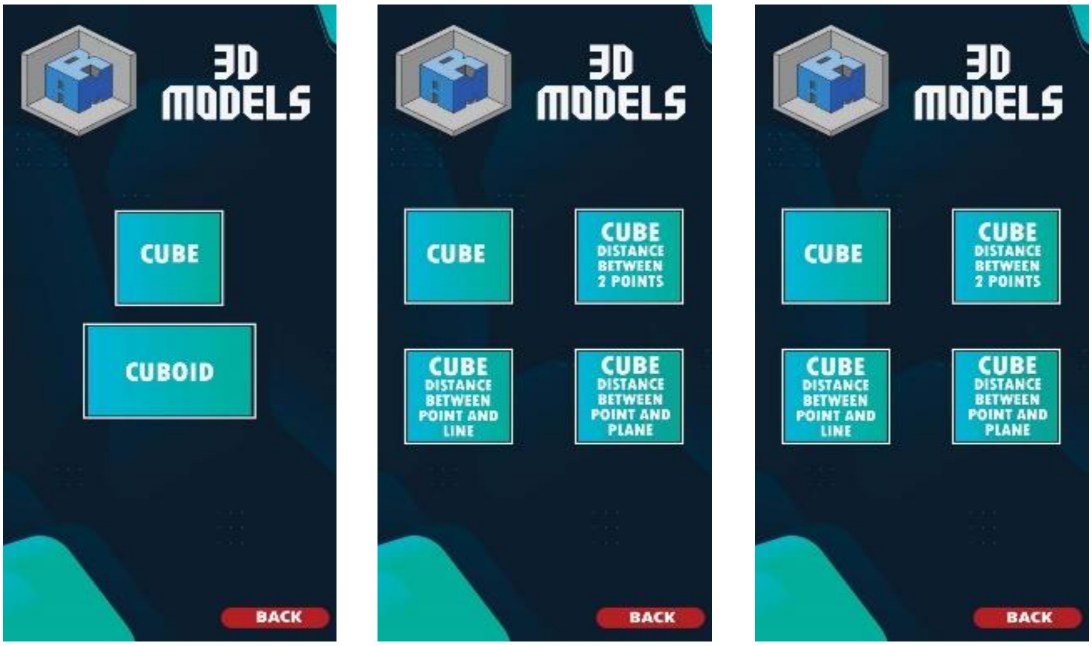
Table 6. Limited trial student response results

No	Aspects	Number of scores	Maximum score	Percentage (%)	Category
1.	Fill	84	100	84	Excellent
2.	Technical	119	150	79	Good
3.	Instructional	163	200	82	Excellent
	Overall	366	450	82	Excellent

Student responses in the limited trial scored 366, with a maximum score of 450. The percentage obtained was 82%, with an excellent category. Students could express their opinions on augmented reality learning media with some practice. Researchers use results from limited trials to fine-tune product development. After improvements are made based on suggestions from validators and students in limited trials, the next stage of learning media is the examination stage. The media that has been improved and given for the examining stage are in Figure 4, Figure 5, Figure 6, and Figure 7.

(a) (b) (c)

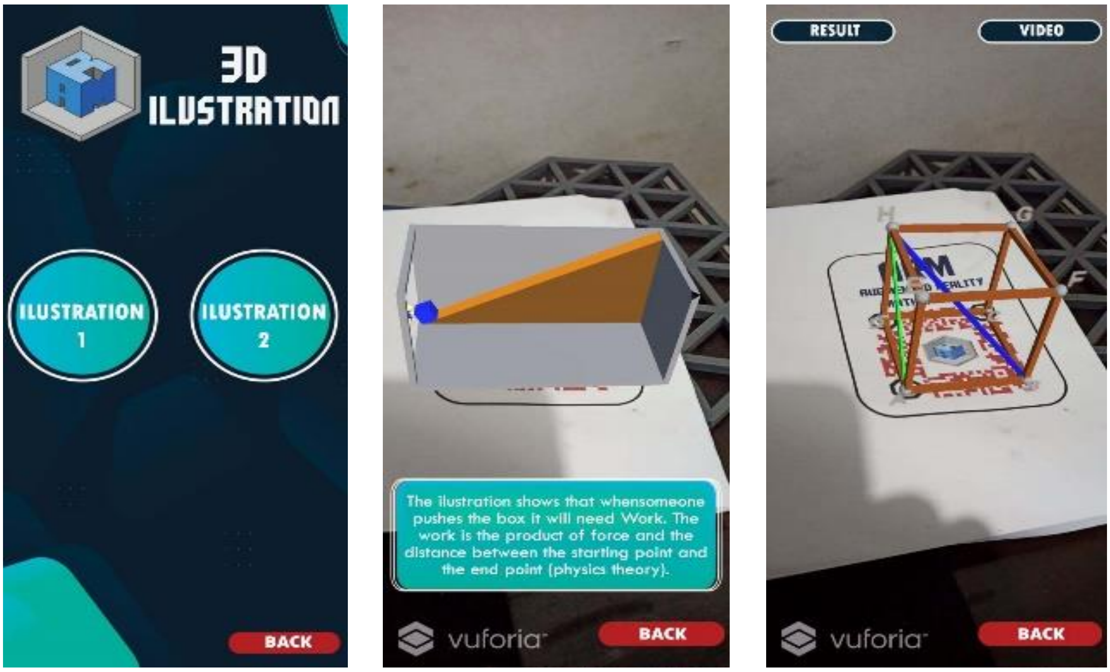
Figure 4. (a) ARM initial view, (b) the main menu and in section, (c) the AR camera sub-menu



(a) (b) (c)

Figure 5. Three-dimensional geometry material menu view

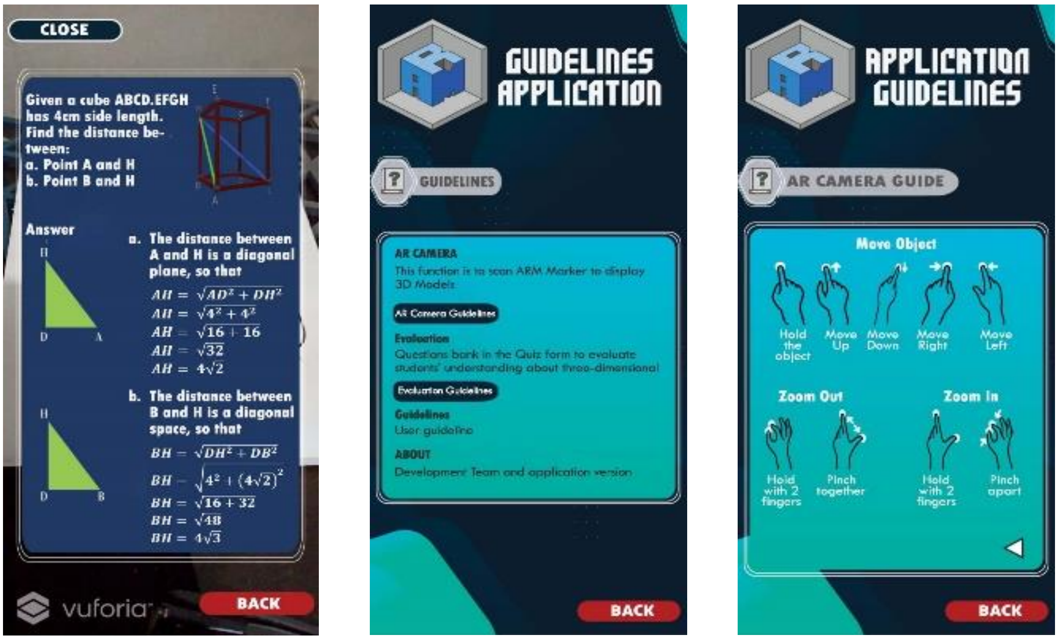
Figure 5(a) shows the appearance of the sub-menu of the three-dimensional model. Figure 5(b) the appearance of the sub-menu of the cube covering the cube of the distance from the point to the point; the distance of point c to the AH line; point distance D to ACH plane. In Figure 5(c) the display of the block sub-menu which includes the point-to-point distance beam; the distance of point B to the DG line; distance point B to ACGE plane.



(a) (b) (c)

Figure 6. Sub display - sub menu on ARM

In Figure 6(a), the appearance of the sub-menu illustration of dimension 3. In Figure 6(b), the definition of the distance between points, the explanation is that the definition of a person pushing a box requires effort. The effort resulted from the force and magnitude of the displacement of the starting point box to the endpoint (science), and in Figure 6(c) an illustration of the cube skeleton.



(a) (b) (c)

Figure 7. Discussion of application questions and guidelines

Figure 7(a) is the discussion view of the mathematical problem-solving ability of the point-to-line distance. Figures 7(b) and 7(c) is the application guide view.

3.1.5. The Evaluating and Examining Sets Testing Developed Media

The examining stage is testing learning media in the learning process by using augmented reality learning media on the ability to solve mathematical problems in geometry. Researchers conducted research for three meetings on three-dimensional matter. Developing increased reality learning media aims to improve students' mathematical problem-solving skills. Researchers conducted a trial of 30 class XII students in one of the high schools in Indonesia to see an increase in mathematical problem-solving skills. Students are given a test of mathematical problem-solving ability in the geometry understanding and then see an improvement in their knowledge before and after students use the augmented reality learning media n-gain formula to see the mathematical problem-solving ability of geometric concepts. Table 7 shows the mathematical problem-solving ability data of geometric areas.

Table 7. Mathematical problem-solving ability test results

Statistical	Average
Initial score	35.47
Final score	40.17
n-gain	0.37

Table 7 shows that there is an average increase. Learning before using augmented reality learning media was 35.47. After using learning media by 40.17. A score of 0.37 if using the n-gain formula, a moderate increase category.

The mathematical problem-solving ability of geometric concepts after being given ARM increases in Figure 8, from the description of the students' answers.

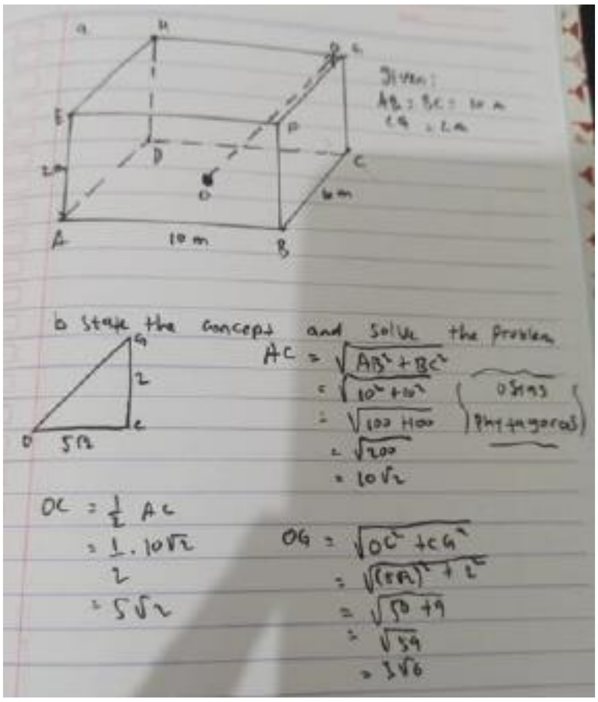
Question:	**Student answers:**
The length of the rectangular swimming pool is 10 m by 10 m, and the width is 2 m. There are waterways in the middle of the pool. Find the distance between someone and waterways if they are in the corner of the collection. a. Draw the illustration of the problem above! b. Solve the problem and state the concept based on the trouble! c. Check your answer before you submit it!	

Figure 8. Question and student answers

Figure 8, In the first stage, shows students illustrating pictures based on problems in the questions and adding data or known points. In the second stage, students use the Pythagoras formula to create a right triangle as a reference. In the third stage, students complete the problem using the Phytagoras question to get the results. The Last Stage indicates the evaluation stage of the student by examining the effects and associating them with the existing data.

3.2. Discussion

STEAM learning with AR media can improve students' mathematical problem-solving and critical thinking skills in geometry (Bedewy et al., 2022; Hebebci & Usta, 2022). Mathematical problem-solving ability is related to necessary thinking skills indispensable in 21st century skills (Sutama et al., 2022). STEAM learning can also enhance collaboration and problem-solving activities (Boaler et al., 2022) and support 21st century skills (Sari et al., 2022). STEAM Learning can facilitate contextual mathematical modelling in solving problems (Kohen & Nitzan-Tamar, 2022). Problem-solving is inseparable from metacognitive strategies, which require a suitable learning model to improve them (Ouyang et al., 2021; Walida et al., 2022). STEAM learning can ease thinking ability, practical knowledge, and ability in technology (Ramli et al., 2022).

The development in STEAM learning must adapt to technological developments because technology itself quickly poses challenges for teachers as an innovation in implementing pedagogic innovations in the classroom (Lavicza et al., 2022). Therefore, technology at ARM is one of the solutions to keep up with technological developments in the educational field of mathematics classes.

The successful use of AR media in STEAM learning with AR media is by other studies. Teachers introduce AR media to students, animating ancient buildings using GeoGebra and 3D printing in mathematics learning. The result is that students can create modeling assignments through experience using AR media and architectural history-building shapes (Bedewy et al., 2021). AR media with STEAM Learning associated with history improves mathematical problem-solving capabilities (Bedewy et al., 2022).

AR media with developed STEAM learning received an excellent response from students; it can support students' motivation and attitudes in learning the material with the media provided. Several studies that show the success of AR media get an excellent response to innovations and perspectives and make learning exciting and holistic (Belda-Medina & Calvo-Ferrer, 2022; Cevahir, 2022; Jesionkowska et al., 2020; Zuo et al., 2023).

ARM, a technology-based media, is an alternative to improving mathematical problem-solving capabilities, especially during the Covid-19 pandemic, which requires distance learning (del Olmo-Muñoz et al., 2023). Thus, in line with this study's results, AR media can improve students' mathematical problem-solving abilities. AR media affects cognitive, affective, and psychomotor skills in various fields, namely geometry, algebra, and statistics (Jabar et al., 2022). The success of solving mathematical problems in geometry with ARM media is also aligns with the use of AR media in geometry, which shows students' preferences in conducting learning, especially in pairs (Sarkar et al., 2020).

ARM media, with STEAM learning, contains evaluation activities that can support students in reflecting on the material. These reflection activities are critical so that students can evaluate and conclude what they know or do not know and support students to immediately correct their understanding of wrong concepts (Syamsuddin et al., 2020). Reflection activities in the ARM section can help students to practice problem-solving because reflective thinking plays an essential role in problem-solving (Kholid et al., 2022).

STEAM learning and developing 21st century skills such as problem-solving can support creativity, productivity, and entrepreneurship (Sari et al., 2022). Thus, STEAM learning can be an alternative to developing creativity in stimulating students' efforts as capital to prepare human resources in the era of globalization. Moreover, there is mathematics, a learning eye, with a critical position in the curriculum for expanding scientific knowledge and technological capabilities (Abdullah et al., 2022).

The success of ARM media is one of the interactions between students and their media; as stated in the student response, they are happy and understand using AR media because of the interactive existence. AR media is a technology-based media that can improve students' understanding of complex and interactive concepts (Kaur et al., 2022). AR media encourages learning and interaction, and there is a better influence on intergenerational group learning (Yun et al., 2023).

4. CONCLUSION

The conclusion of this study is the use of ARM media in STEAM learning three-dimensional geometry material for mathematical problem solving consisting of initial views, menus, and sub-menus of cubes and blocks, discussion of questions, and application guides. ARM media has been validated through media expert tests, educational expert tests, and practicality tests with excellent responses. Thus, ARM media is feasible for students to use in learning activities. AR media with STEAM learning can improve geometry concepts' mathematical problem-solving ability with medium categories. Thus, using this media in classroom learning improves the mathematical problem-solving ability of High School students in geometry.

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