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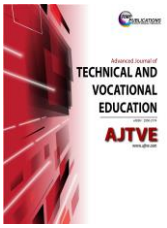

Virtual reality technology in physical education: a systematic review in instructional design & implementation

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Abstract: Virtual reality is an immersive technology that is utilized in education. The increasing growth of physical education research led to the need for a comprehensive examination. Furthermore, due to the rapid growth of VR research, this systematic analysis intends to investigate the instructional design used to develop virtual reality in physical education over the previous five years. As a result, 31 previous research articles on virtual reality technology and physical education were analyzed for this paper. The most instructional design used for VR development is ADDIE followed by Bloom's Taxonomy, while for the implementation of VR, undergraduate students are not the only option for using VR-based applications.

Keywords: *VR technology, Undergraduates, ID trend, Virtual Reality in PE, Immersive Technology*

INTRODUCTION

Virtual reality (VR) is the technology that generates an interactive virtual world that resembles a real-life experience [1]. VR technology enables users to immerse themselves in a virtual world by actively engaging with its content [2]. Furthermore, typical virtual reality is a 3D animation that may be activated by manipulating the handle of a mobile computer or the remote control to cause the digital information to shift in a certain context, such as an environment [3]. VR technology has been used in many fields such as health education, public health, physical education, and geographical education. Despite the rapid growth, the study of VR in PE is still considered in its infancy [4]. Thus, further study is needed in this area.

In technology development, there are several instructional designs used as guidelines to organize appropriate pedagogical scenarios to achieve instructional goals [5]. ADDIE (Analysis, Design, Develop, Implement, and Evaluate) and Bloom's Taxonomy, as well as Merrill's Principle and Gagne's Nine Events of Instruction, are some of the well-known instructional design frameworks used in the creation of new technologies. To determine which of these four instructional designs is the best and most recommended for VR creation, a total of 31 papers were analyzed.

It is impossible to exaggerate the significance of effective instructional design, particularly in the context of education. Many definitions of instructional design (ID) exist. Still, the descriptions all lead to the exact definition: the process of improving instruction by analyzing learning needs and developing learning experiences in an organized manner [6]. Instructional designers frequently employ technology and multimedia to enhance learning. IDs developed a systematic approach to improving learning experiences by analyzing learning needs. Gagne's Nine Events of Instruction, the ADDIE model, Bloom's Taxonomy, and Merrill's Principles of Instruction are the most widely used instructional design methods.

There are five steps in developing a product: analysis, design, development, implementation, and evaluation. It is common to practice system development to implement this ADDIE ID model to facilitate the use of agile methodologies [7]. When it comes to visual learning, Bloom's Taxonomy is a go-to [8]. The design process began with memorization of information, followed by comprehension, application, analysis, evaluation, and finally, a solution. Gagne's Nine Events ID model is widely used in medical, health, and biological education. In one of the studies that have been discussed Gagne's Nine Events ID is from Tambi [9]. Finally, Merrill's Principle is the last ID model to be discovered in this section, which uses five learning principles that are task-centered, activation, application, integration, and demonstration. Recent research shows that Merrill's Principle and Gagne's Nine Events can both reduce cognitive load and foster student learning, as demonstrated by Salehi [10]. Comparing Merrill's Principle to Gagne's model, the results show that Merrill's Principle is the superior design model.

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In addition to the IDs listed above, it is worth noting which one specializes in VR development best. Although there is still a lack of discussion about IDs in VR among researchers, this is not the case. Therefore, this study will identify the most often-used instructional design in VR development.

As VR technology is immersed in PE, several studies have been conducted by using different sampling populations. As common knowledge, VR is a new technology that is quite expensive and not easy to handle. It still needs to be handled by a specialist or technicians. Besides that, most of the previous researches such as Lin, Mokmin & Jamiat and Ogbuanya [11]–[13] used undergraduate students as their sampling population. Following in the footsteps of prior research, this report sought to determine whether or not using VR-based applications by undergraduates is an option for them to pursue.

A few recent studies have suggested that virtual reality-based education for undergraduates be considered as an additional option. Besides that, as there are many fields of study at the undergraduate level, VR technology has been developed according to the particular fields. Health and fitness, physical education, engineering, and electronic technology education are just a few sectors where virtual reality can be applied. According to the statement above, many researchers use undergraduates as a sampling population to observe the effectiveness of VR technology in every field.

Furthermore, according to the expensiveness of having VR tools stated by Lionel [14] the sensitivity of the equipment, and the requirement for experts to put it up, undergraduates may be more likely than elementary or secondary school students to make use of it.

However, from all the statements above, it leads to several questions that arose which are; (i) What is the instructional design used to develop virtual reality? (ii) Are undergraduates the only option for using VR-based applications?

Thus, from these questions, this paper is intended to investigate the instructional design used to develop virtual reality and clarify whether the use of VR-based is only for undergraduates or not in physical education during the previous five years.

MATERIALS AND METHODS

There will be an explanation of the search strategy used to collect the relevant research paper for review in this methodology section. In addition, the eligibility criteria, which include the inclusion and exclusion criteria, will be discussed in detail in this section. The discussion explains how research questions (RQ) will be measured.

Search Strategy

It is the goal of this study to perform a comprehensive review of virtual technology in physical education. According to research papers published between 2017 and 2021 in three digital libraries, Google Scholar, Institute of Electrical and Electronics Engineers (IEEE), and Scopus, the number of papers returned was 1250, 37, and 17, respectively. This includes the Google Scholar search terms "virtual reality technology," "physical education," "instructional," and "design," which are related to physical education and virtual reality technology. In contrast, the Scopus and IEEE search terms are "virtual reality" and "physical education." Another technique employed by Scopus and IEEE is to select the open access option, which links to 37 and 17 papers, respectively. Thus, this research strategy was used to answer RQ1 and RQ2.

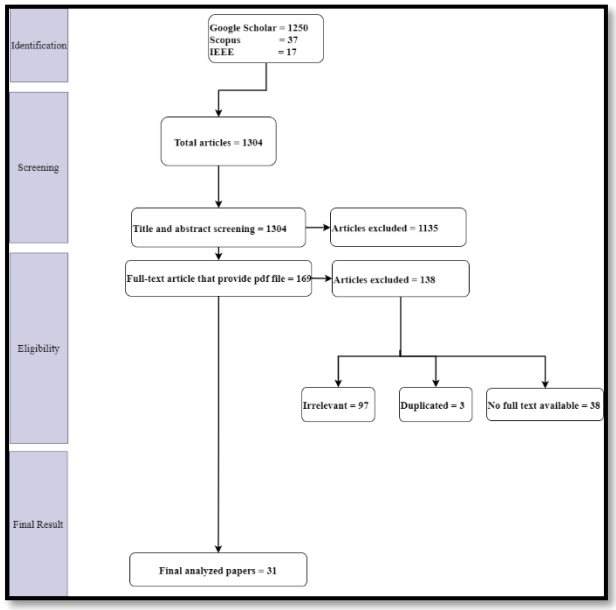

Figure 1. PRISMA Flowchart of study screening and selection.

Eligibility Criteria

There are two types of eligibility criteria: Inclusion criteria and exclusion criteria. This section explains the criteria for inclusion and exclusion.

Inclusion and exclusion criteria

PICO and SPIDER criteria are used to determine eligibility [15]. For example, PICO is commonly used for quantitative evidence, while SPIDER is a qualitative and mixed-method search proposed in this systematic review. Therefore, even though PICO is more sensitive than SPIDER, the SPIDER approach is also required for this systematic review. The inclusion criteria include the title and abstract screening, full-text available, language, quality of the research papers, sampling populations, comparison, and the results.

The title and abstract both call for more research into these topics using virtual reality in instructional design and physical education. When it comes to this inclusion criterion, the language used in a paper is one of the most

important considerations. Researchers must be able to simplify the process of analyzing documents. The quality of the research papers used in the systematic review is another critical factor in its success. Accordingly, it is necessary to carry out a quasi-experimental study on the documents that have been examined. Rather than concentrating on descriptive research, this systematic review will also include quasi-experimental research papers, which can be used to compare each paper's sampling populations, results, and objectives. Thus, it will lead to identify the use of virtual reality in instructional design for physical education.

Besides that, several criteria have been excluded from consideration in this paper. First, title and abstract screening will be performed as described in the inclusion section. Studies that do not fall under the scope of virtual reality technology, instructional design, or physical education will be discarded from consideration for the competition. Due to this decision, one hundred and sixty-nine papers are passed onto the next stage of the process. Exclusion criteria for the article that includes a pdf file will be examined in the following step of the procedure. All of the research papers in this section have been filtered to eliminate irrelevance, duplication, or incomplete texts. A total of 138 studies were excluded, with 97 of them being irrelevant, three duplicates, and 38 not having full texts available. Only 31 final analyzed papers were selected to answer RQ1 and RQ2 as mentioned in Research Strategy.

RESULT

The results of the systematic mapping study will be presented in the following session concerning the research topics. Some of the 31 papers were analyzed, most published between 2017 and 2021 in the Journal.

What is the instructional design used to develop virtual reality?

Twenty-four papers discussed the use of ADDIE ID (n=24) in Table 1. More than two-thirds (77.42 %) of these works referenced the ADDIE, as seen in Figure 2. There are 14 authors out of 24, such as Dong & A, Hadjidemetriou, H. Kim et al, H. S. Lee & Lee, H. Y. Lee et al, C. Li & Li, D. Li et al, H. Li, Meng, Mokmin, Mokmin & Jamiat, Wang, Zamzami and Zhang [12], [16]–[28], who used ADDIE ID to develop VR in physical education. Four authors have utilized ADDIE ID to study the health of children with down syndrome, including the development of motor skills and posture control [29], the use of virtual reality to aid physiotherapists [30], VR technology for the students with autism spectrum illnesses to improve emotional and social abilities [31], [32]. The symbiotic relationship in six articles, ADDIE ID, is used to identify the computational thinking algorithm, students' attitudes toward VR technology, and teachers' perspectives and perceptions [33]–[37].

Two papers utilized Bloom's Taxonomy ID to research primary school students' ability to think critically about physical education, accounting for 6.45% of the total [38]. Besides using ADDIE, Wyk [39] also used Bloom's Taxonomy ID in developing an online course for VR courses to compare which ID is the best to be used. However, none of the articles selected used Gagne's Nine Events of Instruction and Merrill's Principles for VR development. Six other papers did not mention ID as a tool for VR development, although one did employ TPACK and TPD theory in physical education, despite the fact that TPACK and TPD do not fall within the ID category. All 6 articles represented 19.35% for the mostly-used instructional design in VR.

The results show that the most ID used to develop VR is ADDIE, leading to the usage of another three IDs. It means that ADDIE is a more relevant ID to develop the systems, especially for VR systems. Thus, these results have been answered the RQ1.

No	Instructional Design	Number of papers discussed
1	ADDIE	24
2	Bloom's Taxonomy	2
3	Gagne's Nine Events of Instruction	0
4	Merrill's Principles of Instruction	0
5	Not Stated	6

Table 1. Instructional design for VR development

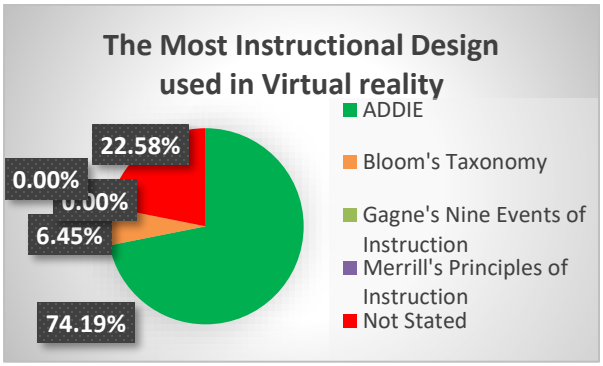

Figure 1. The Most Instructional Design used in Virtual Reality

Is undergraduate the only option for using VR-based applications?

There are several levels of sampling populations used in the selected articles. It includes primary schools, secondary schools, undergraduate students, teachers,

and others, as shown in Table 2 below. The most significant sampling populations used in VR-based are undergraduate students that represented 48.39% compared to others like primary schools (16.13%), secondary schools (16.13%), teachers (6.45%), and others (12.90%). Undergraduate students range between the ages of 18 to 23, whereas teachers, principals, and other members of these professions are between the ages of six and twelve, thirteen to seventeen, twenty-three to thirty-five, and at least thirty-five years old. However, in the Others category, one article used an analysis article to study the bibliometrics of physical education. Another piece does not use participants because the study tested their VR development on hardware and software.

No	Sampling population for VR	Number of papers
1	Primary school students	5
2	Secondary school students	5
3	Undergraduate students	15
4	Postgraduate students	0
5	Teachers	2
6	Others	4

Table 1. The most population participated in VR

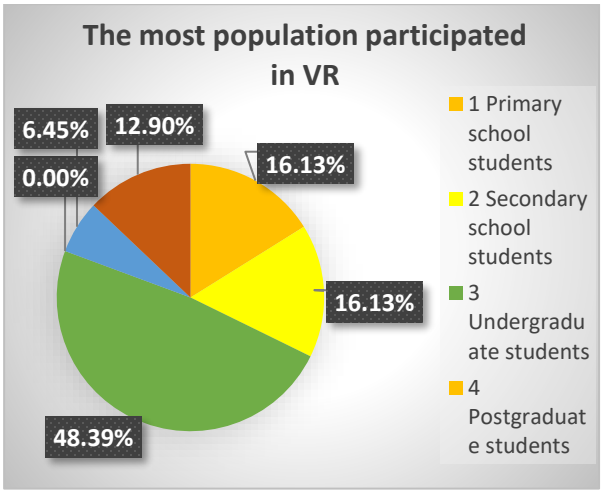

Figure 3. Illustration of the most population participated in VR

Besides that, the results from several articles show that there is no significant difference to say that undergraduate is the only option for implementing VR-based. This is because student interest in VRT increased dramatically after it was adopted, and VRT was implemented in five colleges and universities, accounting for more than 20% of the total student population at the time [18]. Meanwhile, virtual reality and augmented reality are gaining popularity among K-12 students, and 75% of teachers believe that using technology has enhanced their teaching techniques for K-12 pupils [35]. In another situation, Abdelsalam [34] found that the most significant impediment to implementing VR in primary and secondary schools is a lack of an educational context. It might also be related to the cost and operation for implementing it. These challenges have influenced the students' perceptions, resulting in a significant disparity between those who answered yes and those who responded no, with 56 percent saying yes and 10 percent saying no. This statement is also supported by C. Li & Li [23] who stated that VR technology had not been widely used in education because it is expensive and still in its infancy.

However, the population of undergraduate students in the world will reach 9% of the world's population by 2030, according to UNESCO [40]. The same goes for the population of primary schools' students and secondary schools' students where the percentage for them until 2019 was 9.47% (739 million) and 7.71% (601 million), respectively. It means, according to the findings from Meng [18] and Mystakidis [35] above, there will be a demand and supply issue for the use of VR-based applications on both schools' level and undergraduate level. As long as both, supply and demand increase, the equilibrium price will stay the same, increasing the equilibrium quantity [41]. Therefore, as the population grows and the number of suppliers grows, the educational setting will be improved by implementing VR technology in every school or university.

There are still various recommendations for future studies that should be carried out not only for college students and primary schools but also for elementary schools, among other things. In-depth research on virtual reality adoption across a variety of sports was recommended by several authors, including Lee & Lee [27], who also suggested that educational institutions in elementary, secondary, and postsecondary levels consider the long-term impact of systematically applying immersive technology [35]. As a conclusion in this session, undergraduate students are not the only option for using VR-based applications.

DISCUSSION

As the overall result for identifying the instructional design used to develop VR, there are significant differences between the use of ADDIE ID and another three IDs, which are Bloom's Taxonomy, Merrill's Principle and Gagne's Nine Events, which are more than two-thirds of the IDs used in the selected papers. In addition, it is more widely used in VR development for physical education, that is almost 80%.

Besides that, the ADDIE model is always used by developers to develop or create new systems. As most of the systems use agile methodology, ADDIE system is one of the models that may support this methodology compared to others. However, Blooms' Taxonomy is an ID model that is more appropriately

used as a problem-solving technique. It is because this paradigm requires users to work their way up from the lowest levels of memory and comprehension, then apply what they have learned and analyse the results before coming up with the optimal solution. Merrill's Principle is also a problem-based theory. This design comprises four phases. The principles of activation, demonstration, application, and integration are essential to a learner's success. This model's merits are in its strong learner focus. The ideas are geared towards student success. The four phases help teachers plan lessons in a way that engages and motivates students. Gagne's nine Events is a behaviourist learning strategy. This adaptable strategy allows teachers to engage with students in ways that best suit their learning styles. Students gain better learning results and become actual subject matter experts this way.

Besides that, the RQ2 has also been answered in the results above, which show no significant differences. Therefore, even though the higher number of the population who participated were undergraduates, it is not a must for the result to show that the undergraduates are the only option for using VR. In addition, the study from C. Li & Li [23] stated that VR in education is not popular due to the expensiveness of the tools. This statement was denied by UNESCO when they stated that the students' population will increase towards the year 2030. Therefore, the theory of supply and demand strengthens the argument. It is also boosted up with the finding from the previous recent study to explore the use of VR in physical education for school students.

Even if this technology is extremely expensive and difficult to use, we feel that it is not impossible for VR-based applications to be used as important educational materials among school kids if they have adequate instructions on how to operate them. We can observe this in comparison to mobile phones. For the previous ten years, youngsters have been unable to use technology as a learning aid because of the high cost and limited technical skills of the average student. As the Covid-19 pandemic took hold, primary and secondary students were allowed to use their mobile phones as a means of studying.

As a conclusion, it is proved that ADDIE is the best ID to be used in developing VR among others. However, this study proposes to proceed with the combination of the ADDIE model and Bloom's Taxonomy in VR development for PE where ADDIE acts as a guideline of the development system and Bloom's Taxonomy used in creating PE content embedded in VR. This research firmly believes that undergraduate students are not the sole choice for implementing VR-based applications based on the study findings above. As a result, additional research into the potential benefits of virtual reality for primary and secondary school students is required.

CONCLUSION

This paper had performed a systematic review, achieved to answer all the RQs and meet the objectives, which are to investigate the instructional design used to develop virtual reality and VR implementation in physical education during the previous five years. The high percentage of ADDIE IDs used in previous studies conclude that it is the most popular and suitable instructional design in VR development. However, it is important to continue exploring the other three IDs, especially Bloom's Taxonomy, because there is evidence that VR may be used to improve higher-order thinking abilities in physical education by using this ID. Still, it can also experiment in other fields like health education or the public health department. In addition, even though several researchers stated different tones of statement to clarify whether the undergraduates are the only option for applying VR-based applications or not, this systematic review concludes that the group are not the only option for applying VR-based applications. Thus, the results will help the researcher know which issues need to be explored more for future research.

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