Jurnal MATH-UMB.EDU
Vol 12 (3), 2025

DEVELOPING AUGMENTED REALITY-BASED COMICS IN IMPROVING COMPUTATIONAL THINKING AND NUMERACY FOR ELEMENTARY SCHOOL STUDENTS

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Abstrak

Penelitian ini bertujuan menghasilkan Media komik *Augmented Reality* untuk mengetahui keefektifan, kelayakan, dan kepraktisan komik yang dihasilkan untuk meningkatkan kemampuan *Computational Thinking* dan Numerasi pada siswa kelas V Sekolah Dasar. Penelitian dan pengembangan ini dilaksanakan mengacu pada langkah yang dikembangkan oleh Borg and Gall. Uji reliabilitas menunjukkan bahwa variabel dinyatakan reliable dengan melihat nilai *Crobach's Alpha* sebesar lebih besar dari 0,60. Untuk uji reliabilitas pada soal *computational thinking* dan numerasi reliabel karena memiliki nilai sebesar 0,762>0,60. Teknik analisis data menggunakan uji prasyarat yaitu uji normalitas, homogenitas, uji hipotesis, *independent sample t-test*, dan keefektifan relatif. Hasil Penelitian sebagai berikut: (1) Media Komik berbasis *Augmented Reality* berdasarkan penilaian ahli materi dan ahli media sangat layak di uji cobakan dalam penelitian meningkatkan kemampuan *Computational Thinking* dan Numerasi siswa. (2) Media komik Augmented *Reality* memiliki signifikansi 0.00< 0,05. Rata-rata pretest *Computational Thinking* dan Numerasi yaitu 48,66 sedangkan pada kelas kontrol 49,56. Adapun rata-rata *posttest Computational Thinking* dan Numerasi pada kelas eksperimen 74,29 sedangkan kelas kontrol adalah 65,46. (3) Media Komik Berbasis *Augmented Reality* diperoleh hasil signifikan dalam meningkatkan kemampuan *Computational Thinking* dan Numerasi siswa, berdasarkan hasil T-test Post-test dengan nilai signifikansi 0,00<0,05 siswa sebelum dan sesudah menggunakan media komik Berbasis *Augmented Reality*.
Kata Kunci: media, komik, *augmented reality, computational thinking,* numerasi

Abstract

This research aimed to produce augmented reality-based comics to determine the effectiveness, the worthiness, and the practicality of the comics produced in improving computational thinking and numeracy skill for fifth grade elementary school students. This research and development were carried out referring to the steps developed by Borg and Gali. Thus, indicatingthat a statement items were valid. Reliability test showed that the variables were reliable, with Cronbachs Alpha values exceeding 0,60. Reliability test for Computatinal thinking and numeracy showed reliability, with a Cronbachs Alpha value of 0,762>0,60. Data Analysis techniques included preliminary test such as normality test, homogeneity test, independent sample t-test hypothesis test and efective relative. The results of the research are as follows: (1) augmented reality-based comics according to the assessment of material experts and media experts is very worthy of being tested in research to improve students' computational thinking and numeracy skills. (2) augmented reality-based comics as media with a significance value of 0.00< 0,05. The Average pretest score for Computational Thinking and Numerasy is 48,66, while in the control class, it is 49,56. The average posttest score for Computational Thinking and Numerasy in the experimental class is 74,29, whereas, in the control class, it is 65,46. (3) Augmented reality-based comics obtained significant results in improving students' computational thinking and numeracy skills, based on the results of the t-test of post-test with a significance value of 0.00<0.05 students before and after using augmented reality-based comics.
Keywords: *media, comics, augmented reality, computational thinking, numeracy*

INTRODUCTION

Mathematics is a discipline that studies definitions, facts, relationships between space and shape, and theorems (Sinurat & Fauzi, 2022). Mathematics is an exact science that relies on deduction and pure evidence, so that its truth is absolute and cannot be changed (Parnabhakti & Ulfa, 2020). Russefendi defined it as the study of systematic arrangement, including analysis of facts and relationships, as well as the study of dimensions and spatial structures (Susanto & Hidajat, 2021). In accordance with the National Education System Law Number 20 of 2003, learning was defined as an interactive process between students, educators, and learning materials in an educational environment (Rusmana, 2020). Mathematics learning is a process of solving mathematical problems by applying everyday or real-life situations to validate the answers.

Boring mathematics learning is caused by mathematical material that tends to be abstract. Most students consider mathematics learning difficult to solve problems. This is the challenge for teachers to solve the problem so that students do not consider mathematics difficult, boring, and are motivated towards learning. Teachers must have the ability to develop inventive and imaginative educational materials that involve students, foster motivation, prevent boredom, and trigger the spirit of learning mathematics.

How people are taught and learn is influenced by learning tools. How well learning media works has a big impact on how well someone learns, but how poorly learning media works can have a negative impact on how well someone learns. Picture books with Augmented Reality technology are used as teaching aids. These Augmented Reality comics can help students think more computationally, become better at math, and become more active, creative, and original in their learning.

In the previous section, it had been explained that one of the learning media had the ability to improve computational thinking, arithmetic, active learning, and student motivation. Comics are a series of narrative illustrations that convey implicit information to readers (Mardiono, 1998). Comics generally consist of illustrated cartoons, with each character functioning as a means to convey a different message. This unique way of telling stories aims to entertain readers and provide pleasure (Angga et al., 2020). Comic as learning media refers to educational materials that utilize character narratives and dialogues to convey relevant information effectively (Muhaimin et al., 2023). Comic as learning media is an educational tool that prioritizes computational, numerical, active, creative, and inventive thinking in students during the teaching and learning process.

Augmented Reality is a form of technology that creates a simulated environment, often called Virtual Reality (VR). Augmented Reality (AR) is the integration of virtual and real world elements that occur simultaneously or coexist. AR-based comic is ideal because of the widespread use of Android devices among individuals of all ages. Technology will continue to advance every day and will greatly affect computer vision. Computer vision is the science of technology how a system can see something. AR is a technology that is often used today.

AR-based comics contain information about volume and spatial shape features. Geometric shapes used in AR-based comics include cuboids, cubes, rectangular pyramids, triangular pyramids, triangular prisms, cylinders, and cones. An image of a geometric figure is inserted into the comic. The image is a barcode that will later be scanned to produce an animation of the geometric figure. 3D images and animations are used so that students do not just imagine but actually show the shape of the geometric figure.

I talked with the homeroom teacher of grade 5 MI Unggulan Nuris on September 25, 2023 to conduct a student analysis. Interviews with grade 5 teachers of MI Unggulan Nuris revealed that students had difficulty understanding the material and solving mathematical problems related to spatial ideas. These problems occurred in the areas of reading and arithmetic. The preliminary study used a test on students with a total of 15 students with an average score of 55. This proves that the Computational

thinking and Numeracy of grade 5 students at MI Unggulan Nuris are low. Based on the interview findings, it is necessary to provide an explanation regarding the size of the elementary school classroom for Augmented Reality-based comic media. Thus, students can understand the concept of constructing space while studying it. Student understanding is measured by a learning outcome test, later there will be a posttest and pretest in the test. I chose the MI Unggulan Nuris research subject because it meets the number of participants and supports my research.

Augmented reality (AR) based comic books are made for fifth graders because this kind of spatial building material is perfect for children who are just starting to learn to use their bodies. As an interesting comic format, this AR-based cartoon works well. It uses Android and hard file comics. AR-based comic media is suitable and interesting because it helps students understand spatial or geometric concepts that are often challenging in teaching and learning activities. Teaching and learning activities that do not utilize AR-based comic media are less successful in facilitating learning because of their longer explanations. Students may experience a loss of motivation when they are required to learn using the same content for a long time and do not match the expected completion time. Many students have difficulty solving numerical problems related to volume or geometry. Based on the latest research conducted by Pernando and Danang (2022), previous research found that the use of Zahlen's adventure comics provided valid, practical, and useful results. The validity test produced a result of 90.14%, indicating a high level of validity. Likewise, the practicality test obtained a result of 96.2%, indicating a high level of practicality. Furthermore, the paired t-test showed a significant change between the pretest and posttest scores. According to research conducted by Meilindawati et al. (2023), the use of Augmented Reality-based learning media has a very beneficial impact on mathematics education. This innovative approach has been shown to improve student learning outcomes and significantly improve their mathematics abilities. Research findings as reported by Lubis and Dasopang (2020) show that Augmented Reality-based picture story books are considered suitable and effective to be included in mathematics education. Arifin et al. (2020) conducted a study and found that the study produced a learning media called "Artic" which was considered valid, practical, and effective. The validity findings produced a percentage of 91.5%, practicality was measured at 85%, and the n-gain score was calculated at 0.42. Ultimately, this educational tool is perfect for improving students' proficiency in mathematical spatial skills. The previous studies had repeatedly shown that students needed mathematical learning media to help them understand better and encourage them to learn actively, creatively, and in new ways.

The problem that occured in this study was that students experienced boredom with repetitive and limited learning so that it was difficult to concentrate on understanding the material. The use of media that had been used by teachers so far was pictures and other conventional media, so that learning was less effective, active, creative, and innovative. Augmented Reality-based comic as media will increase Computational thinking and Numeracy in students. Students who have an attitude or belief that mathematics is not challenging, and are involved in active, creative, and inventive learning. Further research is needed to investigate the role of comedy learning media in mathematics education. Therefore, the study entitled "Developing Augmented Reality-based Comic in Improving Computational Thinking and Numeracy for Elementary School Students".

Based on the research background above, the purpose of this research was to test the effectiveness, feasibility, and practicality of the comics produced to improve computational thinking and numeracy skills on the fifth grade elementary school students. The difference between the development of Augmented Reality-based comics and previous research lies in the substance of the material, Augmented Reality animation and research subjects. Based on the above problems, a study was conducted entitled "Developing Augmented Reality-based Comic in Improving Computational Thinking

and Numeracy for Elementary School Students".

METHOD

The research method used in this study was the research and development method (R and D). The research and development method is a research method used to produce products and test the effectiveness of the product. According to Borg & Gall (Sugiyono, 2014) the purpose of development research was to develop and validate products that are truly worthy of use. The development research model that will be followed in this study is the development research model proposed by Borg and Gall in (Sugiyono, 2014).

This research model consisted of 10 stages, namely (1) Research and data collection is a research was conducted at MI Unggulan Nuris, (2) Planning was carried out according to the information obtained in the form of a research development proposal, (3) Development of initial product draft is by developing the initial draft components. The selection of components and formats is in accordance with the learning plan, (4) initial field trial conducted by material experts and media experts., (5) revision of trial results is to see the shortcomings of the media that is being worked on, (6) trial Field testing of the main product using small groups to provide effectiveness values of Augmented Reality comics., (7) Product revision is the final stage of revision to achieve perfection so as to produce appropriate media, (8) large-scale field trial/feasibility test will use 2 different classes, namely grade 5A and 5C. Grade 5A was an experimental class using Augmented Reality comic media, while grade 5C was a control class using school book as media, (9) final product revision which included revisions from the wide-scale test with the neglect of improving the sensitivity of the application, and (10) Dissemination/implementation was conducted in 1 sub-district in Jember, namely Kencong sub-district. The research was used to develop Augmented Reality-based comic media for 3D shapes material in grade 5 of elementary school. All stages of this research were carried out completely.

The subjects of the development research were students of grade 5 at MI Unggulan Nuris Jember. In the small-scale product trial stage, 20 students were selected randomly. Meanwhile, for the large-scale trial, there were 2 classes, namely grade 5A and grade 5C. At this stage, a control class and an experimental class will be needed in this study. The stage of small-scale research according to the Borg and Gall stage is utilizing a small trial class first before using a large-scale one. The participants in the small-scale test were selected randomly at the school. The large-scale test used 2 classes in the same environment or at the same school.

The data collection techniques and instruments used were (1) Instrument validation sheet; (2) Test using descriptive test sheets (3) documentation. The data analysis techniques used in this development research include: (1) Reliability; (2) Normality Test; (3) Homogeneity Test; (4) Hypothesis Test; (5) Independent Sample T-Test.

RESULT AND DISCUSSION

The product developed in this study was an Augmented Reality-based comic for the mathematics subject "Volume of 3D Shapes" to improve Numeracy and Computational Thinking. Augmented Reality-based comics are different from comics in general because they use technology so that they can improve numeracy and computational thinking in students.

The researcher used the Borg and Gall model. This research model consisted of 10 stages, namely (1) research and data collection, (2) Planning, (3) Development of initial product drafts, (4) initial field trials, (5) revision of trial results, (6) field trials of the main product, (7) Product revision, (8) large-scale field trials/feasibility tests, (9) revision of the final product, and (10) Dissemination/implementation. The research was used to develop Augmented Reality-based comic media for spatial figure material in grade 5 of elementary school.

This research was conducted at MI Unggulan Nuris, implemented in semester 2 of the 2023/2024 academic year. The classes used were grade 5A and grade 5C. Each class consisted of 28 students. This Research

model consisted of 10 stages, namely first Research and Data Collection. The research and data collection stage at MI Unggulan Nuris has the following problems.

a. The presentation of materials in schools is in the form of book that is not interesting, and the media is not varied enough. Students tend to feel bored in learning. So there is a need for Augmented Reality media in Learning. The results of interviews that have been conducted in class 5 are attached in the appendix.
b. The results of interviews with mathematics teachers stated that so far they had not got media to provide learning about the volume of 3D shapes. The interview was held on 5-7 March 2024. The development of learning media is needed as a tool for conveying information on understanding the volume of spatial figures with technology.
c. Interviews with students stated that students feel bored when learning mathematics on the volume of 3D shapes. Because the teacher delivers learning conventionally or monotonously. Therefore, students need interesting and enjoyable learning media. The interview was held on 5-7 March 2024. Second stage is a planning. The planning was carried out according to the information obtained in the form of a research development proposal. The research development proposal was designed as follows: (a) formulation of the research title; (b) formulation of the research problem; (c) formulation of the objectives and benefits of the research; (d) literature review; (e) methods and procedures for research development including various instruments and activity schedules (f) planning for the creation of application and comic products. Next Stage development of initial product draft. The initial product draft development stage is by developing the initial draft components. The selection of components and formats is in accordance with the learning plan. Furthermore, after selecting the initial draft of the media format to be used, the initial draft design is made, namely the media design. The initial design of the development of Augmented Reality-based mathematical comic media for the volume of 3D shapes is as follows.

Table 1 Product Design Components

No.	Product Design Components Contents	Information
1.	Barcode building space in vuforia	There are 8 divuforia barcodes to check the number of stars from the barcode.
2.	Download unity hub, unity 3D, and blender application.	Download 3 applications for making Augmented Reality applications.
3.	Comic character creation	There are 6 comic characters to be made.
4.	3D object creation in blender application	There are 8 3D creation objects.
5.	Application to convert to android	SDK, JDK, NDK, and graddle.
6.	MASIK Comic Cover	MASIK Comic Design uses characters that have been made.

d. The media preparation had been carried out, then the product design process is as follows.

a). Select the barcode to be checked by Vuforia. There are 8 barcodes entered into Vuforia.

Barcodes that have a Vuforia rating of 4 to 5 stars tend to have a good response and are in accordance with the criteria. The targets that will be used are 7, namely according to the number of spatial structures created.

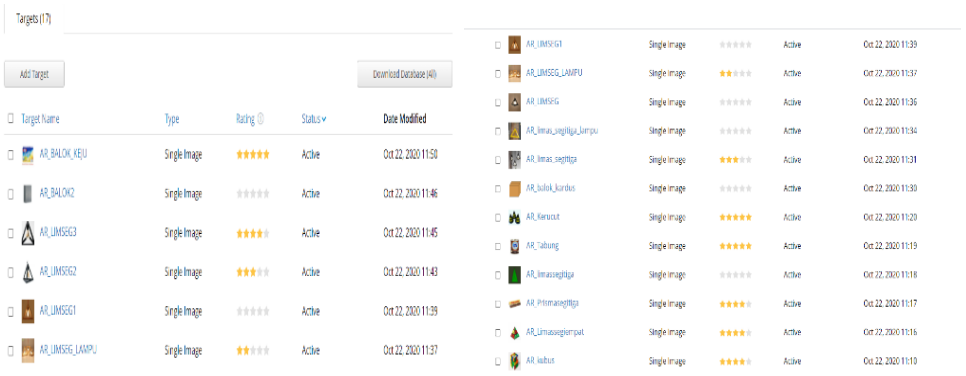

Figure 1 *Barcode Collection in Vuforia.*

b). Download unity hub, install unity 3D and Blender.

Download 3 applications in making Augmented Reality applications and 3D shapes that will be created. Here are the 3 applications that were downloaded.

Figure 2. View of 3 Application that Should be Downloaded

c). Download the barcode registered in Vuforia

Download the barcode or database results to be placed in the Unity 3D application so that Augmented Reality appears on the 3D shapes target.

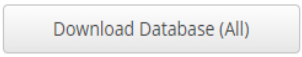

Figure 3. Icon for download in Vuforia

d). Create 3D objects one by one using the blender application.

Create 3D objects according to taste as many as 8 3D objects. After that Save as and move it in the unity 3D application.

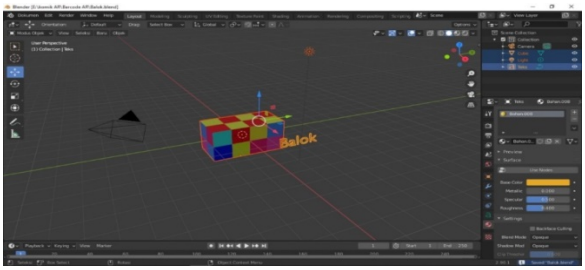

Figure 4. 3D Creation Image in Blender application

e). Input all barcode and 3D components according to their structure in the Unity 3D application.

Combine 3D barcodes according to the shape that has been created. Used when scanning Augmented Reality will appear according to the image and 3D shape that is combined respectively.

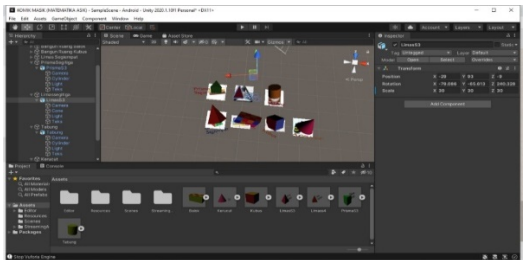

Figure 5. Unity 3D Application Screenshot after matching barcode and 3D

f). Create comics according to the narrative and design.

The comic display as in Figure 4.6 was produced by utilizing Photoscape software and integrating it with Microsoft Word. The comic includes a barcode image generated in Vuforia to ensure maximum performance when the program is run.

Figure 6. Comic display

g). Once the 3D shape is visible, the application is ready to be converted into an APK. Remember to set a name and create a logo for the application.

h). Verify the program installed on Android directly.

i). Here is a visual representation of the application after being combined with the printed comic. The application installation was successful.

Here is the display of the application after being combined with the printed comic. So the application has been successfully installed.

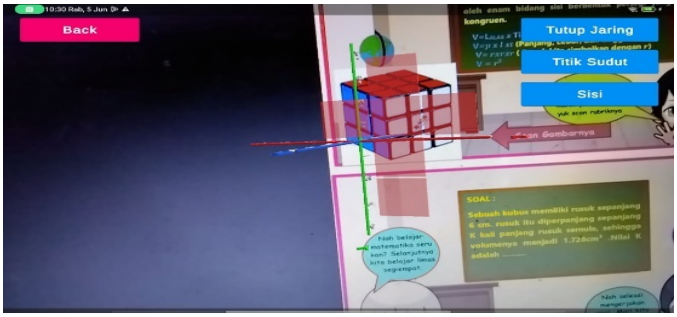

Figure 7. Portrait App View on Android

The next stage initial Field Trial. Initial field trials are trials conducted by material experts and media experts. Validation of materials and media is carried out by lecturers according to their scientific concentration. For material experts, they are lecturers in elementary education concentrating on mathematics, while for media experts, they are lecturers in elementary education concentrating on learning technology. The assessment is carried out by providing an assessment in a questionnaire using a Likert scale and providing suggestions for Augmented Reality media. The following are expert media and Augmented Reality material validators.

The media expert validator is a lecturer in the Elementary Education study program, concentration in Learning Technology, Faculty of Education and Psychology, State University of Yogyakarta. The results of product validity by media experts was 82,5.

The validity of the product determined by the media expert was classified as very practical, with a range of $81 \leq SP \leq 100$ and a specific value of 82.5. Thus, the media is prepared to be used in practical learning efforts. Media validation had identified areas of improvement that need to be changed to increase the effectiveness of the media.

The material expert validator is a Professor of the Elementary Education study program, Mathematics Concentration, State University of Yogyakarta. The results of product validity by material experts was 80. The findings of product validity determined by media experts, namely 80 pieces, are in the range of $61 \leq P < 81$. The product evaluation criteria were classified as practical. Thus, the media is prepared to be used in practical learning efforts. After validating the material, there were specific recommendations for modification that need to be considered in order to improve the usefulness of the media.

Based on the two validations, the average product validity was set at 81.25. This value was in the range of 81 to 100 and according to the assessment criteria was classified as very practical. Therefore, the material was prepared to be used in practical learning activities and the next revision of trial result. The revision stage of the trial results is to see the shortcomings of the media that is being worked on. The validator provides suggestions so that the media that is being worked on becomes more perfect. The validator's suggestions are recorded so that the media is better when tested. The following is a revision of the trial results with the following suggestions.

Table 2. Augmented Reality-based Comic Revision Result

No.	Revised aspects	Revised components	Revised results
1.	Language	The sentences used are effective	Add a storyline to the comic
		Appropriateness of word usage	Change some inappropriate words in the comic
2.	Overall view	Scan barcode symbol	Change the barcode scan instruction symbol to make it clearer.
		Pay attention to the definition of 3D shapes	Change the appropriate definition of geometric shapes

The next stage field testing of main product. Field testing of the main product using small groups to provide effectiveness values of Augmented Reality comics. Here is the analysis of this research data.

a. Reliability test

The results of the questionnaire data reliability test showed that Cronbach's Alpha was $0.762 > 0.60$. The results of the reliability test if more than 0.60 then it could be said to be reliable. So it could be concluded that the questionnaire data of this study was reliable

because it was more than 0.60, with a result of 0.762.

b. Prerequisite Test

The prerequisite test is used to test the hypothesis on students' Computational Thinking and Numeracy. The prerequisite test is carried out using the normality test and hypothesis test. The test uses the help of the SPSS application.

a). Normality test

The first prerequisite test is to use the normality test on students' Computational Thinking and Numeracy. The normality test uses the students' pretest and posttest. This normality test uses Kolmogorov-Smirnov by looking at the significance of Kolmogorov-Smirnov. Data can be said to be normal if the significance value is greater than 0.05. If the significance value is less than 0.05, the data can be said to be abnormal.

The results of this study showed 0.062 and 0.069. It meant that the results of the normality test showed a normal distribution for both the pretest and posttest. So it could be concluded that both data had a significance value> 0.05 and the data was normally distributed.

b). Hypothesis test

Hypothesis testing shows normal and homogeneous distribution. Then an Independent sample T-test will be carried out to show whether the results of this study are significant or not. If H_o is accepted, it means there is no significant difference. If there is a significant difference ($p < alpha$), then H_o is rejected, which means there is an influence or difference.

Table 3. Media Practicality Questionnaire Analysis

Aspect	Percentage (%)	Category
Media Convenience	95%	Very good
Media Appeal	80%	Good
Media Benefits	100%	Very good
Overall	91.667%	Very good

Findings from the media feasibility survey conducted during the field trial on important items. Key aspects of a mathematics teacher's proficiency. Media convenience achieved a total percentage result of 95% with a very good category, in accordance with the percentage results of aspects in the media practicality questionnaire. The media's appeal feature which scored 80% with a very good category was ranked third in the percentage results of the media practicality questionnaire. The aspect of media usefulness received a 100% assessment with a very good category, placing it at the top of the percentage results of aspects in the media readability questionnaire. The overall percentage of 91.667% was included in the "very good" category, which showed that Augmented Reality-based comic media greatly facilitated learning for students and was very useful in the educational process.

The results of the media readability questionnaire from the primary product field trial involving a total of 10 students. The fun aspect had a total score of 80% with a positive category. The level of knowledge indicated by a score of 80% is included in the "good" group. Helping students get a perfect score of 100% with a very good category. The material element really liked with an assessment of 80% in the "good" category. The development element had achieved 100% results and was included in the very good category. The beauty aspect gets a score of 80% with a good category. The practical component was 100%. The next stage is a product revision. Product revision is the final stage of revision to achieve perfection so as to produce appropriate media. Application problems with the following revisions AR camera is less focused sometimes moving, loading when opening one of the geometric shapes, some Android versions are less able, and permissions to install on Android have several errors.

Table 4. Student Response Questionnaire Analysis

Aspect	Percentage (%)	Category
Enjoyment	80%	Good
Understanding	80%	Good
Helping Students	100%	Very Good
Material Ease	80%	Good
Development	100%	Very Good
Interest	80%	Good
Practicality	100%	Very Good
Material Clarity	80%	Good
Media Ease	80%	Good
Overall	86.667%	Very good

The Augmented Reality application has a few changes only related to errors and focus on the application. This application can be done until it is completely ready to use. the next stage is a large-scale field test/feasibility test.The large-scale field test will use 2 different classes, namely grade 5A and 5C. Grade 5A was an experimental class using Augmented Reality comic media, while grade 5C was a control class using school book as media. First, all classes were given a pretest, then 2 classes were given different treatments. Grade 5A was given treatment in classroom learning using Augmented Reality-based comic media while grade 5C was given treatment using conventional learning. After all the appropriate treatments, a posttest was given to students. This posttest aimed to determine the results of the two treatments.

This study was conducted for approximately 2 weeks. The results of this study used the Independent Sample T-test type T-test. The posttest of the 2 classes was given different treatments. The next stage is a final product revision. The final product revision is an improvement of the Augmented Reality application that is less responsive to barcodes, so it is necessary to improve the error application. The results of the final Augmented Reality-based comic product consisted of 2 media, namely comic media and Augmented Reality application. Augmented Reality-based comic as media is a combination of the virtual world and the real world, so the application is used simultaneously. Augmented Reality-based comic can be accessed without using an internet network.

The independent sample T-test is a separate sample T-test, the purpose of which is to compare between groups using Augmented Reality media and groups not using Augmented Reality media. Group 1 and group 2 are not related or separate. The following are the results of the Independent Sample T-test.

Table 5 T-test Results

		F	Sig	T	df	Sig(2-tailed)	Mean difference	Std. Error Difference	Lower	Upper
Value	**Equal variances assumed**	.248	.619	-12.108	110	.000	-25.625	2.116	-29.819	-21.431
	Equal variances not assumed			-12.108	109.963	.000	-25.625	.2116	-29.819	

This T-test used 2 groups, namely group 1 using Augmented Reality-based comic media and group 2 which did not use Augmented Reality-based comic. The results of SPSS showed Sig. (2-Tailed) < 0.05, which meant there was a difference in the average learning outcomes of students between group 1 and group 2. AR comic had been proven to

improve Numeracy and Computational Thinking in students

The relative effectiveness analysis aims to obtain an overview of the level of relative effectiveness of a treatment compared to other treatments (Masyhud, 2016). The relative effectiveness test concludes the level of effectiveness of Augmented Reality comic media compared to classes that do not use Augmented Reality comics or control classes. The following are the results of the effectiveness of Augmented Reality comics

$$ER = \frac{MX_2 - MX_1}{(\frac{MX_2 + MX_1}{2})} \text{ x } 100\%$$

$$ER = \frac{88{,}2142 - 78{,}214}{(\frac{78{,}214 + 88{,}2142}{2})} \text{ x } 100\%$$

$$ER = \frac{10{,}0002}{166{,}4282} \text{ x } 100\%$$

$$ER = 0{,}06024\text{x } 100\%$$

$$ER = 6{,}024\%$$

Based on the calculation results above, it could be concluded that the learning outcomes using Augmented Reality-based comic were better by 6.024% compared to not using Augmented Reality-based comic with a very low effectiveness category. The minimum mastery criteria for mathematics at MI Unggulan Nuris was 75. The value of the groupwithout comics was below the minimum mastery criteria while the group using comics was above it. So that comics had effectiveness and influenced the average value in class. The last stage Research Dissemination. Research Dissemination was conducted in 1 sub-district in Jember, namely Kencong sub-district. The enthusiasm of teachers in making Augmented Reality for learning process was very enthusiastic. It was noteworthy that some of the teachers who attended the dissemination were transformational teachers. Transformational teachers refer to a new program from the government so that teachers are required to be creative in the learning process in the classroom and as tutors for other teachers.

The development of Augmented Reality-based comic media uses the Borg and Gall model. Augmented Reality-based comic media discusses the material on the volume of 3D shapes in grade 5 Semester 2 at MI Unggulan Nuris. This study used 10 stages.

The first stage of Research and Information (Research and Data Collection) includes measuring small-scale research needs and literature reviews. The results of initial observations of students experiencing difficulties and boredom in learning mathematics in grade 5 MI Unggulan Nuris Jember. These results are through interviews that have been conducted at MI Unggulan Nuris Jember.

The second stage of Planning includes compiling a research plan that includes the formulation, objectives of the problems achieved, steps for compiling research, discussion of research which is limited to a research proposal. The third stage is Developing Preliminary Form of Product, namely the development of Product Draft 1 in the form of Augmented Reality-based comics.

The fourth stage of Preliminary Field Testing, namely the initial field test includes assessments by media experts and material experts. The results of the reliability of the questionnaire data showed 0.762> 0.60, which meant that the data was reliable. The results of the normality test showed a normal distribution of 0.062 and 0.069, because the significance value was 0.05. The results of the media expert validation got 82.5 and the material expert got 80, the average validation result category was very good. The overall average validity of the media expert and material expert products was 81.25, which was in the range of 81≤ SP ≤100 with the assessment criteria being classified as very feasible.

The fifth stage of Main Product Revision was the revision of the results of the comic improvement trial. The sixth stage of Main Field Testing (main product field test) was in the form of questionnaire results for media readability, media practicality, and student responses. The results of media practicality had an average assessment of 90.776%, and student responses had an average assessment of 86.667%. The results of the two questionnaires were categorized as very good.

The seventh stage of Operational Product Revision includes revision of a product that has been tested with improvements to camera focus and permission to install the

application. The eighth stage of Operational Field Testing (Wide-Scale Field Test) at the wide-scale field test stage had a T-test result of sig.2 Tailed <0.05. It meant that there was a difference between groups 5A and 5C. Its relative effectiveness was 6.02% which meant there was effectiveness compared to the group that did not use media with a very low effectiveness category. The ninth stage was the Final Product Revision stage, namely the revision of the final product which included revisions from the wide-scale test with the neglect of improving the sensitivity of the application. The tenth stage was dissemination in one of the sub-districts in Jember, namely Kencong sub-district.

The results of the research that had been carried out on Augmented Reality based comics were interesting to use. Children's interest in Augmented Reality was the same as research from Indahsari and Sumirat (2023). According to Ningrum, et al (2022), Augmented Reality-based comic can increase students' interest in learning, and the results of the study are appropriate because the results of student responses are categorized as "Very feasible". The previous research on learning using comics, namely comic-based learning media, was able to produce effective learning for solving mathematical problems and self-confidence (Suryatin Sugiman, 2019). Based on Budiarti's opinion (2016), comic media had a great influence on learning motivation and reading comprehension skills of fourth graders. The use of comics turned out to be effective in learning mathematics, meaning that comics affect students' Computational Thinking and Numeracy.

The benefits of comics are enormous in the process of learning mathematics. The results of various previous studies are as follows: The use of picture books can be effective in gaining learning experiences and can stimulate children to enjoy reading (Utomo, 2018). The use of comics, in addition to containing stories and narratives in general, also contains education and information for readers (Anggito & Sartono, 2022). Comics have very effective benefits for learning, so there is a need for innovations that are appropriate for the current era. Progress and change in all aspects of life are changing the world rapidly. This fact requires students to have various skills that allow them to play an active role and contribute to life now and in the future (Suryanti., et al, 2020). According to Yulistia (2019) Improving the quality of education was not easy. There needed to be innovation and efforts in preparing a superior young generation. The use of technology in the learning process was currently a must, considering that the millennial generation had been influenced by rapid technological developments (Cabaluna, 2022). Learning products using technology are suitable for learning (Najuah et al., 2021). So there is a need for new technology-based innovations, namely Augmented Reality.

Augmented Reality is a technology that combines the virtual world and the real world, so it is suitable to be combined with comics which are a means of information to convey messages easily to students. According to (Gecu-Parmakiz & Delialioglou, 2019) Augmented Reality was a media that combined real and virtual which could help explain geometric shapes to students. According to (Hanid, et al., 2022) Augmented Reality-based comic could significantly improve students' abilities compared to conventional learning. So it could be concluded that Augmented Reality affected mathematics learning, especially for Computational Thinking and Numeracy. The use of Computational Thinking could find out how children do the test, so it would support the accuracy of things studied (Leonarduzzi, et al., 2023).

The results of the study showed that students using Augmented Reality were able to solve problems independently and learned with technology without getting bored. These results were the same as research according to Diantary and Akbar (2022) that stated Computational Thinking was not only a computer system learning process, but it could train students' mentality in solving everyday problems. This Augmented Reality-based comic can cover 4 aspects, namely numbers, measurements, and geometry, algebra and uncertainty and data. These 4 aspects are based on PISA based on the 2020 Ministry of Education and Culture's assessment and learning center (Ayuningtyas & Sukriyah, 2020). The results of the

difference test using the T-test have differences in learning outcomes for grade 5A and 5C.

The results of the T-test and relative effectiveness test showed that the Augmented Reality-based comic development product was feasible to use. The Average pretest score for Computational Thinking and Numerasy is 48,66, while in the control class, it is 49,56. The average posttest score for Computational Thinking and Numerasy in the experimental class is 74,29, whereas, in the control class, it is 65,46. The effectiveness was categorized as very low but in this case the media was not the only factor in learning outcomes. The minimum mastery criteria for mathematics at MI Unggulan Nuris was 75. The value of the group without comics was below the minimum mastery criteria while the group using comics was above it. Thus, Augmented Reality-based comics had effectiveness and influenced on the average value in class. The learning outcomes were influenced by many factors including; student intelligence (IQ), learning media, student interests, health, school environment, family economy, parental support, and other factors. The limitation of this research is only focusing on the geometric shapes for mathematics, due to the limited time for creating comics with different materials which are more complete. This comics also have limitations in terms of dissemination. It had only been distributed to several sub-districts in Jember Regency, East Java Province.

CONCLUSSION

Based on the research that had been carried out, the following conclusions can be drawn: The development of AR-based comic as media could improve Numeracy and Computational Thinking that had validation from material expert with a value of 80, media expert with a value of 82.5. The average of both media and material expert was 81.25 categorized as very feasible; The development of AR-based comic as media could improve Numeracy and Computational Thinking that had a practicality value of 90.76, and student response of 86.667; The development of AR-based comic as media can improve Numeracy and Computational Thinking that had an independent sample T-test sig.2 Tailed <0.05. It could be interpreted that AR-based comic could influence numeracy and computational thinking. The development of AR-based comic had an average pretest Computational Thinking and Numeracy of 48.66 while in the control class it was obtained 49.56. The average posttest Computational Thinking and Numeracy in the experimental class was 74.29 while the control class was 65.46. It could be concluded that Augmented Reality comics were proven to be effective with a significant T-test and the post-test results of the experimental class are greater than the control.

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