LITERATURE STUDY OF AUGMENTED REALITY (AR) MEDIA UTILIZATION FOR DEVELOPING CRITICAL AND CREATIVE THINKING SKILLS OF VOCATIONAL HIGH SCHOOL STUDENTS

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Abstract

Augmented reality (AR) technology is a technology that combines two-dimensional and or three-dimensional virtual objects into a real environment and then projects these virtual objects in reality in real time. The application of AR technology has been implemented in the sectors/fields of shopping and retail, business, social media, gaming, health, social community, military, arts, tourism, broadcasting, industry, and especially vocational education. This research is a literature study, which uses secondary data obtained by embracing and reviewing several research articles related to the use of AR technology media. It aims to describe and interpreted information related to the use of AR media on the development of critical and creative thinking skills in vocational education. It uses descriptive qualitative methods, with the stages including data collection, data reduction, data display, and conclusion drawing. In this study, articles are gathered and selected by using keywords including interactive media, augmented reality, vocational education, critical and creative thinking. As a result, as many as 996 data from 20 articles related to the use of AR media were reviewed. From the results of the literature study, it can be concluded that the use of AR medical technology is effective in developing critical and creative thinking skills of the students of vocational education.

Keywords: Augmented Reality, Critical and Creative Thinking, Vocational Education

INTRODUCTION

Educational programs at the higher education level aim to prepare personnel who can establish expertise and skills in their fields and are ready to work and compete globally (Liu et al., 2020). In general, vocational education aims to prepare students to become members of the community, who have the ability of professional experts in applying, developing, and disseminating technology and/or arts as well as seeking their use to improve people's lives and enrich national culture (Billett, 2011). The development of technology is a development that is able to become a learning aid that is an attraction and understanding that can be more accepted by students (Sudarsana et al., 2019). Students with traditional thinking have difficulty understanding and mastering the training material because they cannot understand and study a phenomenon without visualizing it (Schunk, 2012). According Rizaldi et al. (2020) to the impact of technological improvements in the 21st century led to increased competence in the world of work. The 21st century learning is expected to improve students' learning skills. In the 21st century education, students are expected to have 4Cs skills (creativity, critical thinking,

collaboration, and communication) in facing the era of knowledge in the 21st century (Xu et al., 2019).

Critical thinking is defined as thinking precisely and systematically and following the rules of logic and scientific reasoning, while creativity involves the emergence of new and useful ideas (Leest & Wolbers, 2021). Critical thinking skills include the ability to access, analyze, and synthesize information that can be learned, trained, and mastered. Critical thinking skills are self-regulation in decision-making that will result in interpretation, analysis, evaluation, conclusions, and explanations from eventful, conceptual, methodological, criteriological, and contextual considerations that underlie that thinking (Facione, 1992). Critical and creative thinking has positive implications for students with innovative learning strategies (Chan, 2013). Critical thinking can be developed while solving tasks or problems in a particular domain when students need to apply analytical, selective, evaluative, and rule-based skills. Creative thinking is usually more than a specific context or domain; it is imaginative, generative, spontaneous, inventive, and non-evaluative (Shubina & Kulakli, 2019). Complementary approaches promote the idea of teaching critical thinking and creative skills as interrelated cognitive abilities (Hidayat et al., 2019). The challenge of teaching critical thinking skills and team skills through various pedagogical active learning methods suggests that critical thinking skills should be learned by actively involving students in information inquiry in learning-centered activities, class discussions, collaborative projects, and case projects (Garcia-Souto et al., 2017). Critical and creative thinking skills are considered important by many researchers (Browne et al., 1998), and according to Fauziah (2013), students must learn to be wiser about what they study for developing their skills in problem-solving. The main aim of developing critical and creative thinking skills in students is to prepare them to succeed in the future; and thereby improve their quality of life. According to the wedge between critical and creative thinking can be seen in Figure 1.
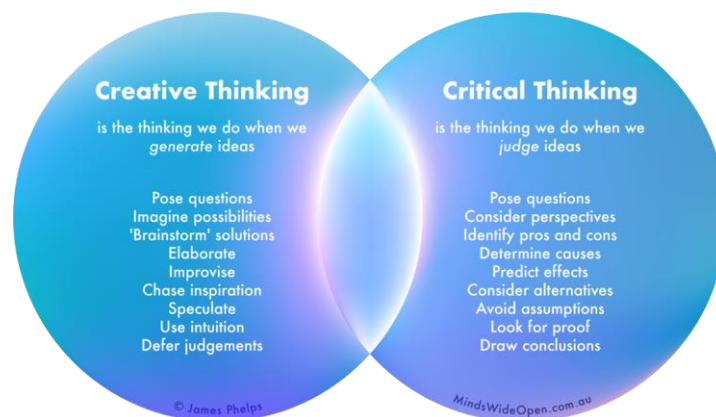
Figure 1: The Relationship between Critical and Creative Thinking

A competition that occurs in the 21st century also fosters competition among nations in the world, thus demanding the development of the quality of human resources (Vegas et al., 2000). The use of interesting and varied learning methods and media is one of the efforts that can be made by teachers to overcome these problems. An example of an effort that can be done is by

visualizing the material by utilizing ICT media in the form of 2D/3D, graphics, and audio. Audio visual presentation will make the visualization of the material more interesting for students (Nicolaou et al., 2019). Therefore, students and teachers can access information independently and carry out teaching activities to improve students' high-level creative thinking in their respective places (Yazar Soyadı, 2015). Teaching by utilizing this technology has a significant effect on the learning process and can help support students in an effort to improve critical and creative thinking skills, because students' ability to formulate and analyze has increased after studying and observing the media-assisted experiment, so that they are more facilitated in understanding the material and concepts.

Augmented reality (AR) is a combination of real and virtual objects in a real environment, running interactively in real time, and there is integration between objects in three dimensions, namely virtual objects are integrated in the real world (Molnár et al., 2018). Merging real and virtual objects is possible with appropriate display technologies, and interactivity is possible through certain input devices, and good integration requires effective tracking. According to (Krichenbauer et al., 2014), one of the challenges for education is to propose several solutions in learning to prepare mature and professional learning media using AR media. The development of AR technology is starting to be used in education that is integrated with technology so that students are able to learn a topic more quickly and easily (Yaman & Karakose, 2016).

AR is very relevant and feasible to be applied in vocational education because AR applications allow a faster understanding of complex spatial problems so that it provides students with great benefits during the learning process (Chen et al., 2011). AR technology, according to Mendoza et al. (2019), as an educational support process from research results shows that students show high interest and motivation. According to Brilian et al. (2020) using AR technology is suitable to be developed for vocational education to adapt learning in the Industrial Revolution 4.0 era related to education management, in terms of planning, implementation, and evaluation carried out effectively and efficiently as possible; overcoming the limitations of distance and time; improving the clarity of the material; developing students' imagination; providing a realistic picture and 3D display which can be delivered quickly and easily remembered; and fostering interest and motivation to learn.

According to Delić et al. (2014), the development of AR in vocational education can be conducted to achieve certain goals and functions so as to provide students with a positive view. AR technology in vocational education can work closely with argonomists, psychologists, and teachers who work closely together to form skills and competencies that reflect and have a positive impact on students (Dr. L. Mekacher, 2019).

Learning research in this era uses advanced technology such as the use of AR media for the learning process, especially in vocational education. However, there are various purposes for using AR media in the vocational education learning process, one of which is an effort to improve students' critical and creative thinking skills. Therefore, it is necessary to know the impact of the use of AR media on the improvement of students' critical and creative thinking skills by looking at the results of previous studies related to the use of AR media. It is expected

that the results of this study can provide teachers and prospective teachers an overview regarding the use of media in AR learning in vocational education by utilizing increasingly sophisticated technology. Based on the description above, this study aims to describe and interpret relevant information regarding the use of AR media to increase critical and creative thinking skills of the students of vocational schools.

METHODS

This research is a literature study that collected data and information from various related scientific sources. The data used are secondary data. The data sources are national and international journals that can be accounted for, related to the use of AR media to improve critical and creative thinking skills of the students of vocational high schools, and also several web pages on the Internet.

This study uses a qualitative approach, by which descriptive data are generated from several journals obtained. The stages of data analysis in qualitative research according to Miles and Huberman (1992:20) are as follows
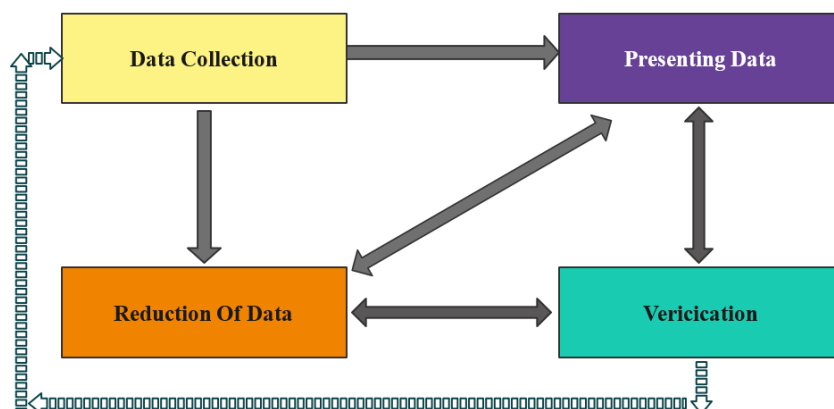
Figure 2: The Model of Qualitative Research Analysis (Miles and Huberman, 1992)

The first stage in qualitative data analysis is collecting data in the field, which can be done by conducting experiments or by conducting a journal review to obtain data and information needed in research.

The second stage is data reduction, by summarizing, selecting points, and focusing the discussion so that the data obtained has a clearer picture and makes it easier for researchers. The third stage is the data presentation, by presenting a narrative text in the form of a brief description that displays the relationship between subjects and the like.

The fourth and last stage is drawing conclusions and verification. The analysis begins by reviewing all data collected from various sources such as interview notes, observation transcriptions, field scripts, and pictures or photographs. During the process of qualitative data

analysis, there are important components, namely, data reduction, data presentation, and conclusion respectively.

DISCUSSION AND RESULT

Augmented reality (AR) media is a learning media in the form of visual technology, consisting of pictures of events that can display 2D to 3D images, with which students are given a natural phenomenon to identify existing problems in groups, and from the problems given, they will make observations using AR media.

Furthermore, students formulate explanations through discussion and conduct analysis through question and answer. It is proven that AR technology fosters student motivation (Khan et al., 2019). Connected verbal and visual information helps students make connections, understand relationships, and recall related details (Kraut & Jeknić, 2015). With AR media, students can improve their intellectual abilities in building and understanding the meaning of the displayed image, which is a form of critical and creative thinking process.

This shows that AR media can help improve students' critical and creative thinking skills. The use of AR media is also considered efficient because it can be used any time by students, both during learning at school and when carrying out independent teach at home (Anggraini et al., 2020). The criteria related to critical thinking skills according to Ennis (1989) are presented in Table 1.

Table 1: Indicators of Critical Thinking Skills

| Critical Thinking Skills	Sub-components of Critical Thinking Skills
1. Providing elementary clarification	• focusing questions • analyzing argumentation • asking, answering, clarifying, and challenging questions
2. Building basic support	• considering credibility (criteria of a source) • observing and considering the results of observations
3. Inferring	• making deductions and considering the results • making and considering induction • making and considering the value of the decision
4. Making advanced clarification	• defining terms • identifying assumptions
5. Strategies and tactics	• deciding on an action • interacting with other people

Generally, creative thinking is correlated to critical thinking. There are three dimensions of creative thinking: synthesising, articulation, and imagination as shown in Table 2 below.

### Table 2: Creative thinking correlated to critical thinking

Critical Thinking Correlated to Creativity	Description
Synthesizing	This dimension includes various activities such as getting benefits from analogous thinking, deducing original results from small parts, and presenting novel and authentic suggestions for the solution of the problem.
Articulation	It involves forming old and new knowledge or expanding the current knowledge with the help of the new one, constructing unusual relationships to produce authentic solutions and making thoughts concrete with the help of imagination and use of the materials.
Imagination	This dimension consists of constructing relationships between valid and reliable thoughts, presenting flexible ways of thought with the help of imagination, to come up with different insights during idea producing processes.

The application of AR technology has also researched by scientists in the field of vocational education. There are 996 articles with keywords augmented reality, vocational education, and critical and creative thinking. To find out research topics related to the use of AR media in vocational education, see using VOSviewer software. The results of the search can be seen in Figure 3.
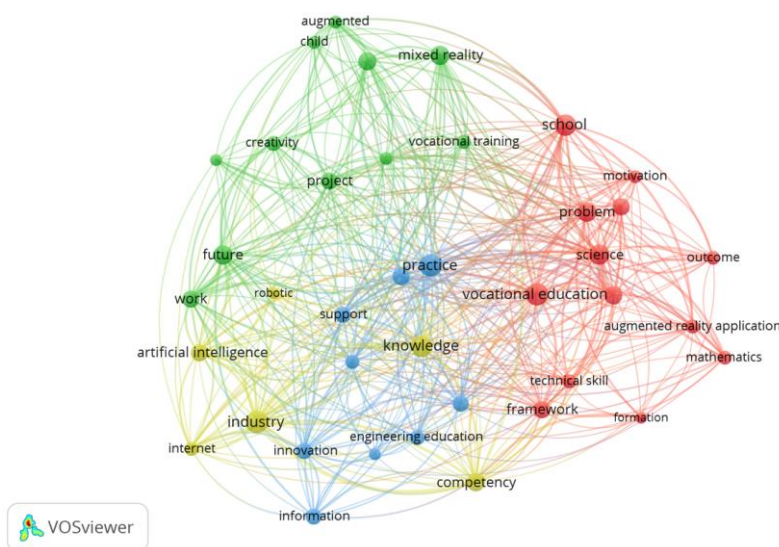

Figure 3: Visualization of research distribution using AR media in vocational education using network visualization

If studied further, learning research using AR media in vocational education with VOSviewer can be seen by visualizing the density for AR keywords in Figure 4.
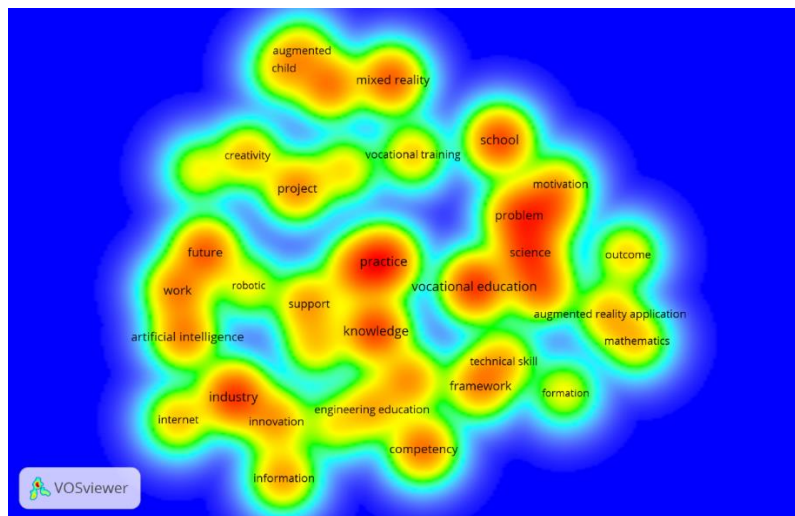
Figure 4: Visualization of the use of AR media using density visualization

Figure 4 shows there are many themes/topics that are applied with AR technology in vocational education, namely: creative, critical thinking, case study, gamification, vocational training, motivation, robotic, artificial intelligence, industry, mathematics, competence, and professional training. The 996 articles used in the research were published between 2018 and 2021, and they show that there is a relationship between the use of AR media with critical and creative thinking skills in participants educated in vocational education. Researchers who conduct research using AR media in several journals are indicated by thick gradations of color. If studied further, learning research using AR media is related to vocational education providers with VOSviewer, which can be seen in Figure 5.
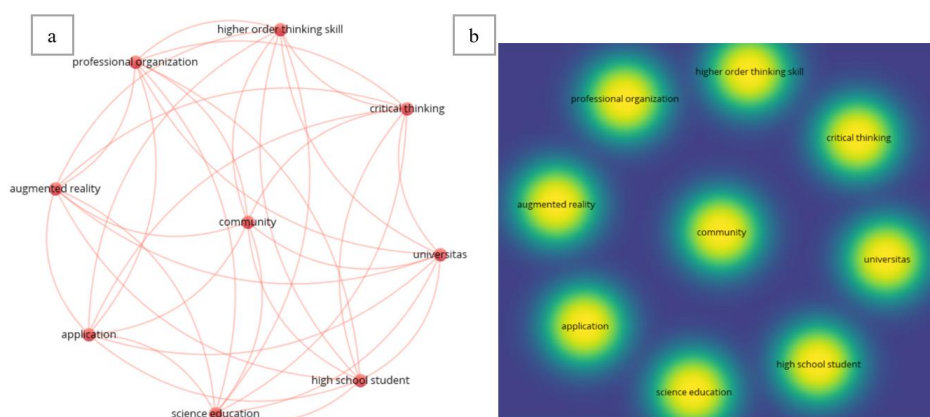
Figure 5: AR media related to vocational education (a) with network visualization; (b) with density

Based on the dimensions of creative thinking, its general characteristics can be listed as follows: flexibility, authenticity, multiple thinking, wondering, thinking fast and independently, being open to criticism, rationalism, being suspicious, coming up with different

solutions, realizing and defining the problem, and to suggest possible solutions (Gilhooly, 2015). The following is a table presenting the results of the journal analysis which has been done.

Table 3: Benefits of using AR Interactive Media to Improve Critical and Creative Thinking of Students

Num	Article Title	Writer	Journal Results	Review Analysis
1.	Virtual and augmented reality in education	(Gudoniene & Rutkauskiene, 2019)	This research develops a model of teaching media based on VR and AR. The teaching media serves different integration in a platform designed for teachers and students.	This teaching model is integrated into the platform designed not only for teachers but also for students. Theory of learning can be specially personalized and learning progress can easily be monitored and assessed. Virtual reality and augmented reality are very important to create a new learning atmosphere and the newest platform for supporting the learning process.
2.	Creating Interactive Physics Education Books with Augmented Reality	(Farrell et al., n.d.)	This media has the potential to teach complex materials with 3D.	The use of this media has the potential for learning to develop critical and creative thinking.
3.	Developing critical thinking competence in algebraic thinking using augmented reality for junior high school	(Rahardjoni et al., 2020)	The weakness of using AR-based learning is that it cannot be applied in rural areas because there are no adequate facilities. Therefore, AR can only be applied in urban areas	AR can improve critical thinking and algebraic thinking skills in junior high school students.
4.	The effectiveness of Augmented Reality based Learning on Vocational Competencies of Vocational School Students	(P. Herlandy et al., 2020)	Based on the findings, the use of AR-based learning media can be applied to vocational learning in vocational schools by adjusting the material.	The application of AR media has a significant effect on the improvement of students' vocational competence, which can be seen from the difference in learning outcomes between the experimental class and the control class at the end of the lesson, namely at the time of the posttest.
5.	The Potential of Augmented Reality for Vocational High School Learning Amid COVID-19 Spread	(Mansyur, 2020)	AR media is related to human psychology, the media used, how to communicate with others, where the media will provide an immersive experience for users and influence affective, and cognitive, and behavioral aspects.	AR-based learning in vocational high schools can improve understanding, have a longer memory, improve motivation and critical and creative thinking, not require sophisticated equipment to operate, and reduces learning costs.

6.	Framework for designing motivational augmented reality applications in vocational education and training	(Bacca et al., 2019)	The findings show a positive impact in four dimensions for the control and experimental groups. This means that students report positive levels of motivation after learning with AR applications.	The framework introduced in this paper is an empirically supported foundation that contributes to the design and development of motivational AR applications that effectively support student motivation.
7.	Effects of Augmented Reality on Student Achievement and Self-Efficacy in Vocational Education and Training	(Sirakaya & Cakmak, 2018)	The findings show that while the use of AR improves students' achievement, it has no effect on the theoretical knowledge of self-efficacy and self-efficacy assembly skills.	This study presents the effect of using AR in vocational education and training on student achievement and self-efficacy.
8.	Development of an Instructional Model with AR technology for Vocational Certificate Students	(Pipattanasuk & Songsriwittaya, 2020)	This study presented the development of learning models with AR technology for direct practical laboratory experiments for vocational certificate students.	AR helps students remember the information they have just learned so that they can train critical and creative thinking in a more interactive class.
9.	Some pedagogical observations on using augmented reality in a vocational practicum	(Lester & Hofmann, 2020)	AR media is very helpful for practicing in learning design, and provides long-term evaluations, especially about the effectiveness of subsequent learners in the workplace.	AR as a direct substitute for direct instruction supports greater learning management thereby exploring the self-confidence and competence of apprentices.
10.	A Virtual Laboratory Application For Vocational Productive Learning Using Augmented Reality	(P. B. Herlandy et al., 2019)	AR technology as the latest technology in computer development graphics can be expanded to produce 3D animation that can support vocational education.	AR application which builds vocational competence achieved by students at the vocational education level consists of conceptual competence, procedural competence, and interpretative competence.
11.	Augmented Reality (AR) And Virtual Reality (VR): The Future Of Interactive Vocational Education And Training For People With Handicap	(L. Mekacher, 2019)	AR/VR provides a positive and enjoyable experience it only encourages students to develop their skills in a professional environment.	The strength of VR/AR in technical education lies in the fact that it makes students want to learn more about the topic, which in turn contributes to the success of the lesson so as to develop students' critical and creative thinking.
12.	Augmented Reality for Vocational Education Training in K12 Classrooms	(Belani & Parnami, 2020)	The research demonstrates beneficial opportunities to promote and integrate AR	Platform for vocational training uses AR for experiential teaching and to be integrated into traditional teaching training

			in vocational skills training.	methodologies so as to develop students' critical and creative thinking.
13.	The technology of augmented reality based on 3D modeling to improve special skills for vocational students in the era of industrial revolution 4.0	(Tuwoso et al., 2021)	In this study, AR technology improves the special skills of graduates of vocational education students, which consist of idea development (78%), infrastructure utilization (82%), knowledge deepening (90%), professional organization (88%), and mental stimulation (90%).	The developed AR has a very good level of attractiveness and feasibility based on online learning media experts and material experts, and it can improve the special skills of vocational education graduate students.
14.	Augmented Reality Application in Vocational Education: A Case of Welding Training	(Agrawal & Pillai, 2020)	A potential use of AR in vocational training is explored, by creating learning modules such as this one that will serve as an intermediary step of learning between textbooks and real practice sessions.	AR technology creates a safer introduction of practical sessions and greater interest in students by exploring interactions using mobile AR so as to develop critical and creative thinking.
15.	Augmented reality for introducing fuel cell as electrochemical energy conversion on vocational school	(Sendari et al., 2020)	The AR application is valid, with the average percentage score being 94.44% and 89.58% in terms of media and material aspects, and the implementation of the process to students being 95.79%, which can be concluded that students can be accepted.	AR applications use technology that uses smart phone cameras to display digital content, making it easier for students to think critically and creatively.
16.	Improving Vocational Training in the Philippines using AR	(Dayagdag et al., 2019)	AR technology can save costs. Training solutions for technical vocational training can address the trainees' identified difficulties.	The use of AR is important to continuously improve the delivery of training in academic and technical vocational institutions.
17.	Effect of Augmented Reality and Simulation on the Achievement of Mathematics and Visual Thinking Among Students	(Aldalalah et al., 2019)	The results of AR technology show that the use of AR improves students' learning achievement and visual thinking.	This study provides support for the effect of augmented reality on learning achievement and visual thinking among students.

18.	Augmented Reality for Integer Learning: Investigating its potential on students' critical thinking	(Suryanti et al., 2020)	The use of AR-based media is able to create an interactive learning atmosphere. It makes students involved in learning, understand the material more easily, and able to solve problems.	AR-based learning media is appropriate for teachers to use to improve students' critical thinking skills.
19.	The playground effect: How augmented reality drives creative customer engagement	(Jessen et al., 2020)	AR supports a unique form of customer creativity that differs from previous conceptualizations of creativity through its relationship to customer engagement.	The use of AR increases customer creativity and, in turn, offers a source of intrinsic satisfaction to customers.
20.	Interactive learning media innovation: Utilization of augmented reality and pop-up book to improve user's learning autonomy	(Elmunsyah et al., 2019)	This article produces an innovative learning media development design by utilizing smartphone technology and AR to increase student learning independence.	The use of AR technology can improve students' critical and creative thinking and learning independence, which will improve the quality of education.

Based on data from several articles that have been selected, the enthusiasm of students in learning at this time is due to the teaching that is integrated with real life and involves the use of current technology. The knowledge and experience of students is also in line with technological developments that are increasingly advanced. Thus, the use of interactive media which is accompanied with the selection of the right learning model makes students very enthusiastic in learning. The use of AR in teaching can produce clear explanations and can help teach abstract concepts that cannot be presented realistically. AR technology can be assessed through gadgets anywhere and anytime.

Submission of learning materials can be started by integrating the technology to be used as a medium in learning. These interactive media display digital material and phenomena with 3D visualization that helps students in the process of understanding the material, problem-solving, and improvement of critical and creative thinking skills. Technology used is packaged well in interactive learning media. Students find it easier to visualize difficult materials encountered in real life. Therefore, AR can increase student interest in learning the material presented. Based on data from several articles that have been selected, the high percentage of the indicator is due to the ability of students to formulate and analyze the various kinds of questions that have been presented very good, after doing experimental observations with the help of the application.

This proves that the use of interactive media affects the process student learning. By using the technology which is currently in the learning process, such as the use of AR media, students will practice more in the thinking process and understand the material and the problems presented. The use of this media has considerable potential in improving students' academic dimensions as well as their critical and creative thinking skills.

CONCLUSION

Based on the results of the discussion of the literature obtained, the use of AR media has a significant effect on the improvement of students' critical and creative thinking skills, especially students of vocational education. A further analysis can be a reference for teachers in using media assistance for the learning process. However, the model selection process used during learning must still be well adapted to the characteristics of the material which will be delivered.

Acknowledgement

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