Development of Augmented Reality Atlas Volcano Series Media in Social Sciences Learning

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Abstract **– The purpose of this research is to determine 1) the development of Augmented Reality Atlas Volcano Series media (ARAVS) that is suitable for use; 2) increasing student learning outcomes from the cognitive aspect; and 3) find out students' responses to interest after using the ARAVS media. This research and development (R&D) process refers to design model of Dick and Carey. The trial of the developed product was carried out at Model Terpadu Bojonegoro State High School with a field trial sample of 120 class X students. Data were analyzed using descriptive statistics, paired sample t-test, and discriminant test. The results of the product development validation test from social studies learning developer experts and learning media experts are in the very feasible category. The results of small group trials are in the feasible category, and field trials are in the very feasible category. The results of the t-test on cognitive aspects showed that there was an increase in student learning outcomes on volcanism in social studies subjects after using AR media. Students have a positive interest in using the ARAVS because the media (ARAVS) is considered concrete, innovative, and interactive. Media (ARAVS) is not boring and is not difficult to adapt to social studies learning. In general, the formative evaluation shows that the product resulting from this development is very suitable for use as an alternative to virtual and digital-based media in social studies learning on Volcanism material.**

Keywords **– Augmented reality, atlas volcano series, social sciences.**

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1. Introduction

Interactive and interesting learning, such as augmented reality (AR), is a form of learning innovation based on digital information technology [1]. AR presents interactive digital technology supported by 3-dimensional visuals by combining the real and virtual worlds [2], [3]. Real environments and virtual objects are integrated with AR technology so that complex and conceptual material becomes clearer through media that prioritizes visual aspects [4], [5]. Complex and conceptual material is found in Social Sciences subjects, especially in volcanism material in high schools, which is generally only presented in the form of text and pictures in a book. This makes learning about volcanism less interesting and static. Through AR learning media, the phenomenon of volcanism can be visualized dynamically and interestingly by utilizing digital technology.

Augmented reality "Atlas Volcano Series" (ARAVS) is designed as an AR medium to bring a more vivid learning experience and visualize the volcanic phenomenon in three dimensions.

The AR Atlas Volcano Series (ARAVS) was developed to understand geological material, especially lithospheric phenomena related to symptoms of volcanism.

This AR-based media is designed to provide visualization of objects on the face of the earth with information packaged in an interesting and interactive way. According to Shelton and Hedley [6], visualizing objects in three dimensions makes learning more interesting and is expected to increase understanding of the material (learning outcomes). Many previous studies have revealed that digital technology through AR can increase motivation and learning achievement. Avila-Garzon and Bacca-Acosta [7], argue that AR makes a major contribution to improving student learning outcomes in various scientific fields such as science, social sciences, and engineering sciences.

AR has great potential to improve social science learning outcomes [8]. The development of digital technology through the application of AR is currently encouraging social studies subjects to be directed towards the scientific aspect by including technology topics in the curriculum [9]. AR helps teachers deliver material more efficiently and effectively. AR media is an innovative digital-based media that is integrated into the learning process to build students' sharper understanding and analysis skills [10]. One of the materials that require observation is the symptoms of volcanism on volcanic objects in social studies subjects so that it is easier for students to understand what the actual process and types of volcano formation are, but because the observation object is too large and requires going to the field, demonstration media are needed in learning. The media is in the form of imitations/replicas that provide a real and realistic picture. AR using and developing AR media, which is specifically intended as a learning resource and communication process tool in social studies learning.

In this condition, it is hoped that social studies learning activities will be more effective and efficient. The activities provide direct experience so that the material studied by students is no longer abstract. This is confirmed by Sudjana and Rivai [11], that learning delivered by the teacher, by visualizing it in a real way that resembles the actual form or condition will be more effective and increase students' enthusiasm in receiving the material. One application or technology that can be used to create learning media so that it can be visualized is augmented reality (AR) technology.

Augmented reality, according to Martono [12], is an application or technology that combines the real world with the virtual world from initially only two dimensions to three dimensions in real or real conditions and circumstances. The benefit of augmented reality applications in learning is that they trigger students' mindsets to think critically about problems and events that occur, either in the past or in everyday life [13].

So that this media can provide direct learning, wherever and whenever students want to carry out the learning process. The data entered can be in the form of 3D images, audio, comments, location data, or historical context, or in other forms.

The following are some of the research results that are closely related to the use of social studies learning media; namely, according to Supardi [14], who developed audiovisual-based integrated social studies learning media based on data findings, the media was declared good for implementation in learning and received a positive response from students so that they can receive social studies learning well and optimally. Findings reveal that students will be motivated to learn by applying AR media [15], [16]. The application of the make-a-match model in social studies lessons using the help of video media provides an increase in learning motivation by 78.17% and has an effect on students' learning completion and outcomes by 86.96% [17]. Meanwhile, augmented reality media on science material based on the results of the ANCOVA p-value $<\alpha$ (0.05) shows that there is a significant influence on augmented reality media on problem-solving skills, increasing enthusiasm for learning and results [18]. About student learning, the development of AR learning media carried out by Efendi *et al*. [10] describes the heritage topic of the Singasari kingdom using a 4D research model used in history subjects at vocational schools with the aim of testing the effectiveness of learning media (ARC). Several studies mentioned above show that learning media influences interest and increases creativity, so it has an impact on good and improved learning outcomes. The difference in this research is the focus of the material presented, namely visualizing volcanic object material in Indonesia using the AR application so that students can understand the process of volcano formation and the types of volcanic shapes in Indonesia.

Based on the results of a survey on March 27-28, 2024, the author distributed a questionnaire in the form of a link via the Google Forms application to students at Model Terpadu Bojonegoro State High School to find out the conditions of Social Sciences learning.

The results obtained showed that many students considered social studies lessons to be less important, very boring, and considered a burden for them to memorize. The total number of 120 students proves this; 80% of students stated that it was "boring," and another 20% of students stated that learning social studies was "fun." Apart from that, from the survey results, 70% stated that educators use conventional teaching methods and educators are less aware of how important learning media is, so students, in this case, only act in one direction and are only informants.

The problem faced by teachers at SMAN MT Bojonegoro is that they have not been able to master the use of learning support applications fully. Social studies learning is still monotonous and cannot be delivered and presented in an interesting way to students. Meanwhile, learning continues as usual, and the longer there is no innovation in social studies learning, the students will also become increasingly bored, and the material will also be difficult for students to receive well. Traditional learning is combined with new learning innovations to be effective in achieving learning outcomes [19]. Learning innovations that involve activities and active interactions with students will be able to increase understanding and retention significantly [20].

Augmented reality (AR), which will be implemented in social studies learning about volcanism, will be made real/3D, just like the real field studies in volcanic areas in Indonesia. Apart from seeing the shape in 3D, students will also get direct information (audio and visual) regarding the differences in the types of volcanoes in Indonesia. According to the print media, it is in the form of a book to detect the AR marker, and this application can be downloaded via the Google Drive link. By using augmented reality (AR) technology, students can participate in real social studies learning about volcanic material without having to visit various places that contain geographical elements in volcanic areas. For this reason, in social studies learning, especially on volcanism material, it is necessary to develop digital technology innovations in the form of AR, such as the "Atlas Volcano Series" (ARAVS), which provides new learning experiences for students about how digital technology can be adapted to enrich the teaching of social sciences. This research was conducted on high school students and social studies subjects on volcanism with volcanic objects in Indonesia. The aim of developing ARAVS is to provide understanding and find out students' interests regarding the use of ARAVS media on volcanism material and how its effectiveness can be seen in improving learning outcomes.

2. Methodology

The procedure in this research refers to the research and development (R&D) design. The development design used is Dick and Carey [21]. This model consists of 9 steps, namely: 1) identifying the core competencies of the subjects; 2) analyzing basic competencies in subjects; 3) analyzing student characteristics; 4) formulating learning objectives; 5) developing assessment instruments; 6) developing learning strategies; 7) developing and selecting teaching materials; 8) designing and implementing formative evaluation; and 9) revising teaching materials. The trial of the developed product was carried out in class. The trial sample was selected based on purposive sampling, namely students who had low, medium, and high initial abilities and interest in learning geography.

The small group trial consisted of 30 children, and the field consisted of 120 children. Research and development will be carried out in April-May 2024. This type of research and development data is in the form of quantitative and qualitative data. Qualitative data in the form of input, responses, and suggestions for improvement based on the results of expert assessments obtained through questionnaires/consultations with social studies learning design experts. The data are as follows: 1) learning aspects from social studies learning development experts; 2) aspects of learning tools by social studies learning developer experts; 3) aspects of the content of learning materials by social studies learning development experts; and 4) aspects of learning media by expert learning media developers.

Quantitative data includes: 1) information obtained from questionnaires from social studies learning design experts in the form of percentage figures, which are then explained descriptively; 2) tests measuring student learning outcomes before and after using ARAVS during the learning process; 3) student response questionnaire regarding interest in learning after implementing ARAVS. Data collection techniques use product feasibility test questionnaires by social studies learning design experts, learning feasibility observation sheets by teachers, student interest response questionnaires, and learning outcomes tests.

Quantitative data analysis techniques in the form of questionnaire results from social studies learning design experts are converted into percentages to determine the feasibility of ARAVS. Quantitative product feasibility data in the form of expert validation data is interpreted in the form of qualitative sentence descriptions based on the average data obtained and the respective data criteria. The criteria are as follows:

Table 1. Feasibility assessment criteria for the ARAVS

Assessment criteria	Information
0% - 20%	Not feasible
21% - 40%	Not worthy
41% - 60%	Decent enough
61% - 80%	Worthy
81%-100%	Very worthy

Source: Research results (2024)

The learning outcome test data in the application of ARAVS was then analyzed using the t-test with a pre-experimental design of one group pretest-posttest in a single group. The pretest score is obtained from the student's score before using it, and the posttest score is obtained from the test score after learning. The learning interest questionnaire data in the application of ARAVS was then analyzed using discriminant statistics. After students use ARAVS, they are asked to fill out a questionnaire to assess whether they are interested in ARAVS media or not. Interest in using ARAVS media is measured with a score range of 1-10 based on concrete, innovative, difficult, boring, and interactive aspects.

3. Results and Discusion

The development of Augmented Reality Atlas Volcano (ARAVS) Series media product has been developed using Dick & Carey RnD design. Following is a brief description of the design process and development:

3.1. AR Atlas Volcano Series (ARAVS) Development Process

The development of ARAVS learning media aims to help students construct the knowledge they gain through meaningful learning experiences. In social studies learning specifically about volcanic material, the use of this media is used to invite students to observe volcanoes in Indonesia so that students are not passive or silent, but they find out through investigation and exploration of material from the visual form of volcanoes assisted by ARAVS media. The discovery or renewal process refers to the design developed by Dick & Carey [21], which includes nine stages.

First, the learning outcomes are identified, namely carrying out curriculum analysis related to learning outcomes in the Merdeka curriculum. In this case, the analyzed learning objectives are class.

Second, an instructional analysis should be carried out, namely identifying learning objectives, especially in the cognitive domain, namely student learning outcomes in understanding the phenomenon of volcanic volcanism in Indonesia. An instructional analysis needed for evoke students' learning interests and identifying student responses after using ARAVS in social studies learning.

Third, student characteristics are analyzed, which include the characteristics of students' cognitive development, learning styles, and initial abilities. Based on Piaget's cognitive development, high school children aged 15-18 years are at the formal operational stage. Namely, children are able to formulate an alternative hypothesis for the problem and then check the data to answer the hypothesis until finally making a viable decision. Based on the results of a questionnaire analysis regarding the learning styles of Bojonegoro Integrated Model High School students totaling 120 children, it is known that in class or 23%. Volcanic material in Indonesia is a continuation of lithospheric material, so they already have initial knowledge about Indonesia's physiographic conditions, which is one of the advantages of Indonesia's natural resource potential.

Fourth, formulating learning objectives that include students' abilities, namely 1) analyzing the process of volcanism, 2) analyzing the distribution of volcanoes in Indonesia, 3) analyzing the types of volcanoes in Indonesia, and 4) analyzing the structure of volcanoes in Indonesia. Fifth, namely developing an assessment instrument for the cognitive domain in the form of a test of learning outcomes for understanding material on the phenomenon of volcanism and a questionnaire on student interest in learning. The development of an assessment instrument is intended to measure changes in the ability to understand learning outcomes before and after learning and to determine student responses to interest after using ARAVS.

Sixth, namely, developing learning strategies are as follows. In this activity, the learning strategy developed includes a combination of the sequence of learning activities, methods, media, and time. This learning strategy can be seen in the learning implementation plan (teaching module). The sequence of learning activities in the teaching module follows the direct instruction syntax. Seventh, namely developing and selecting instructional materials in the form of basic teaching materials for student books and social studies teacher books for class X in the Merdeka curriculum. Apart from basic teaching materials, ARAVS media was also developed. The following is the ARAVS media development design.

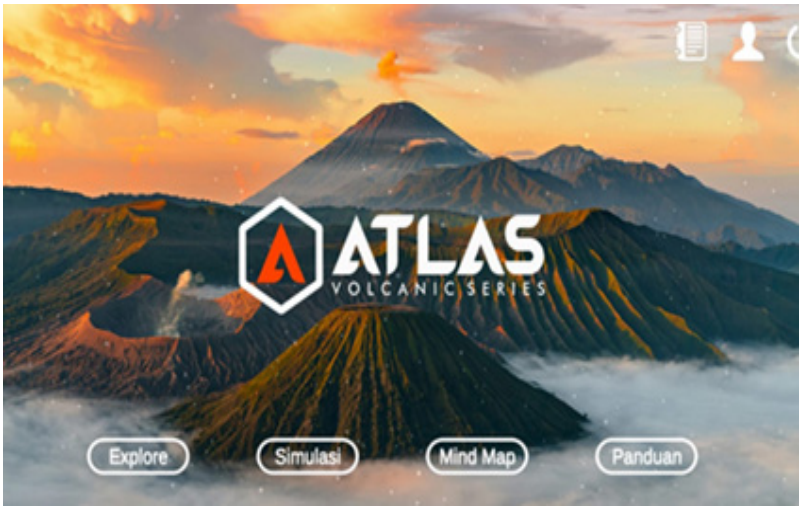

Figure. 1. Main view of the Atlas Volcano Series

The Atlas Volcano Series (ARAVS) has four main menu buttons: Explore, Simulation, Mindmap, and Guide https://unesa.me/ATLASMEDIA).

- On the explore menu button apps, there is volcanism material in the form of 1) Volcanism process, 2) volcano distribution map, 3) volcanic structure, 4) volcano classification, and 5) eruption factors. In the five volcano materials, students can see how the phenomenon is in the form of descriptions and supported by visualization of 3-dimensional objects using marker.

Figure 2. Display of the explore option and marker

- On the simulation menu button, students can access further descriptions of volcanoes with 3-dimensional visuals, where students can zoom in and out on volcano objects, rotate objects up and down, and rotate objects to the right and left freely. The simulation menu also includes a video of a volcanic eruption.

Figure 3. Volcano simulation menu display

- On the mindmap menu button, important concepts in volcanism are displayed, including 7 important concepts: volcanic structure, volcanic distribution areas in Indonesia, factors that cause eruptions, classification of volcanoes, types of eruptions, eruption products, and mitigation of eruption disasters.

Figure 4. Volcanism mindmap display

- In the guide menu, it is shown how to use ARAVS, which includes: 1) opening the ARAVS application by selecting the explore button; 2) taking the marker and placing it in the desired position; 3) directing the smartphone camera at the marker; 4) the application will load features and wait a few moments; 5) a 3-dimensional model will appear on the smartphone screen according to the selected marker; 6) features in the application can be operated using the available buttons.

Figure 5. Atlas Volcano Series guide menu display

Eighth, design and carry out formative evaluation. At this stage, validation tests are carried out by experts on the development product, namely ARAVS. Expert validation tests are carried out before testing on students. The validator is an expert in the field of social studies learning design, namely the social studies learning developer validator for validating models, social studies materials, and expert validation of the media used for ARAVS. Ninth, revise learning teaching materials. Things that are deemed to require improvement are applied to learning so that learning at the next meeting runs optimally.

The feasibility test of learning model experts obtained an average score of 4.84 in the very good category with an overall percentage score of 97% in the very good category.

These results show that all indicators place the AR Atlas Volcano Series in the very good category and very suitable for use in classroom learning (Table 2).

Table 2. Learning process feasibility test results

No	Indicator	Score	Category
1	Logical theoretical rational	4,6	Very good
2	Syntax steps	4,8	Very good
3	Systematic learning activities	4,8	Very good
4	Support system	5	Very good
5	Instructional and accompanying impacts	5	Very good
	Average score	4,84	Very good
	percentage	97%	Very worthy

Source: Research results (2024)

Next, a feasibility test was carried out by learning device experts to determine the quality of implementation of the AR Atlas Vulcano Series when used in class. At this stage, the validated product is in the form of a teaching module that has been prepared on social science material for class X, even a semester, with material on Mount Apai (volcanism) in Indonesia. The following are the results of the feasibility test for learning device experts.

Table 3. Learning device feasibility test results

No	Indicator	Score	Category
1	Formulation of goals	4,8	Very good
2	Election and organization	4	Good
3	Selection of learning sources and media	5	Very good
4	Learning models and methods	5	Very good
5	Assessment of learning outcomes	4,6	Very good
6	evaluation test	4,8	Very good
	Average score	4,7	Very good
	percentage	94%	Very worthy

Source: Research results (2024)

Based on Table 3, it is known that the results of the feasibility test for learning devices in the form of teaching modules for the implementation of AR Atlas Vulcano Series media obtained an average score of 4.7 and an overall percentage score of 94%. These results show that the overall indicators place ARAVS learning tools in the very good category and are very suitable for use in classroom learning. The third validation was carried out on ARAVS media for the suitability of social science material for class X even semester. The following are the results of the feasibility test from learning material experts.

Table 4. Study material feasibility test results

No	Indicator	Score	Category
1	Content quality	5	Very good
2	Instructional quality	4,8	Very good
3	Technical quality	5	Very good
	Average score	4,9	Very good
	percentage	98%	Very worthy

Source: Research results (2024)

Based on Table 4, it is known that the feasibility test results from material experts obtained an average score of 4.9 and an overall percentage score of 98%. These results show that the overall indicators place the material available in ARAVS media in the very good category and very suitable for use in classroom learning.

Furthermore, a validation test was also carried out for the learning media aspect in the form of ARAVS media on social science material for class X, even semester, on the topic of volcanoes in Indonesia. The following are the results of the feasibility test from social studies learning media experts.

Table 5. Learning media feasibility test results

No	Indicator	Score	Category
1	Visual media	5	Very good
2	Digital quality	5	Very good
3	Use of digital technology	5	Very good
	Average score	5	Very good
	percentage	100%	Very worthy

Source: Research results (2024)

Based on Table 5, it is known that the media feasibility test results obtained an average value of 5 and an overall percentage value of 100%. These results show that the overall indicators place ARAVS learning media as very good and very suitable for use in the classroom.

Table 6. Results of small group and field trials

No	Indicator	Trial score	
		Small group trials	Field trials
1	Content quality	3,85	4
2	Instructional quality	3,85	5
3	Technical quality	4	4
	Average score	3,90	4,3
	Percentage	78%	87
	Criteria	Very worthy	Very worthy

Source: Research results (2024)

After ARAVS has been validated and declared feasible by expert designers of models, media, and learning materials for use in social studies learning, the next stage is a trial. The first trial was carried out on a small group of 15 students to determine the advantages and disadvantages of implementing this media in increasing students' interest abilities and learning outcomes. Based on Table 6, the results of the ARAVS trial on students as users show that the results of the small group trial as a whole obtained a percentage score of 78% in the feasible category. Furthermore, the field trials showed that the overall trial results obtained a percentage score of 87% in the very feasible category.

So, it can be concluded that the product resulting from the development of this learning model and media is very suitable for use as an alternative in social studies learning.

3.2. Learning Results Using the AR Atlas Vulcano Series

The analysis of the effectiveness of using ARAVS media is based on tests (pretest and posttest) of students' cognitive aspect abilities in social studies subjects in class. Before carrying out the difference test analysis, a prerequisite test is first carried out, namely the data normality test. Based on the results of data normality with the Shapiro-Wilk test, the pre-test data was 0.86, and the post-test data was 0.200. Based on the results in the Shapiro table, the sig value for the results of the initial ability (pretest) and final ability (posttest) each amounted to more than 0.05, so it can be said that the data is normally distributed, so the paired sample t test can be continued. The following is Table 7, which shows the results of the paired sample t-test.

Table 7. Pre-test-post-test score processing results

	T	Df	Sig. (2-Tailed)
Pair 1. Pretest-Posttest	9.526	120	.001

Source: Research results (2024)

Based on the results of the paired sample t-test which has been calculated, a sig. (2-tailed) value of 0.01 < 0.05 is obtained, it can be concluded that there is a difference in initial ability (pretest) and final ability (posttest) regarding understanding volcanoes (volcanism) in class X students. It can be concluded that ARAVS media can significantly increase understanding of volcanism material. These findings are also strengthened by research by Turan *et al.* [22], which states that in geography learning on the topic of geomorphology, mobile-based AR can improve student perception and academic achievement and reduce the level of student cognitive load. Meanwhile, Azi [23] found other friends who thought that AR did not have a big impact in improving students' academic abilities when compared to traditional learning using textbooks and smart boards. However, if studied from the student's perspective of learning social sciences, the use of AR media can significantly increase motivation and interest in learning. Students who implement AR media experiments find it more enjoyable to deepen material that visually displays three-dimensional objects.

Students gain new learning experiences through ARAVS media, thereby helping them understand abstract and difficult concepts from social studies material, especially the phenomenon of volcanism. AR can increase understanding of the complexity of geographical material concepts [24], [25]. Rellia [26] conveyed his findings that AR with the CILL (Content and Language Integrated Learning) approach can improve learning outcomes, engagement, motivation, and retention in geography learning when compared to traditional classes. By integrating geography material with English in interactive and immersive AR packaging, this content-based learning provides significant benefits in learning. Carrera and Asensio [27], emphasized that AR is able to improve average learning outcomes, especially aspects of spatial orientation in geographic material because objects on the earth's surface and topography can be displayed visually with a 3-dimensional model.

AR provides permanent improvements in learning outcomes and academic abilities, which are strengthened by the fact that AR technology contains stimulants that are more effective in learning, and students have great interest in its use. AR is suitable for the cognitive development of secondary school students with good virtual and digital competencies [28]. According to Marini *et al.* [29], the use of AR integrated with the metaverse significantly improves learning outcomes regarding understanding scientific material. The implementation of AR and metaverse integration facilitates students to be more active in in-depth and participatory learning. The experiment Tetep *et al.* [30], applied AR as a learning media for Natural and Social Sciences, while in the control group, learning was applied that can be used every day through textbooks. This research shows that there is a significant difference between the experimental group and the control group regarding literacy skills, where the experimental group has better literacy skills compared to the control group.

3.3. Interest in Learning Using the AR Atlas Vulcano Series

Analysis of student interest was obtained from the responses of students who filled out questionnaires after they applied ARAVS media. Discriminant analysis is used to determine whether students have interest or not in the AR Atlas Vulcano Series media. Students were asked to rate on a scale of 1-10 the factors that influence interest in using AR Atlas Vulcano Series media, including concrete, innovative, difficult, boring, and increasing understanding.

The results of statistical analysis using the discriminant test showed that of the 120 students who filled out the response questionnaire, there were 24 students who were interested in using the AR Atlas Vulcano Series media in learning, while six students were not interested in the AR atlas vulcano series media.

Table 8. Tests of equality of group means

	WilksLambda	F	df1	df2	Sig.
concrete	,501	27,878	1	28	,000
innovative	,761	8,808	1	28	,006
difficult	,867	4,288	1	28	,577
boring	,991	,250	1	28	,621
interactive	,733	10,174	1	28	,003

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	,301	30,592	5	,000

Source: Research results (2024)

Based on Table 8, it can be concluded that concrete, innovative, and interactive ARAVS media influence students' interest in using AR media ($p = 0.000$, 006, and $0.03 < 0.05$), while the difficult and boring factors have no influence on students' interest. in the use of AR media ($p= 0.557$ and $0.621 > 0.05$). The Wilks Lambda test results also show significant differences in interest factors in using the AR Atlas Vulcano Series in the discriminant model with a p-value of 0.000.

According to students, learning through ARAVS provides more concrete volcano material. ARAVS learning media can visualize abstract concepts into concrete ones with real examples for students. Through AR ARAVS, students can independently simulate the process of volcanic events, the types of volcanic eruptions, and the shapes of the types of volcanoes in Indonesia. Apart from that, the use of ARAVS learning media makes students better at remembering and applying the instructions given to them during the learning process. The use of AR helps clarify abstract concepts into concrete ones so as to clarify material exploration and improve academic abilities [31].

AR media is concrete in nature, making the material more clearly understood and attractive, making it easier for students to learn and making students optimize their potential to improve learning outcomes [32].

This is in accordance with the opinion of Volioti *et al*. [33], which states that AR can be very suitable when applied to geographic study objects because it is able to enrich the learning experience and increase understanding because it is able to present abstract geographic concepts into concrete ones through the visualization of three-dimensional objects. Through concrete and interactive material, the application of AR provides high satisfaction by providing high feedback on aspects of AR media interest.

The students' responses considered that the application of ARAVS was an innovative media; they felt that this media was something new to apply in learning, thus motivating them to increase their curiosity about the material further. Chitaniuc and Iftene [34], developed GeoAR as a learning media innovation that transforms traditional learning towards digital-based learning.

The implementation of GeoAR is an innovative new method for delivering lesson material in an interesting and interactive visual-based manner in the digital era. AR is an innovative development in interactive learning and facilitates students with more active experiences to deepen their understanding of the material [7].

The findings of Wei [35] at five private universities in Malaysia suggest that there is a significant relationship between teacher innovation in using AR on learning outcomes and student learning motivation because AR media is very suitable for students' current and future learning needs.

Students assess the application of ARAVS as having the ability to learn more interactively. The interactive AR Atlas Vulcano Series media can facilitate students to reflect independently and continue the material according to the learning needs they want to achieve. AR promotes an interactive, responsive, and dynamic learning environment, especially for integrated lessons such as natural and social sciences [30] . AR can increase student involvement through an interactive learning process viavirtual objects that are manipulated to represent realistic earth surface phenomena [36]. Meaningful interactive AR learning media is an important key to the effectiveness of learning outcomes. AR has the ability to visualize three-dimensional objects that students can use to learn interactively. Implementation ofinteractive AR media, not only increases understanding but also attracts students' interest, bringing the lesson material 'alive.' Through the application of the augmented reality instructional tool (ARIT), abstract and complex geographic material becomes more concrete and flexible so that it can improve overall learning outcomes for both male and female students [37].

The application of ARAVS can be adapted easily by students. Student response: The application of ARAVS is that it is not a difficult medium to use and is not boring. Students at SMAN MT Terpadu Bojonegoro are no strangers to digital technology because the school facilitates students to use smartphones during learning.

Various digital-based applications that are accessed via smartphones are often used in the learning process. Students will not feel bored and will instead be challenged to use AR media as digital technology. Innovative digital-based learning media applications, creating interactive and interesting learning experiences in the digital era, make students more enthusiastic in developing digital skills and literacy [38].

Through the application of AR, students will not be bored but rather interested in learning, especially with material presented digitally with more real and dynamic objects [39]; AR media is used easily by students as a digital generation and makes AR a fun medium and facilitates students to learn independently [40]. Although AR offers many benefits, it has several disadvantages, such as expensive devices, the need for training for users, and if used for a long time, it can cause health problems such as headaches and eye fatigue [41].

4. Conclusion

This research presentsa product in the form of ARAVS media. The validation test results of the final product development from social studies learning developer experts and learning media experts are in the very feasible category. The results of small group trials are in the feasible category, and field trials are in the very feasible category. The results of the t-test on cognitive aspects showed that there was an increase in student learning outcomes regarding volcanoes and symptoms of volcanism in social studies subjects after using the developed product. Students have an interest in the application of ARAVS media because they consider this media to be concrete, innovative, and increase understanding. In general, the formative evaluation shows that the product resulting from this development is very suitable for use as an alternative media in social studies learning.

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