

The Development of Teachers' Competences in Utilizing Augmented Reality-Based Media in Geometry Learning

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Abstract

This program aims to develop teachers' competences in using and utilizing technology in the form of Augmented Reality (AR)-based media that can be used in geometry learning. This community service program is in the form of a training for elementary school teachers. This program is motivated by the results of a study which shows that of 257 teachers from 39 cities in Indonesia only 28% claimed to be familiar with AR-based media while 72% of teachers claimed not to know them, some of whom were teachers in Tasikmalaya City. Therefore, it is necessary to develop their competences so that they will know and be able to use AR-based media to adapt to the times. This training was carried out from the smallest scope, namely at an elementary school in Tasikmalaya City, SD Negeri Leuwianyar. The potential for using digital media in the school is quite high because the facilities are quite supportive. The problem was, teachers rarely used digital media, including the use of AR-based media. This training program was carried out by adapting the stages of the ADDIE model, namely Analyze, Design, Develop, Implement, and Evaluate. The results of the training showed that teachers strongly agreed that the training could develop their knowledge and encourage them to use AR-based digital media for learning.

Keywords: teachers' competences, augmented reality, geometry learning

INTRODUCTION

Augmented Reality (AR) is one of three immersive technologies that continue to evolve today. Other technologies in question are Virtual Reality and Mixed Reality. Augmented Reality (AR) is described as a technology that combines 2D or 3D virtual objects with the real environment directly. This concept allows the projection of such virtual objects in real time, thus creating an interactive experience that combines the real world and the virtual world. According to Dede et al. (2017), learning experience designed to teach complex knowledge or complex skills is often based on guided constructivist social learning theory that emphasizes mastery of certain tasks in situations that are realistic and personally relevant to learners. Immersive technology allows learners to feel as if they are surrounded by, entered, engaged, and/or interacted with something so that they can build a personalized interpretation of the experience (Dede et al., 2017). This is one of the drivers of the study of how immersive technology is used in learning to be one of the current trends. In general, AR is divided into two, namely marker-based and markerless. Markers

can be detected using electronic devices (for example: smartphones) to display certain visual images. Whereas, if AR is operated without markers, technologies such as GPS (Global Positioning System) can be a substitute for barcodes (Cristobal et al., 2018; Pence, 2010).

AR-based learning has been widely implemented, including in mathematics learning. For example, research conducted by Chen (2019) proved that a group of sixth grade students in one of the elementary schools in Taiwan who carried out mathematics learning with the help of AR showed better performance than those who did not use AR. In addition, students in the AR group also had higher motivation, confidence, and satisfaction and lower anxiety (Chen, 2019). The positive effects of using AR in mathematics learning are also shown in Sun & Chen's (2019) research which showed that there were positive effects in terms of visualization, interaction, and student attitudes in geometry learning. This encouraged fifth grade students in an elementary school in Taiwan to be more involved in learning activities with lighter cognitive loads, so that their learning performance became better (Sun & Chen, 2019). Referring to the results of the studies, it could be concluded that AR technology has a potential to be used as a medium in geometry learning. This certainly needs to be supported by teacher competence as teachers are responsible for guiding students in the learning process.

However, according to the results of a study conducted by Nuryadin et al. (2023) which focused on discovering Indonesian elementary school teachers' experiences of using Augmented Reality (AR) for learning, it was found that the majority of the teachers were not familiar with AR, let alone use AR technology for learning. The survey, which involved 257 teachers from 39 cities in Indonesia, found that only 28% stated that they were familiar with AR-based learning media, while 72% of them stated that they were not familiar with them. Then, among the 28% of teachers who said they were familiar with AR, the majority said they never (50.86%) and rarely (21.92%) used Augmented Reality (AR) media for learning geometry.

In that study, a number of problems were found, such as: 1) teachers did not know the definition, benefits and how to use AR-based learning media; 2) teachers did not have awareness of the potential benefits of AR technology for learning; 3) teachers did not have the technical skills to use AR as a mathematics learning medium, especially geometry topics; 4) teachers did not have pedagogical skills in designing learning that supports the use of AR in mathematics learning, especially geometry topic; 5) teachers did not have the pedagogical skills to design Student Worksheets (LKPD) that support the use of AR in mathematics learning, especially geometry topic; 6) teachers did not use AR in teaching mathematics, especially geometry topics; 7) teachers did not receive support from schools and policy makers regarding the use of AR technology for teaching mathematics, especially geometry topic; 8) teachers were not yet aware of the various other AR applications available on App Store or Play Store that can be used for mathematics and other learning. This finding is in stark contrast to the findings in a study conducted by (Alkhattabi, 2017), which found that 71.3% of female and 83.5% of male teachers in elementary schools in Saudi Arabia were familiar with AR technology. Therefore, a program is needed to introduce the use of AR to elementary school teachers. This program aims to develop teachers' competences in utilizing AR-based media through training by providing theoretical and practical training. Helping teachers in using appropriate media is important to achieve targeted learning outcomes (Setiawan et al., 2023).

METHOD

Given that the community service program implemented aims to develop the competence of elementary school teachers in the use of AR-based learning media, the program was carried out by adapting the ADDIE instructional design model which consists of a number of stages, namely analyze, design, develop, implement, and evaluate (Branch, 2009). The ADDIE model can be seen in Figure 1.

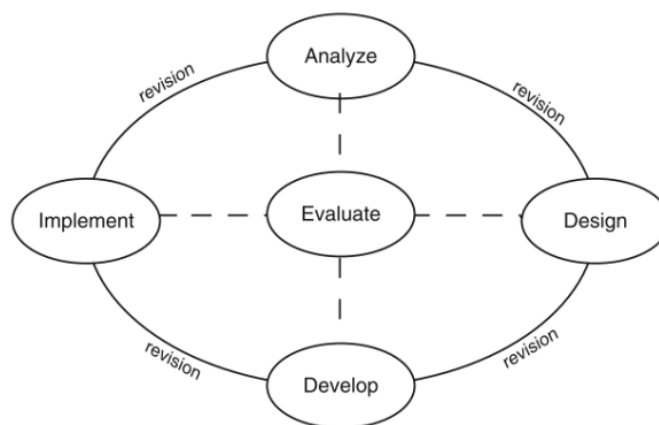


Figure 1. ADDIE Model

In order to analyze needs and conditions, a number of things were carried out, namely (1) validating performance gaps related to the use of AR-based media for mathematics learning; (2) defining instructional goals (e.g., create instructional goals based on Bloom's Taxonomy); (3) analyzing learners (e.g., the number of trainees, their characteristics, attitudes, and experience level); and (4) identifying available resources (e.g., content resources, human resources, instructional facilities, and technology resources).

At the design stage, things carried out include (1) conducting an inventory of tasks (for example, cognitive tasks and motor tasks); (2) developing targeted performance (e.g., create performance targets to be achieved consisting of performance, conditions, and criteria); and (3) creating assessment strategies.

At the stage of developing training activities, several activities were carried out, namely (1) creating training content; (2) selecting or developing learning media (e.g. selecting or developing media to improve the quality of learning, presenting and/or strengthening learning content, and accommodating different learning styles of learners); (3) developing training instructions for participants.

At the stage of implementing training activities that had been designed and developed, some activities performed were (1) preparing instructors; (2) preparing prospective trainees (e.g., creating training schedules, and conducting pre-training communications); and (3) conducting the training.

At the stage of evaluating the training activities, several activities carried out were (1) determining evaluation criteria; (2) selecting and developing an evaluation instrument, that is a questionnaire; and (3) conducting evaluation using the questionnaire.

RESULTS

Analyze

The implementation of the training program began with an analysis of strengths, weaknesses, opportunities and threats (SWOT) to the target audience. The results of SWOT the analysis are presented in Table 1.

Table 1. SWOT Analysis of the Training to be Conducted

<i>(Strengths)</i>		<i>(Weaknesses)</i>	
1. Teachers are already quite familiar with the use of technology for learning, especially after learning during the COVID-19 pandemic		1. There are many senior teachers who are not proficient in using digital technology so training is likely to be focused on teachers who have sufficient digital skills	
2. Teachers generally have adequate <i>smartphones</i> to use AR applications.		2. Not all students have <i>smartphones</i> for implementation in the field after the training.	
3. A geometry learning media product in the form of an Android application based on AR technology has been developed, named ARBIM-GEO (<i>Augmented Reality-Based Instructional Media</i>).		3. The application that has been developed is only available for the android operating system.	
4. A Learning Plan (RPP) designed to support the use of AR in geometry learning has been developed.			
4. A Student Worksheet (LKPD) which contains target images that can <i>be scanned</i> using the ARBIM-GEO application has been developed.			
5. There are many other AR applications available on App Store or Play Store that can be used for mathematics learning so that they can expand training materials.			
<i>(Opportunities)</i>		<i>(Threats)</i>	
1. Increasing teachers' knowledge and awareness about the benefits of AR technology for learning.		There might be a resistance from teachers who consider AR technology complex.	
2. Improving teachers' technical skills in using AR technology as a learning medium.	1.	Lack of support from schools and stakeholders regarding the use of AR technology for learning.	
3. Improving teachers' pedagogical skills to design lessons that support the use of AR in geometry and mathematics learning in general.			
4. Improve teachers' pedagogical skills in designing Student Worksheets (LKPD) that support the use of AR in learning geometry and mathematics in general.			
4. Increasing teachers' knowledge about various other AR applications available on App Store or Play Store that can be used for mathematics and other learning.			

Design

The training was designed as an activity that is carried out directly in an elementary school with the target audience being elementary teachers. In designing this training, the community service team also paid attention and considered the conditions of the trainees and the availability of facilities and infrastructure at the school that would be used as the place to carry out the training.

The training was designed to focus on four topics: 1) introduction to AR in mathematics learning; 2) designing AR-based Lesson Plan (RPP) using the Flipped Classroom model; 3) the use of ARBIM-GEO application assisted by the Student Worksheet (LKPD); 4) introduction of other AR applications that can be downloaded at App Store or Play Store. To optimize the implementation of training, it was supported by direct practice in using AR in mathematics learning, especially geometry topic. Training participants would be directed to download and install the ARBIM-GEO application on their own mobile phones, after which they were directed to scan the images contained in the LKPD that had been prepared. All topics would be integrated in a training module, so that trainees could learn it further independently after the training was complete.

Develop

The development of the training module begins with determining the type of module, namely a printed module that was created using the Microsoft Office Word application to write the contents of the module and using Corel Draw in designing the module cover and the back page of the module. Here are the front and back covers of the training module that were developed.



Figure 2. The Training Module

The training module was developed systematically including the module cover, copyright page, preface, table of contents, list of figures, table of tables, introduction, main content consisting of 4 chapters, bibliography, and back cover page. It was written on B5 size paper with Times New Roman font size 12pt and space 1.5.

The Student Worksheet (LKPD) and the ARBIM-GEO application, which were integrated into the training module, were the result of a developmental research conducted in the previous study. Thus, they can be integrated directly with the training content presented in the training module. The Student Worksheet (LKPD) and the ARBIM-GEO application are shown in Figure 3 and 4, respectively.

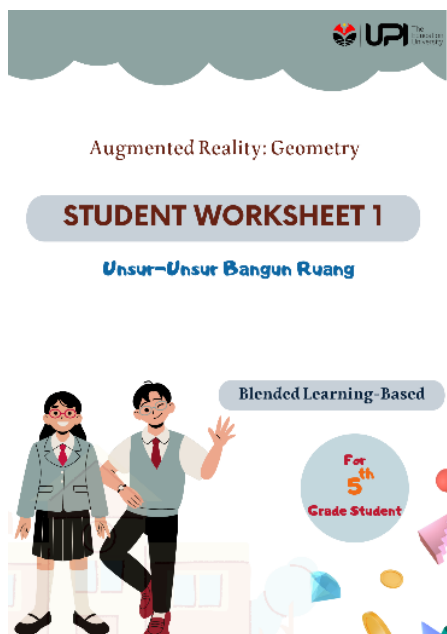


Figure 3. An Example of Student Worksheet



Figure 4. ARBIM-GEO Main Menu

In relation to curriculum, basic competencies that are used as a reference for the training module two basic competencies for fifth grade elementary school, namely, number 3.5 “explain and determine the volume of a spatial figure using volume units (such as a unit cube) and the relationship between cubes and cube roots” and number 4.5 “solving problems related to the volume of geometric figures using volume units (such as unit cubes) involving cubes and cube roots”. However, the content of the training module covers not only these topics but also other topics/subjects that can be taught using AR.

Implement

Teacher competence training in utilizing AR-based media for geometry learning was held on Saturday, September 16, 2023 at SD Negeri Leuwianyar Kota Tasikmalaya. Participants who attended the training were school principals, teachers who served as homeroom teachers and subject teachers. The content delivery media was an interactive whiteboard owned by the school. The training methods used were presentations, demonstrations, simulation, and discussion.

The first speaker explained about mathematics learning, especially geometry learning and learning media that can be used, including AR. Meanwhile, the second speaker delivered his presentation focusing on the use of ARBIM-GEO and the Student Worksheet and also the introduction of other AR applications that can be downloaded on the App Store or Play Store.



Figure 5. First Presenter Delivering Her Presentation



Figure 6. Second Presenter Delivering His Presentation

The training participants did not only listen to the presentations but also had a chance to try the ARBIM-GEO application using the Student Worksheet. The participants also had a chance to ask some questions during the Q&A/discussion session. The question did only relate to the use of digital technology for mathematics learning, but also about the pedagogical aspect of mathematics teaching.



Figure 7. Training Participants Involved in Q&A session



Figure 8. A Training Participant Trying the ARBIM-GEO application

Evaluate

The training ended with an evaluation by providing a number of questions and statements through a Google Form. Questions and statements included teachers' knowledge and experience in using AR-based media and expectations for future training. Based on the answers collected, it was found that most teachers did not know AR-based media before the training, the percentage was 73% and the experience of teachers using AR-based media almost all had never used it with a percentage of 91%. Then, there were also statements related to four aspects, namely learning aspect consisting of three statements, behavioral aspect consisting of two statements, reaction aspect consisting of one statement and outcome aspect consisting of one statement. The recapitulation of the teacher questionnaire is presented in Table 2.

Table 2. Teacher Questionnaire on Training Implementation

No	Aspect	Score	Percentage
1	Learning	165	96%
2	Behavioral	110	96%
3	Reaction	51	93%
4	Outcome	55	96%

Statements related to the learning aspect were used to measure teacher knowledge after attending training, so the statements submitted include teacher knowledge of AR, the benefits of AR, and examples of AR applications. These statements could measure the extent to which the effect of training programs on improving teacher knowledge. So it can be seen based on the teacher questionnaire that the score obtained was 165 with a percentage of 96%, indicating that teachers strongly agreed that this training improved their knowledge.

Statements related to the behavioral aspect were used to measure the extent to which teachers exhibited positive behavior after attending the training. The statements included the extent to which the training encouraged teachers to learn more about the use of AR and to utilize AR-based media in learning. So it can be seen that the score was 110 with a percentage of 96%, indicating that the teachers had a positive behavior and strongly agreed that the training encouraged them to learn more about and utilize AR-based media in learning.

A statement related to the reaction aspect was used to find out what the teacher would do after the training. Based on the questionnaire, this statement obtained a score of 51 with a percentage of 93%, indicating that teachers strongly agreed that after training they will learn various types of digital technology for learning. It indicates that the teacher reacted very positively to the training that had been carried out. A statement related to the outcome aspect was used to measure the extent to which the level of teacher satisfaction of the training. The result indicator reached a score of 55 with a percentage of 96%. It shows that the results of the training implementation have had a good impact on the trainees.

Based on the evaluation performed using the questionnaire, it can be concluded that all indicators received a high percentage in the sense that all training participants strongly agreed that this training had provided knowledge, participants were satisfied with the implementation, presenters, and training facilities and participants could also had a chance to try the ARBIM-GEO application.

CONCLUSIONS AND RECOMMENDATIONS

The development of teachers' competences in utilizing AR-based media in geometry learning have been carried out in the form of a training program. This activity was motivated by the results of previous research showing that teacher knowledge of AR-based media was very limited, even though nowadays teacher competence in mastering technology is very necessary. Thus, this training is carried out through a community service program in the hope that it can help educators develop their competence in order to adapt to the times. The training was carried out based on the ADDIE model including analyzing the needs and conditions, designing the training to be carried out, developing a training module and all facilities that support the training, implementing the program, and conducting evaluation to measure the success rate of the training. Based on the evaluation results, the implementation of this training received a high score and percentage. It

shows that the trainees were very satisfied with the training materials, presenters, and facilities provided.

Based on the evaluation results, it is necessary to conduct other training programs both related to the use of AR-based media and other digital technologies for learning. The training can involve not only the teachers but also elementary school students so that both of them can have direct experience of joining training that focuses on harnessing digital technology for learning.

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