Augmented Reality Blended Learning Instruction: The Impact on Growing Motivation, Attitudes, and Knowledge in 3D Geometry

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Abstract: The COVID 19 pandemic promotes several new technological products to facilitate learning process. However, there are still few studies on the integration of Augmented Reality (AR) technology into Blended Learning (BL), particularly on the education of prospective mathematics teachers. This research examines the effect of using augmented reality blended learning during the COVID 19 epidemic on 3D geometry, as well as the learning motivation and attitudes. 15 prospective teachers, including 4 males and 11 females, at one of Indonesia's private universities were engaged in to determine how 3D geometry is understood. Data on learning motivation and attitudes were collected through questionnaires and interviews and analyzed using descriptive statistics and paired-samples t-test. The results show that during the COVID-19 pandemic, augmented reality blended learning facilitates the comprehension of 3D geometry knowledge by prospective teacher applicants and promotes learning motivation and attitudes. Therefore, the use of new technology is significant to prospective teachers' needs, especially during the COVID 19 pandemic, to facilitate their teaching practice in real classrooms.

Keywords: augmented reality, blended learning, knowledge of 3D geometry, learning motivation, learning attitude

1. Introduction

Blended learning (BL) is one of the approaches used in higher education to prepare potential teachers (PT) to become professionals (Caner, 2010; Vaughan & Lawrence, 2013; Yilmaz & Malone, 2020). This is because PT plays an important role in preparing future instruction for actual classes (Chookaew, Howimanporn, Sootkaneung, & Wongwatkit, 2017). PT educators' use of BL influences the increase in insight and direct knowledge of how it is successfully applied in learning (Chigeza & Halbert, 2014). Direct knowledge from BL is received through the face-to-face and online learning process (Graham, 2006). According to Kanchanachaya & Shinasharkey (2015), the use of BL simultaneously improves comprehension of teaching practice and concepts.

Several innovative items, such as Google and flipped classrooms, Edmodo, Moodle, and Augmented Reality (AR) technologies are used through BL in online learning (Bondarenko, Mantulenko, & Pikilnyak, 2018; Wichadee, 2017; Estacio & Raga Jr, 2017; Estacio & Raga Jr, 2017; Chen et al., 2017). AR is one of the new technologies used for online instruction, commonly applied in education to facilitate learning process within and outside the classroom (Coimbra, Cardoso, & Mateus, 2015; Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013; Ozdamli & Hursen, 2017; Sun, Wu, Fan, & Dong, 2019). This is because AR simultaneously combines digital information and physical objects. Moreover, it accurately identifies and creates new images of physical objects through a tablet or smartphone (Azuma, 1997). The new AR reality creates information, experience, knowledge, and comprehension of mathematical concepts from something abstract and difficult to understand, observe, or solve directly (Bower, Howe, McCredie, Robinson, & Grover, 2014; Dunleavy & Dede, 2014).

AR technology is useful for PT in the classroom, especially in higher education (Uygu, Yelken, & Akay, 2018). The AR application is very entertaining because it motivates and encourages PT learning (Uygu et al., 2018). According to Sudirman, Yanaiwati, Indrawan, & Melawaty (2020), the use of AR increases learning motivation and attitudes, as well as the understanding of geometric concepts. However, the AR application in the classroom faces various obstacles, such as inadequate infrastructure (Delello, 2014). Furthermore, it is time-
consuming when applied in the classroom, and teachers lack the competencies required to use this technology (Delello, 2014).

The use of AR is not new because it has been integrated into BL by several studies. For instance, Chen et al. (2017) integrated AR into BL to support science education's learning process. Moreover, Papanikolaou, Delianidi, & Ilioudis (2016) applied AR for primary school student learning. In line with this, Kusdiyanti, Nurrudin Zanky, & Prasetyo Wati (2020) used AR to enhance vocational high school students' performance. Pujiastuti & Haryadi (2020) also integrated AR in BL to improve the understanding of food security. However, there is still no study that uses AR in BL to assist the learning process in the education of prospective mathematics teachers. There are 3 significant innovations in the use of AR in BL in the study. First, AR is used as an application to help students in online learning. Second, the application helps PT to directly deepen the 3D geometry concept. Third, it provides a menu to test the understanding of 3D geometry.

This study provides an overview of the effect of using AR in BL on learning inspiration, attitudes, and knowledge of 3D geometry during COVID 19, based on the previous explanation.

2. Method
2.1. Research Design
This study used the quasi-experimental group pretest-posttest design to determine the impact of using Augmented Reality Blended Learning (ARBL) instruction on prospective teachers’ 3D geometry knowledge during COVID 19. The impact of using ARBL instruction was measured from the pre-test and post-test results. This is in line with Privitera & Ahlgrim-Delzell (2019), which stated that a quasi-experimental group pretest-posttest design only measures one set of dependent variables from the results of a given treatment.

2.2 Participants
This study used 15 participants from one of Indonesia's private universities, including 4 males (27%) and 11 females (73%) aged 18 to 21. They were asked to read and sign a permission statement before the study began and be active in the research process. A total of 15 Prospective Teacher’s, including 4 boys, 11 girls, and modified-21 years old, volunteered to engage in this study. Additionally, 2 universities, male and female, were recruited by 15 research participants for an in-depth inquiry via interviews. They were recruited because they were the most active and mastered how to use AR well. Also, they were highly motivated during the process of using ARBL instruction.

2.3 AR Design and Usage Procedure
3D geometry was the theme chosen (Cubes, Blocks, Prisms, Limas, Tubes, Cones, and Spheres). The subject is selected according to the university's syllabus. In AR, the subject to be studied is already available. The AR menu design consists of four menus. First menu is “Ayo Bermain AR”; second menu is “ethnomathematika”; third menu is “Ayo Belajar Geometri”; and the fourth menu is “evaluasi”.

On the menu, “Ayo Bermain AR” containing 16 AR animations in the form of local wisdom in Indonesia. One of them is “drum”, a 3D animation that is displayed in the form of a representation of a Baduy traditional house. Next will display a geometry object that resembles the shape of the drum. After displaying the tube object in the form of 3D, elements appear on the tube and its properties.
Material content to deepen the concept of geometry is available on the “Let's Learn Geometry” menu available in AR. There are 16 (sixteen) materials available, but in this study only on the topic of 3D geometry (Cubes, Prisms, Limas, Tubes, Cones, and Spheres) as shown in Figure 3.

![Fig. 3. Material Menu](image)

The content of the information provided through the video is designed according to prospective teachers' needs. Also, on the “evaluation” menu, to assess the level of prospective teachers' effective learning (see Figure 4). The test menu is conditionally set out. To be able to work on 3D geometry content assessment, prospective teachers' must be able to work on 2D geometry problems. In BL, the implementation of AR was conducted out for 7 meetings and was planned in two steps, adopting the characteristics of BL. Face-to - face learning is the first step, while AR-assisted learning is the second level. In Figure 5, this can be shown.

![Fig. 5. ARBL Instruction](image)
In the first stage, namely (1) conveying the learning objectives; (2) explain the material; (3) provide training; (4) check understanding and provide feedback; (5) provide independent training. This direct learning process was carried out for 3 meetings. In the first stage (1) Conveying the objectives and preparing of prospective teachers’ (PT) to use BL; (2) Explaining the material; (3) Giving the exercise; (4) Checking the understanding and giving feedback; (5) Giving autonomous exercise. This process lasted for three times of meetings.

For the second stage, the learning process was done by integrating AR. This process carried at PT’s home.

2.4 Collection of Data and Analysis

Data were collected using various approaches and tests to measure 3D geometry knowledge. The tests were given as descriptions with 10 items before and after the ARBL instruction. Questionnaires were then issued to 15 prospective teachers’ to determine the effect of learning motivation and attitudes. This report adopted a questionnaire by Di Serio, Ibáñez, & Kloos (2013) with minor changes in the dimensions of focus, importance, and trust based on learning motivation. Furthermore, on the learning attitude, this study adopted a questionnaire by Díaz-Noguera, Toledo-Morales, & Hervás-Gómez (2017), which includes the dimensions of relevance, satisfaction, reliability. The data processing also utilized interview methods in analysis. Interviews were conducted to explore in-depth PT information on learning motivation and attitudes after using ARBL instruction. The interviews involved questions on the obstacles in using ARBL, the advantages, and whether the participants felt inspired to teach their technical class using the technology.

The N-gain score \( g \) of Hake was used in the analysis to determine the improvement in knowledge of the 3D geometry of PT. A paired-samples t-test with SPSS 22 was used to statistically test the pre-test and post-test results. Furthermore, using the Method of Successive Interval (MSI), the ordinal data from the questionnaire effects of learning motivation and attitudes were translated into interval data. MSI is used to facilitate the study of descriptive data on the impact of motivation and behaviors after using ARBL instruction.

3. Results

3.1. Impact on 3D Geometry Knowledge

The impact of using ARBL instruction on 3D geometry knowledge is determined by increased knowledge using normalized gain. The descriptive statistical results of 3D geometry knowledge before (pre-test), after (post-test), and N-gain are in Table 1.

Table 1. Descriptive Statistics after N-Gain

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Value</th>
<th>N-gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>Minimum</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Maximum</td>
<td>70</td>
<td>90</td>
</tr>
</tbody>
</table>
The 3D geometry knowledge test results were given before and after learning. The calculation obtained an average pre-test and post-test of 55 and 71, as well as the variants of 107.14 and 200.71, respectively. Descriptively, Table 1 shows that the pre-test average is smaller than the post-test average. Additionally, the N-gain value of 0.517 obtained shows an increase in 3D geometry knowledge in the moderate category, implying the impact of using ARBL instruction. However, the significance of using ARBL was tested with the paired-sample t-test in Table 2.

**Table 2. Paired-Samples T-Test**

<table>
<thead>
<tr>
<th>Pair</th>
<th>Pre-Test - Post Test</th>
<th>Paired Differences</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Std. Error Mean</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-16.00</td>
<td>6.866</td>
<td>1.773</td>
<td>-9.025</td>
</tr>
</tbody>
</table>

Table 2 shows that the sig (2-tailed) value is 0.000 <0.05, indicating a significant impact on 3D geometry knowledge after using ARBL instruction.

**3.2. Impact on Motivation and Learning Attitudes**

A motivation questionnaire was given after learning activities during COVID 19. The questionnaire used a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree). The learning motivation was indicated by 3 dimensions, including attention, relevance, self-confidence. Each dimension is given 8 statements. The transformation of data conversion from ordinal to interval, using the Successive Interval (MSI) method produced the following description:

**Table 3. Learning Motivation Questionnaire Results**

<table>
<thead>
<tr>
<th>Average Total Score (%)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>61.29</td>
</tr>
<tr>
<td>Relevance</td>
<td>77.20</td>
</tr>
<tr>
<td>Confidence</td>
<td>69.72</td>
</tr>
<tr>
<td>Total</td>
<td>68.45</td>
</tr>
</tbody>
</table>

The level of motivation to learn prospective teachers after using ARBL instruction was in the high category, with an average score of 68.45%. The prospective teachers attention level in learning moderate, with an average score of 61.29%. Furthermore, the use of ARBL instruction fulfills the level of prospective teachers learning needs in the high category, with an average score of 77.20%. Therefore, learning ARBL instruction makes prospective teachers have self-confidence in carrying out tasks, falling in the high category with an average 69.72% score.

The attitude questionnaire was given after learning activities to 15 prospective teachers. The questionnaire used a Likert scale with five options (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree). The learning attitude was indicated by 3 aspects, including relevance, satisfaction, and reliability. The aspect of relevance and satisfaction comprised of 9 statements, while only 5 were used for reliability. The questionnaire consisted of 16 and 7 positive and negative questions, respectively. The conversion of data from ordinal into interval using the Method of Successive Interval (MSI) obtained the following descriptions:

**TABLE IV: LEARNING ATTITUDE QUESTIONNAIRE RESULTS**

<table>
<thead>
<tr>
<th>Average Total Score (%)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance</td>
<td>84.36</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>67.41</td>
</tr>
<tr>
<td>Reliability</td>
<td>67.08</td>
</tr>
<tr>
<td>Total</td>
<td>80.29</td>
</tr>
</tbody>
</table>

Prospective teachers attitudes towards ARBL instruction are in the high category, with an average 80.29% score. The questionnaire results show that the use of ARBL instruction is relevant to the needs of prospective teachers. It is used properly and adequately and is included in the very good category, with an average 84.36% score. Furthermore, prospective teachers satisfaction with ARBL instruction is included in the medium category, scoring 67.41% on average. The reliability aspect is in the medium category, with an average score of 67.08%.

**3.3. The Interview Data**

In-depth interviews were conducted (W) with one woman (P) and one male (L) prospective teachers. The interview subject was related to the learning experience when using ARBL instruction. The following is an example from the interview:
1. Female Prospective Teachers (P)

W: Have you ever participated in using Blended Learning?
P: I never practiced using Blended Learning.
W: Do you know about technology in augmented reality?
P: I did not realize what it was before the innovation of augmented reality.
W: What do you think about the ARBL that is being implemented during COVID 19 to help the learning process of Geometry?
P: In my experience, learning by using emerging tools was more practical and engaging in the period of COVID 19.
W: In the process of implementing AR in BL during COVID 19, did you encounter any obstacles?
P: My smartphone is connected to the problem because it has little memory storage. Therefore, I have to uninstall some files to install this program. Furthermore, there is weak internet connectivity, causing issues when viewing video content.
W: During COVID 19, does the use of AR in BL motivate you to participate in the learning process?
P: The implementation of new technologies is new, especially the use of AR in the learning process during COVID 19. It makes me feel involved in exploring the step of learning.
W: Do you feel inspired when you are a real educator to apply the use of new technologies?
P: I feel inspired. I will continue to use modern technologies in my competent classroom as I am a true teacher. I have to look first, though, at the conditions of the school where I teach.
W: Does ARBL expect you to pay attention to the learning process and observe it very well?
P: Yes, of course, but to me, that is different.
W: Does the use of ARBL help you learn the concept of 3D geometry?
P: Very useful since the menu in AR gives an animation that visualizes 3D geometry concepts. Many videos often explain geometry materials along with exercises. This will add to the expertise. I have learned from my 3D geometry.

2. Male Prospective Teachers (L)

W: Have you ever participated in using Blended Learning to learn?
L: Never, and I just got information about AR at this meeting.
W: Do you know about technology in augmented reality?
L: I already know about AR technology, but I do not know how to use it.
W: What do you think about the ARBL that is being implemented during COVID 19 to help the learning process of Geometry 3D?
L: I could feel the new sensation of learning to use AR applications with BL during COVID 19. The idea of designing Augmented Reality based learning in BL is very good. We are not only studying geometry but also knowing about new technologies, such as AR. Also, this new knowledge spurs PT to be more familiar with other technologies as a reference for making learning media.
W: In the process of implementing ARBL during COVID 19, did you encounter any obstacles?
L: The problem is accessing video material in this application. Internet data is required to view the video material.
W: During COVID 19, does the use of ARBL motivate you to participate in the learning process?
L: In my opinion, using Augmented Reality in BL during COVID 19 is quite good and interesting. This is because 21st-century teachers must adapt and use new technology.
W: Do you feel inspired when you are a real educator to apply the use of new technologies?
L: I am very motivated to follow every step related to the AR learning process in BL during COVID 19.
W: Does AR in BL expect you to pay attention to the learning process and observe it very well?
L: In my opinion, this study gives me more knowledge of 3D geometry and also provides real-time visualization of 3D geometry. It can be easier when I do 3D geometry exercises.
W: Does the use of AR in BL help you learn the concept of 3D geometry?
L: I am interested in making this application. I think this application is suitable for studying geometry 3D. Therefore, I am interested in using this application.

The interview results show several obstacles in the learning process during COVID 19. These include constraints in the prospective teachers smartphone specifications, limited memory, network access, and internet quota connectivity to images. Ultimately, Prospective Teachers provides a positive understanding of using ARBL instruction during COVID 19. This is because they believe that during COVID 19, the use of ARBL instruction makes learning more realistic, engaging, comfortable, and helps implement new sensations. Additionally, it helps them have motivation and a positive attitude. For instance, they study and understand the information discussed in this lesson. Prospective teachers enjoyed every learning process and thought the use of ARBL was a new experience that met their criteria. Also, the use of modern technologies in research makes universities interested and encouraged to apply it in their professional classes.
4. Discussion

According to this research, most prospective teachers did not know about the new technology developments, such as Augmented Reality (AR). This is because AR technology is relatively new and has not been widely integrated into the geometry class (Nincarean, Alia, Halim, & Rahman, 2013; Vargas, Fabregat, Carrillo-Ramos, & Jové, 2020). However, in the past decade, there has been increased interest in implementing AR in education (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014). The increase is insignificant because there are many obstacles in integrating AR into learning. These constraints are due to infrastructural factors, such as access and mobile phone specifications. In support of these findings, Delello (2014) stated that integrating AR into the classroom is challenging. This is because the use of AR may take time, and teachers may be unskilled in using the technology, or it could be hindered by inadequate infrastructure.

According to other prospective teachers interview results, the use of AR in BL during COVID 19 makes learning more interactive and presents new sensations. The interaction effect between prospective teachers allows them to feel the application of technology in learning. These results support other international research findings that the use of AR presents interactive learning. This is because it presents more tangible objects, and it is attractively designed. Moreover, AR is friendly and able to be supplemented with instruction (Syawaludin, Rintayati, & Subiyantoro, 2020). According to Uygur et al. (2018), AR applications are very entertaining, motivating, and facilitate learning.

The AR integration into BL positively affects prospective teachers motivation and learning attitudes. These findings confirm Chookaew et al. (2017), which stated that AR-based learning motivated to build teaching materials, helping them prepare as prospective teachers. Also, Uygur et al. (2018) stated that the use of AR technology motivates and facilitates learning for prospective teachers. These results are in line with previous studies, which found that the integration of AR technology with local wisdom increases PSMT learning (Sudirman, Yaniawati, Indrawan, & Melawaty, 2020).

The use of AR integration into BL impacts prospective teachers positive attitude. In line with this, Díaz-Noguera et al. (2017) stated that there was a change in PT attitudes towards AR by using ICT in learning. This positive attitude is seen when PTs are actively involved in learning complex topics. Furthermore, they participate in designing and making multimedia material proposed in the learning module (Díaz-Noguera et al., 2017). Prospective teachers positive attitude is because the AR applications are able to integrate virtual aspects, such as animations and 3D geometric shapes, into real environments (Sudirman et al., 2020). Therefore, according to Díaz-Noguera et al. (2017), PST must develop a positive attitude towards the use of AR applications as learning tools. This is because they relate to their role as future teachers adaptive to technological developments.

5. Conclusion

This article describes the impact of using ARBL instruction during COVID 19. The findings show that the use of ARBL instruction increases knowledge of 3D geometry, as well as the learning motivation and attitudes of prospective teachers during COVID 19. Their impact is proved by active involvement at each learning stage. Additionally, the relevance dimension is one of the most dominant aspects affecting the prospective teachers 3D geometry knowledge, motivation, and learning attitudes. According to prospective teachers, the use of new technology-based learning, such as AR or BL, is relevant to their need to become future teachers adaptive to new technological developments. Prospective teachers should practice various new technologies to support its teaching practice in professional classes. However, the use of new technologies, such as AR, is not easy to implement in the classroom. Therefore, support in terms of facilities and infrastructure is significant in the successful application of AR technology. Moreover, AR technology's successful classroom application requires training in designing and integrating various subjects, especially mathematics.

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