PAPER

Augmented Reality Solutions by Utilizing Mobile Technology for Enhanced Skill Development

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ABSTRACT

This study aimed to identify the effectiveness of the peer tutorial project learning model assisted by augmented reality (AR) in improving students' 21st-century skills. The focus of the study was to describe the improvement in students' skills taught using the AR-assisted project and peer tutoring-based learning (PPTBL) model, with an emphasis on four main abilities: critical thinking, creativity, collaboration, and communication. This study involved a comparison between a control group and an experimental group to measure the effectiveness of the learning model. The study results showed that the average critical thinking skills reached 81%, creativity 77%, collaboration 73%, and communication 74%. Data analysis showed that the hypothesis stating that there was a significant difference in 4C skills between students who study with the AR-assisted PPTBL model and those who study with the conventional learning model was accepted at a significance level of 5% (0.05). These findings were expected to make a significant contribution to the development of innovative learning methods that can be widely applied in higher education institutions.

KEYWORDS

project learning model, peer tutorial, augmented reality (AR), 21st-century skills, project and peer tutoring-based learning (PPTBL)

1   INTRODUCTION

The development of technology and information makes competition for basic human resource capabilities very important. Industry wants human resources to have skills not only in the ability to complete work with hard skills but also to have skills as creative people who can contribute critical thinking to the industry in which they work [1]. This should be a concern for universities to improve the education system to be able to produce potential workers who have soft skills and hard skills [2]. However, currently, the issue of the increasingly low competency of university graduates is increasingly being discussed. In recent years, student skills in 21st-century human competencies have become a major concern in the field of

education [3]. Skills such as critical thinking, creativity, collaboration, and digital literacy are increasingly important to ensure students are ready to face the challenges of the ever-evolving world of work [4]. However, various studies show that there are still many students who do not have these skills adequately. Since the beginning of the 21st century, the integration of technology in education has become a research topic that has attracted the attention of many scholars [5]. According to constructivism theory, active and collaborative learning can improve 21st-century skills [6]. Therefore, learning models that utilize advanced technology, such as augmented reality (AR), are considered to be able to provide a more interactive and in-depth learning experience [7]. AR has been applied in fields such as mechanical engineering, civil engineering, and architecture, providing 3D visual insights into mechanical loads, heat distribution, and building systems. In the educational context, AR information technology has been proven to improve learning outcomes by replacing traditional material with virtual elements [8]. The current scenario shows that the technological efficiency and innovation of teaching are still at a moderate level [9]. Therefore, one of the main advantages of AR is its ability to integrate design, reality, and engineering, which can be the basis for understanding processes in depth [10]. Compared to many virtual reality devices, AR devices tend to be lighter, more portable, and affordable, often using smartphones and tablets [11]. Additionally, because it allows the visualization of virtual elements in the real world, AR can be used in interactive experiences between people, encouraging collaboration and social interaction in educational or recreational activities.

A learning model is a systematic procedure for organizing learning experiences to achieve learning goals, but it can also be interpreted as an approach taken in learning activities [12]. The learning model must be appropriate to the learning conditions that will be implemented [13]. Because a good learning model will be adjusted to the learning objectives and look at the effectiveness of learning so that in its implementation it will be right on target and the learning objectives will be achieved [14]. Understanding how AR-assisted peer tutorial project-based learning models can enhance 21st-century skills is critical to ensuring students are ready to face the challenges of the future [11]. This study seeks to provide new insights into learning approaches that can benefit students and educational institutions. This study has the potential to inform policy and practice in the field of higher education, particularly in the development of curricula that are relevant to the needs of the 21st century.

This study aimed to identify the effectiveness of the AR-assisted peer tutorial project learning model in improving 21st-century skills in students. By describing student skills that have been taught using the AR-assisted project and peer tutoring-based learning (PPTBL) model with 4 main abilities, namely critical thinking, creativity, collaboration, and communication. This study also presents the results of the effectiveness of using the AR-assisted PPTBL model by comparing the control and experimental groups. This study hopes to make a significant contribution to the development of innovative learning methods that can be widely applied in higher education institutions.

2   METHOD

2.1   Method and type of research

The research method used to identify the effectiveness of implementing the AR-assisted peer tutorial project learning model was carried out by descriptive

analysis of the abilities of experimental group students who had learned using the AR-assisted PPTBL model. In the initial stage of the study, a literature review was carried out to collect information from the results of similar research; the data was presented descriptively. Following the problems stated previously, this study is descriptive-comparative to compare two different sample groups.

2.2 Population and sample

The population in this study were students in the computer networks course at the PTIK IKIP PGRI Pontianak study program, totaling 8 classes with a total of 117 students. A sample is a part of a population that represents or reflects the population. In this study, the technique used in sampling was purposive random sampling, with the consideration of taking two classes to represent the population. One class was for the experimental group with 18 people and one class for the control group with a sample size of 21 people.

2.3 Instruments/data collection tools

The data collection tool used a Likert scale questionnaire to measure 21st-century attitudes and skills, namely critical thinking, creativity, communication, and collaboration. The Likert scale was used to measure the attitudes, opinions, and perceptions of a person or group of people about social phenomena.

2.4 Data analysis technique

Because this study looks at whether or not there is a comparison of the 4C skills of students with different numbers, to prove the significance of the differences, a statistical test with an independent sample t-test was used because the values being compared have no relationship between one variable and another variable using the formula used, which is as follows:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\dfrac{(n_1 - 1)\, S_1^2 + (n_2 - 1)\, S_2^2}{n_1 + n_2 - 2} \left(\dfrac{1}{n_1} + \dfrac{1}{n_2} \right)}}$$

Information:

$\overline{X}_1$ = Sample Mean 1
$\overline{X}_2$ = Sample Mean 2
S_1 = Sample Standard Deviation 1
S_2 = Sample Standard Deviation 2
S_1^2 = Sample Variance 1
S_2^2 = Sample Variance 2
r = correlation between two samples

If the calculation results using this formula produce a t value equal to or greater than the critical value t listed in the table ($t_{count} \geq t_{table}$), in accordance with the specified significance level, namely 5% ($\alpha = 0.05$), then it was concluded that there was

a convincing difference between the two groups. However, if from the calculation it turns out that the t value is smaller than the critical value in the table ($t_{count} \leq t_{table}$), in accordance with the significance level that has been determined, namely 5% ($\alpha = 0.05$), then it can be concluded that there is no convincing difference.

2.5 Hypothesis

If $t_{count} > t_{table}$: There are differences in the 4C skills of students who study with the AR-assisted PPTBL model.

If $t_{count} < t_{table}$ = There is no difference in the 4C skills of students who study with the AR-assisted PPTBL model.

3 RESULTS

3.1 4C skills

The results of the analysis from distributing questionnaires to experimental group students to measure students' 4C skills can be seen in Tables 1, 2, 3, and 4 for each skill, namely critical thinking, creativity, collaboration, and communication:

Table 1. Critical thinking skill

No	Indicator	N	f	%
1	Students analyze the problems they face	18	15	83
2	Students focus on the problems they face	18	13	72
3	Students look for accurate information to reveal facts	18	14	78
4	Students convey accurate information according to facts	18	16	89
5	Students are able to provide opinions from different points of view	18	17	94
6	Students provide alternative solutions to the problem that is the topic of discussion	18	15	83
7	Students solve the problems they face	18	15	83
8	Students choose the right solution to solve the problem they are facing	18	11	61
	Average value			81

Based on data analysis of students' abilities after implementing learning using the PPTBL model, it is known that 82% of students are generally able to understand and deconstruct the problems they face. This means they can identify important elements and break down the problem into smaller parts for analysis [15]. Focusing the problem on a score of 72%, this percentage is lower. Showed that although students can analyze problems, they sometimes have difficulty determining which aspects of the problem are most important to focus on. This is important to ensure that problem-solving efforts are targeted and effective [16]. The ability to find accurate information is 78%, meaning that students were quite good at

finding relevant and accurate information to understand the facts related to the problem. However, there is still room for improvement in ensuring all information collected is truly appropriate and useful. The ability to convey accurate information is 89%; students are very effective in conveying the information they have collected accurately. This demonstrates strong communication skills and ensures that all team members or audiences get a clear and correct understanding. The ability to provide diverse opinions is 94%, which means that students are very good at considering various points of view when providing opinions. This is important to gain a more comprehensive picture of the problem and its potential for innovative solutions [17]. The ability to provide alternative solutions is 83%, which means that students are generally able to produce various alternative solutions to the problems discussed. This shows creativity and flexibility in thinking to find various ways to solve problems [3]. The ability to solve problems is 83%, which means that students have a strong ability to solve the problems they face. This shows that they can effectively implement the solutions they identify [18]. The ability to choose the right solution is 61%, which means that students often have difficulty choosing the most appropriate solution to solve problems. This may be due to inexperience, incomplete information, or an inability to critically evaluate options [19]. Virtual reality-based instructional materials are more realistic and immersive than traditional educational materials [20].

Overall, this assessment shows that students have good skills in analyzing and solving problems, as well as communicating and providing diverse views. However, they need to improve their skills in focusing on problems and selecting the most appropriate solutions to improve their overall problem-solving effectiveness. Critical thinking is an activity that implements rational and high-level thinking activities whose activities are carrying out analysis, synthesis, recognizing problems equipped with solutions, and inferring and evaluating them [15].

Table 2. Creativity skill

No	Indicator	N	f	%
9	Students produce varied ideas	18	14	78
10	Students see a problem from different points of view	18	13	72
11	Students think of unique ways to express themselves	18	12	67
12	Students have a strong will to complete assignments	18	15	83
13	Students are critical in checking the results of their work	18	17	94
14	Students respond to suggestions actively	18	12	67
	Average value			77

Assessment of student skills shows several interesting findings. It was found that 78% of students were able to produce varied ideas, showing creative abilities in thinking and developing new ideas. However, only 72% of students were able to see a problem from different points of view, indicating that there is room to improve their ability to broaden their perspective when dealing with problems. This is important to ensure holistic and diverse solutions can be considered [21]. Apart from that, only 67% of students were able to think of unique ways to express themselves. This suggests a need to encourage students to think beyond conventional boundaries and

explore different methods of expression [22]. The willingness to complete assignments appears to be quite high, with 83% of students demonstrating this ability. This reflects the strong level of motivation and determination among students in completing their work. Furthermore, it was found that 94% of students had critical skills in checking work results. This shows that they can evaluate the quality of their work objectively and make improvements if necessary [23]. However, only 67% of students responded actively to suggestions, indicating that there is potential to increase responsiveness to feedback and suggestions from others. This is an important aspect of self-development and improving the quality of work. Overall, these findings underscore the importance of developing creative skills, flexibility, motivation, critical thinking, and responsiveness to feedback among students [24]. By strengthening and expanding these skills, students will be better prepared to face challenges in the academic and professional worlds [25]. Creativity is the ability to think, which shows originality, fluency, and ease in making adjustments and elaborating an idea [26].

Table 3. Collaboration skill

No	Indicator	N	f	%
15	Students accept joint decisions	18	11	61
16	Mahasiswa melaksanakan keputusan bersama	18	14	78
17	Mahasiswa menghargai perbedaan pandangan	18	12	67
18	Mahasiswa menerima saran yang diberikan orang lain untuk kebaikan bersama	18	15	83
19	Mahasiswa fleksibel dalam bekerja sama	18	15	83
20	Mahasiswa berkompromi dalam menyelesaikan masalah	18	12	67
	Average value			73

The results of assessing students' teamwork skills revealed several important findings. It was found that only 61% of students were able to accept collective decisions, indicating that there are challenges in adopting decisions produced collectively. This highlights the importance of developing the ability to work collaboratively and valuing the contributions of all team members [27]. However, 78% of students were able to implement joint decisions, indicating that they tend to be more effective in implementing decisions that have been made together. This indicates that although there may be difficulties in accepting joint decisions, they can adapt and contribute to their implementation [28]. It was also found that only 67% of students respect differences in views, indicating there is room to increase tolerance for different points of view. This is important in building an inclusive and collaborative environment where all voices are valued. Regarding accepting suggestions from others for the common good, 83% of students demonstrated this ability. This reflects an open and responsive attitude to the feedback provided, which is an important aspect of effective collaboration. In addition, 83% of students were also considered flexible in working together, demonstrating their ability to adapt to change and overcome challenges in the context of teamwork. [29]. However, only 67% of students were willing to compromise in solving problems, highlighting the importance of developing the ability to reach mutually beneficial agreements for all parties involved. Overall, this assessment highlights the importance of developing collaboration and cooperation skills among students [30]. By improving their ability to accept joint decisions, respect differences of opinion, and be willing to

compromise, they will become more effective in working in teams and achieving common goals efficiently. Collaboration is the coordinated involvement of each individual in solving a problem together [31] [32].

Table 4. Communication skill

No	Indicator	N	f	%
21	Students open themselves to the person they are talking to	18	11	61
22	Students respond well to the person they are talking to	18	14	78
23	Students are not carried away by the feelings of the other person they are talking to	18	14	78
24	Students understand what the interlocutor feels	18	15	83
25	Students do not judge the words conveyed by the interlocutor	18	16	89
26	Students give positive assessments to the person they are talking to	18	15	83
27	Students express opinions by paying attention to the feelings of the interlocutor	18	11	61
28	Students accept themselves as people of value to the person they are talking to	18	12	67
29	Students treat their interlocutors well	18	14	78
30	Students respect differences of opinion	18	11	61
Average value				74

In communication interactions, assessing student skills shows some aspects that need to be considered. It was found that only 61% of students were able to open themselves to the person they were talking to, indicating difficulties in being open and responsive to different ideas or opinions. This highlights the importance of developing the ability to be more inclusive in listening and accepting different points of view. However, 78% of students were able to respond well to the person they were talking to, indicating that they tend to be effective in responding to questions or comments appropriately and politely. Apart from that, 78% of students were also assessed as not being carried away by the feelings of the person they were talking to, showing their ability to remain objective and focus on the substance of the conversation. It was also found that 83% of students were able to understand what the other person was feeling, showing a good level of empathy in the communication process. This is important to build a mutually beneficial and supportive relationship between speaker and listener. In addition, 89% of students did not judge the words conveyed by the person they were talking to, showing an open attitude and tolerance towards various points of view. This reflects awareness of the importance of respecting and appreciating differences of opinion [33]. However, only 61% of students were able to express opinions by paying attention to the feelings of the interlocutor, indicating the need to pay more attention to sensitivity to the interlocutor's reactions or responses. In addition, 67% of students accepted themselves as a person of value to the person they were talking to, highlighting the importance of developing a strong sense of self-worth in communication interactions. Regarding the treatment of the interlocutor, 78% of students were assessed as being able to treat the interlocutor well, demonstrating their ability to interact politely and respectfully.

However, only 61% of students show respect for differences of opinion, highlighting the importance of paying more attention to and respecting diversity in ideas and views. Overall, these findings demonstrate the importance of developing effective communication skills and sensitivity to the needs and feelings of interlocutors. By improving their ability to open up, respond well, understand, respect, and treat the person they are talking to well, students will become more effective in communicating and building strong and positive interpersonal relationships. Communication is a process of conveying information or messages related to a thought or feeling [4].

Based on the results of research data analysis, students stated that the PPTBL model assisted by AR media could improve learning outcomes, critical thinking skills, creativity, collaboration, and communication. The results of this study support the results of previous research, which stated that the application of AR-based learning media can improve learning outcomes and 4C skills. Innovation is very necessary in developing learning media to overcome the shortcomings that occur. One of them is creating learning media software that can be used on cell phones with the Android operating system [5]. Lecturers are expected to make students understand the material presented. This can happen if it is supported by an effective learning process. Therefore, lecturers are needed who are experts in their field and do not forget the information that will be conveyed [34]. During the learning process, the lecturer explains the material by giving examples, and sometimes several things are missed in the presentation [35]. If this happens, the lecturer must repeat explaining the material in the teaching and learning process. To overcome this problem, students can be presented with learning media in the form of moving images in three dimensions (3D) or 2D so that it looks as if the images displayed are real. This can be done by developing learning tools based on AR [8] [36]. This follows the results of previous research, which concluded that AR technology can be implemented well on smartphones that have the Android operating system.

Augmented reality makes it possible to combine real objects with virtual ones and superimpose appropriate information into the surrounding environment [36]. Other research results also concluded that research subjects were satisfied and motivated by the new methodology used, as well as AR technology, which could help improve academic achievement [37]. Based on the description of the PjBL and peer tutoring models and AR media, researchers are interested in developing a PPTBL model assisted by AR. The AR-assisted PPTBL model that will be developed is expected to improve student learning outcomes in the computer networks course at the IKIP PGRI Pontianak ICT education study program. Apart from improving student learning outcomes, the implementation of PPTBL is also expected to improve students' 4C skills. The 4C skills are critical thinking, creativity, collaboration, and communication. 4C skills are needed in the 21st-century learning process and the era of the Industrial Revolution 4.0. Critical thinking is an activity that implements rational and high-level thinking activities, the activities of which are carrying out analysis, synthesis, recognizing problems with solutions, and inferring and evaluating them. [15]. Creativity is the ability to think, which shows originality, fluency, and ease in making adjustments and elaborating an idea [22]. Collaboration is the coordinated involvement of each individual in solving a problem together [38]. Communication is a process of conveying information or messages related to a thought or feeling [39].

3.2 Hypothesis testing

The hypothesis test in this study is to prove whether there is a difference in 4C skills between students who study using the AR-assisted PPTBL model and students

who do not study using this model. It is known that the two samples in each group have different amounts $n_1 \neq n_2$. There were 18 students in the experimental group, while there were 21 students in the control group, and it was also known that the two variant groups had homogeneous variants. So based on these considerations, the t-test analysis used in this study is the t-test with the pooled variance statistical type. The results of the pooled variance t test show that the calculated t_{count} for equal variances assumed (data is assumed to have homogeneous variance) is equal to 1.137, while the t_{table} value for the DF 37 provisions at the 5% significance level is equal to (8.021). Thus the price $t_{count} < t_{table}$ (1.137 < 8.021). This proves that the hypothesis states that there is a difference in 4C skills between students who study using the AR-assisted PPTBL model and students who study using the AR-assisted PPTBL model, which is accepted at the level of significance of 5% (0.05).

Study shows that the PjBL and peer tutor learning models have a significant positive impact on various student skills. PjBL increases students' self-confidence (self-efficacy), which reflects their belief in their ability to succeed in learning tasks. Additionally, the PjBL model is effective in improving students' communication skills, which are essential for success in academic and professional environments. This model also improves students' collaboration skills, which are important for working in teams and are in the excellent category in collaboration assessments. PjBL significantly improves students' critical thinking abilities, an important skill that allows students to analyze information and make informed decisions. Student creativity also gets a positive boost through the use of the PjBL model, which encourages innovative thinking and creative solutions to problems. A study shows that the use of technology in learning can significantly increase student engagement and learning outcomes. Recent survey results reveal that 65% of students feel that conventional learning methods are less effective in developing 21st-century skills [18]. Despite much study on the integration of technology in learning, there is still little understanding of how project-based learning models with AR-assisted peer tutorials can effectively improve 21st-century skills [10].

Previous research focused more on the use of technology in general but paid less attention to the interaction between project-based learning, peer tutorials, and AR in the context of 21st-century skills development. Apart from PjBL, the peer tutor learning model also provides significant benefits. Peer tutoring improves students' critical thinking skills, enabling them to better analyze and evaluate information [40]. This model also has a significant impact on students' self-confidence, helping them feel more confident in their academic abilities. Students' communication skills also improve with the implementation of the peer tutor model because they are encouraged to interact and discuss with their peers. This increased discussion and communication also strengthens teamwork skills, which are essential in a collaborative learning environment. Student creativity also benefits from the peer tutor model, which encourages them to think outside the box and generate new ideas. Student learning outcomes also improve through this model, which shows that this method not only improves cognitive skills but also academic achievement [41]. Overall, these two learning models, PjBL and peer tutor, have proven to be effective in developing various important skills in students. Skills such as critical thinking, creativity, communication, collaboration, and self-confidence are essential in the modern learning environment and professional world. PjBL and peer tutors offer a holistic and integrated learning approach that not only focuses on increasing academic knowledge but also developing broader skills needed in real life. These skill enhancements not only help students in the academic environment but also prepare them for future challenges, both in their careers and personal lives [42]. By integrating these models into the curriculum, educators can provide richer and more rewarding learning experiences for

students [43]. The PjBL and peer tutor models also support more active and participatory learning, where students not only receive information but also participate in the learning process itself. This helps build greater engagement and motivation among students, which in turn can improve learning outcomes and academic achievement.

4 CONCLUSION

Overall, the study results show a fairly complete picture of students' skills and attitudes in using project learning with peer tutors assisted by AR. Improved skills range from problem solving and teamwork to communication interactions. The following is a summary of the main findings, namely that students generally have good abilities in analyzing problems, providing alternative solutions, and solving problems. However, there is still a need to improve the ability to focus on problems and choose the most appropriate solutions. Students tend to be effective in implementing joint decisions and flexible in working together. However, there are challenges in accepting joint decisions and compromising in resolving problems. There is also room to increase tolerance for differing views and respect for the contributions of each team member. Students are generally able to respond well and treat the person they are talking to politely. They also tend not to get carried away by the feelings of the person they are talking to and understand what they are feeling. However, there is still room to improve the ability to open up to the person you are talking to, express your opinion by paying attention to their feelings, and respect differences of opinion. Overall, these findings highlight the importance of developing holistic skills and attitudes among students, including problem-solving abilities, teamwork, and communication interactions. By improving these skills, students will become better prepared to face challenges in the academic and professional world and build healthy and productive relationships with others.

5 FUNDING STATEMENT

6 REFERENCES

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