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Application of Augmented Reality (AR) In Vocational Education: A Systematic Literature Review

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ABSTRACT

In education, Augmented Reality has been widely used to complement the standard curriculum. This article aims to examine how the application, and impact of the use of AR in Vocational Education. The Systematic Literature Review method is used to identify, study, evaluate, and interpret Augmented Reality in vocational education. Research data were identified by help of the PRISMA 2020 form. Article was collected from Science Direct database. There were 454 articles. After being selected using inclusion and exclusion criteria, the data used were 14 articles. The results of the study reveal that AR is applied in learning as an innovative learning medium, a new approach to learning to improve students' understanding of knowledge, and skills and provide a concrete learning experience. The integration of AR in education has the impact of increasing students' understanding and learning experience, promoting positive attitudes, making the learning process fun and interesting and learning efficiency.

Keywords: Augmented Reality, Teaching, Learning, Vocational Education

INTRODUCTION

This rapid development of technology makes most students who are still learning by listening to subject matter delivered by the teacher or by just reading books often feel boring for students [1]. With the rapid development of technology today, learning methods as usual are not fun nowadays [2]. Augmented Reality is a technology that can be applied in by several area including education [3] . The integration of technology in the learning process has emerged a lot to create fun but effective learning [4]. One of them is the use of augmented reality in learning. In its development, augmented reality is used as a learning medium to explain information so that it can be accepted and also provide interaction in the learning process [5]

Augmented Reality (AR), 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 [6]. This AR technology allows users to see virtual objects added to the real world with contextual layers of information [7]. In the world of education, AR has been widely used to complement standard curricula. Text, graphics, video, and audio can be superimposed into a student's real-time environment that can provide different experiences to students [8].

Bibliometric analysis of the use and development of augmented reality in the world of education has been carried out by a group of researchers who took sources from 2015 to 2021, The study concluded that augmented reality is not only used in the industrial world but has also been applied in vocational education [9], [10]. The use of augmented reality in recent years has already resulted in the development of technical skills in education. Research shows that the use of augmented reality in education can increase students' awareness of the knowledge of two-dimensional objects depicted through augmented reality into three-dimensional objects [11]. Research on the use of augmented reality learning media in schools can have a significant impact on students' ability to understand learning concepts [12].

The purpose of this piece of work is to examine the implementation and impact of augmented reality in vocational education.

RESEARCH METHOD

Systematic literature reviews are methods of identifying, evaluating, and interpreting all research related to a particular topic that is available and relevant to answer a particular research question or topic area, or phenomenon of interest by transparently and including all evidence and assessing its quality [13]. This article was created using the SLR method to examine the application of Augmented Reality in Vocational Education.

At the beginning of the review, the research question is spelled out as a goal that must be answered. The database selected for the search is then indicated, as well as search

keywords, and criteria followed for the evaluation and selection of studies. Finally, we introduce the publication included at the end of the process [14].

1. Search Strategy

The data in this literature review, Article is sourced from the Science Direct database. Terms - selected terms searched in the title, keywords, and abstract of the article. In this systematic review, the search strings used are: "augmented reality AND education", "augmented reality AND learning", and "augmented reality AND teaching".

2. Study Selection

The study selection process is an iterative and incremental process, which is divided into several stages with different activities carried out. The search was carried out to obtain articles on the results of research on augmented reality in the world of education. The initial search yielded 454 articles.

3. Inclusion and Exclusion Criteria

Inclusion and exclusion criteria should be applied in any study. Inclusion and exclusion criteria are established to select relevant studies to obtain answers to the research questions asked. Inclusion and exclusion criteria

Table 1. Inclusion and exclusion criteria

Inclusion	Exclusion
a. Research relating to augmented reality for educational or vocational learning purposes	a. Research related to virtual reality or mixed reality
b. Research articles published between 2018 - 2022	b. Research articles not published between 2018 - 2022
c. Research articles are written in English	c. The article was written not in English
d. Open access to research articles or can be downloaded the full version	d. Research articles cannot be downloaded for the full version
e. The research follows the appropriate structure and research methods	e. The article is not a literature review, review and bibliometric research

First of all, 454 papers were reviewed against inclusion and exclusion criteria, so 154 articles were duplicates, and 35 articles needed to be deleted because they were reviewed and bibliometric. Then the 265 articles were further read and reviewed with inclusion and exclusion criteria, 15 articles were relevant to answering research questions. This data extraction procedure is represented through the PRISMA 2000 pipeline [15].

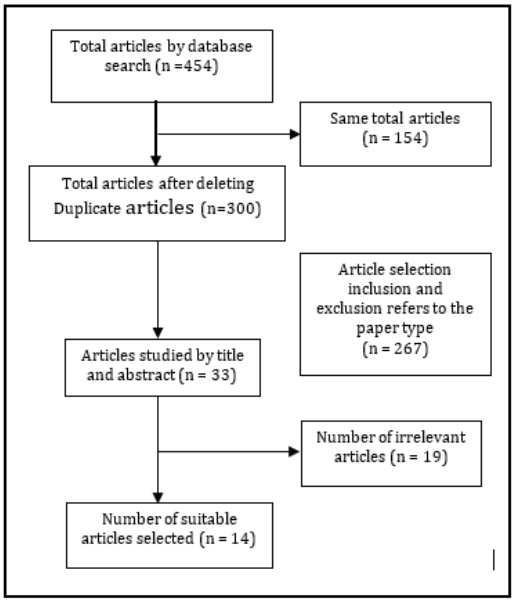

Figure 1. Article selection process

After selection, the articles used in this study are as in the following table:

Table 2. Selected articles

Writer	Heading	Year
Mourtzis, Dimitris, Zogopoulos, Vasilios, Vlachou, Ekaterini	Augmented Reality supported Product Design towards Industry 4.0: a Teaching Factory paradigm	2018
Often, Adrian Trandabăț, Diana	Enhancing the Attractiveness of Learning through Augmented Reality	2018
Chang, Shao-Chen Hwang, Gwo-Jen	Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions	2018
Sorko, Sabrina Romina Brunnhofer, Magdalene	Potentials of Augmented Reality in Training	2019
Yip, Joanne Wong, Sze-Ham Pick, Kit-Lun Chan, Kannass Wong, Ka-Hing	Improving the quality of teaching and learning in classes by using augmented reality video	2019
Scaravetti, Dominique Doroszewski, Dominique	Augmented Reality experiment in higher education, for complex system appropriation in mechanical design	2019
Mourtzis, Dimitris Siatras, Vasilis Angelopoulos, John Panopoulos, Nikos	An Augmented Reality Collaborative Product Design Cloud-Based Platform in the Context of Learning Factory	2020
Sharma, Bhanu Mantri, Archana	Assimilating Disruptive Technology: A New Approach of Learning Science in Engineering Education	2020
Pranoto, Hady Panggabean, Francisco Maruli	Increase The Interest in Learning by Implementing Augmented Reality: Case studies studying rail transportation	2019
Kao, G. Y.M., & Ruan, C. A	Designing and evaluating a high interactive augmented reality system for programming learning	2022
Kostov, G., & Wolfartsberger, J	Designing a Framework for Collaborative Mixed Reality Training	2022
Solmaz, S., Dominguez Alfaro, J. L., Santos, P., Van Puyvelde, P., & Van Gerven, T	A practical development of engineering simulation-assisted educational AR environments	2021
Conley, Q., Atkinson, R. K., Nguyen, F., & Nelson, B.C	Leveraging augmented reality to teach probability and sampling. Computers & Education	2020
Agrawal, Richa Pillai, Jayesh S.	Augmented Reality Application in Vocational Education: A Case of Welding Training	2020

RESULT AND DISCUSSION

In the results and discussion section, the researcher will complete the research questions with several answers obtained from the literature review process.

1. How is the Application of Augmented Reality in Vocational Education?

The following table describes the application of Augmented Reality based on selected articles:

Table 3. Table of applications of AR in vocational education

No.	Heading	Application of AR in Vocational Education
1	Augmented Reality supported Product Design towards Industry 4.0: a Teaching Factory	Application of advanced visualization techniques in product design

	paradigm	
2	Enhancing the Attractiveness of Learning through Augmented Reality	To improve communication and collaboration skills
3	Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions	Augmented Reality (AR) based learning to develop flipped learning systems and test the effectiveness of the proposed approach
4	Potentials of Augmented Reality in Training	As an innovative learning medium that demonstrates several use cases and optimizes education and training to meet the needs of digitalization more successfully
5	Improving quality of teaching and learning in classes by using augmented reality video	Improving students' learning experience and improving their understanding of complex issues by incorporating mobile augmented reality (AR) applications into sewing workshops where threading tasks are performed to facilitate better learning
6	Augmented Reality experiment in higher education, for complex system appropriation in mechanical design	To visualize design or simulation models and apply real system manipulations, related to various representations, especially for students who do not have technological skills
7	An Augmented Reality Collaborative Product Design Cloud-Based Platform in the Context of Learning Factory	For product design, customization, and visualization with the use of AR will also be developed to gather useful insights about the skills and competencies acquired by the participants
8	Assimilating Disruptive Technology: A New Approach of Learning Science in Engineering Education	Elaborating the understanding of ohm's law using AR technology. A marker-based AR application called AROhm has been developed that can make students learn in an augmented Hands-on way to give them a new and concrete learning experience
9	Increase The Interest in Learning by Implementing Augmented Reality: Case studies studying rail transportation	Application of augmented reality technology in the learning process. The case study used in this paper is the implementation of augmented reality in the subjects studied related to railway technology.
10	Designing and evaluating a high interactive augmented reality system for programming learning	To find a solution to make the concept of programming more real.
11	Designing a Framework for Collaborative Mixed Reality Training	To propose methods to extend collaborative extended reality (XR) applications to various platforms to support collaborative learning, but also other types of applications such as collaboration and remote maintenance
12	A practical development of engineering simulation-assisted educational AR environments	Engineering simulation with AR/VR education is still challenging and requires expertise from various disciplines throughout technical development. Case studies were developed to teach chemical engineering concepts using the liquid soap synthesis process during the COVID-19 Pandemic
13	Leveraging augmented reality to teach probability and sampling. Computers & Education	Explore ways for students to learn basic statistical reasoning skills authentically and interestingly
14	Augmented Reality	AR applications are designed and developed

	Application in Vocational Education: A Case of Welding Training	to provide welding knowledge and skills and training

The table above shows the application of augmented reality in vocational education from selected journals. From this table, it can be concluded that 6 articles show the balance of AR in education generally aimed at improving students' knowledge, skills, and learning experience in more interesting and different ways ([11], [16], [17], [18], [19], [20]). In its use in schools 5 articles show AR is integrated into the learning process as an interactive learning medium [21], [1], [22], [23], [24]. While the other 3 articles show the application of AR complementing the new approach to learning [25], [26], [27]. The application of AR in learning can improve the student learning experience through interactive learning media that are applied with various learning methods.

2. How does the Use of Augmented Reality in Vocational Education Impact?

The following table explains the impact of using augmented reality in vocational education based on selected articles:

Table 4. Impact of the use of AR in Vocational Education

No.	Heading	Impact of AR Use
1	Augmented Reality supported Product Design towards Industry 4.0: a Teaching Factory paradigm	By using Augmented Reality, Teaching Factory participants have real-world experience of scaling the insights of the products they are designed and can interact with. the assembly of the final product is carried out 10% faster
2	Enhancing the Attractiveness of Learning through Augmented Reality	The use of augmented reality to improve communication and collaboration skills between children, especially children with autism, and game-based student evaluations in various teaching areas, allows for a stress-free testing environment
3	Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions	AR-based flipped learning is not only beneficial for students in terms of improving their project performance, but also increases learning motivation, critical thinking tendencies, and the self-efficacy of their group
4	Potentials of Augmented Reality in Training	The integration of AR technology in training and further development leads to significant cost reductions
5	Improving quality of teaching and learning in classes by using augmented reality video	These findings are consistent with the post-test value and the time it takes to learn the threading task. Some feedback items demonstrate higher learning efficiency with the use of AR video
6	Augmented Reality experiment in higher education, for complex system appropriation in mechanical design	Assistance in follow-up procedures (handling operations in practice sessions or assembly/disassembly operations). Here, AR is used as an educational support tool and introduces students to technology relevant to the industry.
7	An Augmented Reality Collaborative Product Design Cloud-Based Platform in the Context of Learning Factory	The proposed application allows the utilization of different platforms to suit easier implementation in any industrial environment at a low resource cost. Thus, breaking the boundary between the device utilization of similar platforms, the application's proposed

		collaborative design combines most of the existing devices in a more realistic collaboration experience
8	Assimilating Disruptive Technology: A New Approach of Learning Science in Engineering Education	Theme-based projects facilitate students to think outside the curriculum, and industrial projects help them to adjust to industry expectations. Results from the review of the technical expertise and documentation of the expert committee are enhanced. Competent students are allowed to continue their 6th-semester project as an institute research project (IRP) The vision of the IRP is to shape students with industry expectations and push their technical skills toward product development
9	Increase The Interest in Learning by Implementing Augmented Reality: Case studies studying rail transportation	The application of augmented reality technology in learning materials helps the learning process and increases the impressive and fun factor in the learning process and makes the learning process more interesting. The application of Augmented Reality in learning materials provides more information about the object being studied, information about the shape, and texture, and provides more visualization of the object.
10	Designing and evaluating a high interactive augmented reality system for programming learning	The students in the high interactive group achieve a more positive experience in assembling puzzle cards to learn to program AR-based instruction, especially in the high interactive AR mode, helping students improve their programming performance, get higher learning motivation, reduce their cognitive load, and obtain a high level of technological acceptance
11	Designing a Framework for Collaborative Mixed Reality Training	Gain useful insights into collaborative training and serve as a good starting point for future projects
12	A practical development of engineering simulation-assisted educational AR environments	Engineering stimulation with AR can facilitate versatile and sustainable educational tools for use in an active learning environment
13	Leveraging augmented reality to teach probability and sampling. Computers & Education	AR also had a positive impact on participants' perceptions of engagement. Thus, it will be strategic to continue to focus on the relationship between learning acquisition and engagement for research ideas involving the design and implementation of AR
14	Augmented Reality Application in Vocational Education: A Case of Welding Training	The final product is a mobile application that uses AR marker-based which can be used on Android phones

The table above shows the impact of augmented reality in vocational education from selected journals. From the table, it can be concluded that the impact of implementing AR in the world of education is very positive. The use of AR in learning can increase student understanding and provide a concrete learning experience [21], [22], [18], promoting a positive attitude [25], [26], [16],

[27], [17] and [24], the learning process becomes fun and interesting [1] as well as efficiency in learning [17], [19], [23] and [20]. So the impact of applying AR in vocational education is to provide a concrete learning experience to students, the learning process becomes interesting and fun, a positive attitude arises and efficiency occurs in learning.

The impact of applying augmented reality to learning is related to student. The results of a pilot study show that the proposed teaching scheme significantly improves learning motivation, student creativity, and the teaching of creative design [28], After AR training, it showed superior total scores and performance compared to conventional training (student performance) [29], The implementation results indicate the impact of the learning environment on students' scientific knowledge and attitude change [30], and learning effectiveness [31]. Not all research has a significant impact, and the use of augmented reality in research may not show a significant impact [32]. This has a huge impact on learning,

Limitations

This article describes the implementation of Augmented Reality in vocational education. The specified articles are downloaded from the Science Direct database in the range of 2018 – 2022. Selected articles are research articles not reviewed articles or bibliometric studies.

CONCLUSION

The application of augmented reality in education as a whole is an example of how schools are addressing the ever-evolving technologies in the industry and ensuring students, especially from vocational education compete with the competencies available in the job market and set by the industry. Traditional learning carried out in the classroom is no longer fully effective in terms of conveying information and materials to students and is considered a method that does not contribute to productivity and instills learning motivation in students. Meanwhile, the application of virtual learning defines the variety of technology and supports educational strategies in promoting independent learning for students, increasing their productivity, and engaging them with effective learning. In addition to extensive online information, students can explore unlimited valid resources and introductions to online learning that contribute to improved collaboration between students and overall improve clear ways of communication and increase self-confidence. Innovations in learning strategies with augmented reality integration introduce simple learning and flexible time and location engagement where these strategies are available for distance learning and require only low investment.

Overall, modern strategies of a combination of technologies such as augmented reality implanted in the classroom promote better and more

conducive learning compared to traditional learning and thus improve student achievement academically and intellectually.

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