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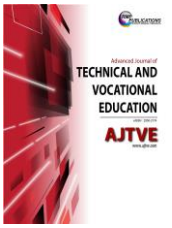

Augmented Reality Technology in Physical Education: A Systematic Review in Instructional Design, and AR Implementation Option Over the Last 5 Years.

Ummie Haniffah Binti Ariffin, Nur Azlina Binti Mohamed Mokmin, and Muhammad Aminuddin Akmal Bin Mohd Hamizi*

Centre for Instructional Technology & Multimedia, Universiti Sains Malaysia,
11800 USM, Pulau Pinang, Malaysia.

Abstract: Augmented Reality (AR) is one of the advanced digital technologies that is being used in education. As its growth globally, significant research has demonstrated the value of AR as a pedagogical resource in a variety of educational settings. However, little is known regarding the contribution of AR technology in the teaching and learning process in the context of Physical Education (PE), necessitating a thorough investigation. Hence, this systematic review is presented to identify the most commonly used instructional model in developing AR materials for PE and its implementation option towards undergraduates over the previous 5 years. With a total of 22 research papers analysed in this review, this paper provides vital insight that meets the study's objectives. The findings indicate that ADDIE was the most frequently used instructional design by the previous researchers, and AR technology adoption was not the only option for undergraduates in the last five years.

Key words: *AR Technology, Instructional Design, Digital Learning Application, Physical Education, AR-Assist Instruction,*

INTRODUCTION

Digital technologies are increasingly being employed to assist in the teaching and learning processes. As the country was afflicted by a pandemic outbreak, the trend of incorporating digital learning applications during lessons grew significantly. Augmented Reality (AR), one of the forms of digital technologies, is also not left behind. Unlike virtual reality where the environments are completely virtual, AR creates a mixed reality that offers the perception that virtual objects are present in the real world [1]. AR also has the ability to projects augmented images to users through optical see-through displays or see-through video displays, which are most commonly used in conjunction with a hand-held mobile device, such as a smartphone or tablet [2]. In light of the current dominance of gadgets such as tablets and smartphones in our country today, mobile-based AR has emerged as the most commercially viable product when compared to other types of AR technologies such as projector-based AR or Spatial Augmented Reality (SAR), and wearable augmented reality (WAR) [3].

In the present age, AR can be used in a variety of areas including educational aspects. There are a lot of subjects that are already emphasized in the utilization of AR. However, for subjects such as Physical Education (PE), the growth of research study or available AR apps in the market is still lacking. It is an important course that was introduced by the Ministry of Education (MOE) which previously applies video-assisted instruction in order to integrate the knowledge of sports with skill drilling [4]. It is also known as one of the subjects for the K-12 school curriculum in the form of a series of classes to guide students to become physically educated by encouraging people to promote good health by the exploration of sports and health activity [5]. Learning environments that utilise AR technologies have previously been known to be effective in promoting an active learning approach, owing to their ability to transfer taught knowledge into long-term memory after it has been learned [6]. In the intersection of AR and PE, some researchers underlined the suitability of this technology in PE class [7], [8]. One of the advantages of incorporating AR technologies into PE is that it can improve training experiences thanks to the use of a 3D camera that records every movement of a player which helps to describe the procedures and possible corrections based on the collected footage [9]. So that, the students can practice independently without the need to be frequently monitored by their coach. Besides that, it also has great potency to deliver the content in a three-dimensional perspective, (i) to facilitate simultaneous

Corresponding Author: Nur Azlina Binti Mohamed Mokmin, Centre for Instructional Technology & Multimedia, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Malaysia,+604-6536267

and collaborative learning opportunities, (ii) to transform the invisible to visible, and (iii) to connect the gap between formal and informal learning environments [10]. As it allows the combination of numerous media types such as text, audio, video, and animation to construct a great virtual space, it has excellent potential in attracting and immersing students into the learning process [11], [12]. This allows educators to upgrade traditional methods in teaching by blending the lessons with the use of AR technologies. Thus, this technological advancement brings about a new trend in adopting AR to various educational subjects such as astronomy [13], mathematics [14], physics [15], including physical education [4].

As the evolvement of educational technology arises, some researchers agree that Malaysia's schools have reached a high level of readiness to the adoption of AR in their educational settings [16] [17]. However, from the perspective of university students, particularly undergraduates, new technologies have generally been adopted quickly [18]. Not only that, some of those technologies have become incredibly useful resources in their education. This is demonstrated by the use of E-learning. As a consequence, does this technology provide them with an additional option in addition to the other approaches to educational technology that they are presently using?

In order to develop a good pedagogical resource, an instructional design model needs to be used. Instructional Design (ID) is generally defined as the systematic development of instructional specification which consists of the entire process of evaluating the learners' needs, establishing the ultimate aims and objectives of instruction, designing and developing the materials, implementing and assessing all instructional and learner activities to ensure the instructional quality [19].

There are many types of Instructional Design (ID) models that were proposed and widely used for the development. However, in this study, only four among the most popular ID were chosen, which are ADDIE, Bloom's Taxonomy, Gagne's Nine Events of Instruction, and Merrill's Principles of Instruction. ADDIE ID is a model which is more concerned with course structure rather than the learning process of learners which differs from the other three models. Due to many ID models having several traits with ADDIE, ADDIE's structure that comprises analysis, design, development, implementation, and evaluation become the most popular ID used for the development.

Bloom's Taxonomy, Gagne's Nine Events of Instruction, and Merrill's Principles of Instruction are more concerned either only with the learning process of learners or balance between the two [20]. Each of these models has its focus. Bloom's Taxonomy ensures that students get over the difficult stages of remembering and comprehending new material [21]. Gagne's Nine Events of Instruction is based on the mental event information processing model [22]. While, Merrill's Principles of Instruction, enhance learning when creating and developing training programs [21]. Thus, in producing an effective instructional design specifically in the context of education, the significance of each model needs to clarify.

Even though these AR technologies are suited to be embedded in PE or sports, many studies said that the AR-assist instruction is infrequently applied in those areas [4], [8]. Thus, this paper presents a systematic review of the implementation of AR in PE which leads to the following research questions as a guideline for conducting the study and investigating the applicability of AR in PE; (i) What is the instructional design used to develop augmented reality? (ii) Is AR-based application an option for undergraduates?

Finally, the instructional design that is being used to develop AR will be identified in this research. It will also be clarified whether or not it is possible to adopt AR among undergraduates over the preceding five years (2017-2021).

METHODOLOGY

In this section, the methodology or process used to perform the systematic review will be presented and discussed in detail. This explanation includes the search approach used to identify all the relevant previous studies and, their eligibility criteria up until the total number of relevant studies that will be utilised to assess the result at the conclusion.

Search Strategy

A systematic review flow process, PRISMA developed by Liberati [23] was utilised as a guideline for performing a systematic review in this study. The PRISMA's flow procedure which includes identifying relevant primary studies from available databases, screening titles, and abstracts, determining eligibility, and selecting the best papers to include, was designed to acquire the most relevant primary studies for the aim of a systematic review.

To gather significant studies linked to augmented reality technology, numerous databases were consulted, including Google Scholar, Scopus, IEEE Xplore, and Springer. Since this systematic search was undertaken to assess papers linked to AR in physical education, many other educational disciplines, such as mathematics, science, and history, have been identified in the literature. In order to maintain the relevance of this study and achieve its objectives, only articles published in peer-reviewed journals about augmented reality technology in physical education from 2017 to 2021 were considered.

As a starting point, several search strings that included a combination of AND while OR operators

were used to locating relevant research. The AND operator was used to combine multiple terms, and the OR operator was applied to identify alternative phrases [24]. In order to obtain related articles on the application of instructional design in augmented reality, the following search keywords were used: ("Augmented Reality" OR "AR") AND "Instructional Design," which produced a total of 177 research when all databases were combined. While searching for related papers on AR technology in physical education, search strings such as ("Augmented Reality" or "AR") AND ("Physical Education" or "Sports" or "Physical Activity") were used, yielding a total of 1360 studies in total.

Following that, the title and abstract screening will be performed on the total number of research papers obtained in both interests, (i) AR and Instructional Design, and (ii) AR in Physical Education, respectively. This procedure will exclude studies that are irrelevant or that are not open access. During this phase, a total of 1534 research papers will be brought forward to the next phase, which involves identifying the most relevant studies among them.

Finally, the qualifying criteria for the studies that were chosen will be determined. Those papers that do not fulfill the predetermined criteria will be excluded from consideration, while the remaining papers will be considered. It will be necessary to obtain and read the whole text from the selected studies in order to complete this step, which will be accomplished through a skim and scan method. A total number of relevant studies will be acquired after the study. This document will be thoroughly examined in order to answer each of the research objectives that were previously stated. The illustration of the flow process can be referred to in Figure 1.

Eligibility Criteria

In designing eligibility criteria that consist of inclusion and exclusion for selection of relevant research studies, a study conducted by Methley that differentiated between PICOS, PICO, and SPIDER search was used as the reference [25]. Thus, in this study, PICO (population, intervention, comparison, and outcomes) for quantitative studies and SPIDER (sample, phenomenon of interest, design, evaluation, and research type) for qualitative studies were chosen and used for reporting this systematic review.

Inclusion

For inclusion criteria, access to the full text of the selected research studies is required. When conducting research, it is critical to make certain that the studies under consideration meet the criteria and are appropriate for analysis in order to achieve the objectives of the present study. Those studies are required to meet the following requirements, (a) the research studies need to be published between 2017 to 2021 to keep the relevance of this study, (b) the language used must be in English, (c) include participants from various ages and backgrounds, (d) the used of AR technologies as the intervention during the experiment, and (e) provides findings or outcomes from those experiments. Since some of the objectives are to insight the trend of AR technologies in PE context and instructional design used for AR development, the additional requirement for the sixth criteria is either (e) AR intervention used in PE, sport, or physical activity or (f) the use of an instructional design model for AR development.

Through this selection process, 22 primary studies were chosen. From this amount of research papers, only 6 studies discussed the instructional design model used for AR development, while the rest are the intervention of AR in PE context including, sports and physical activity (see Figure 1).

Exclusion

There are several criteria to be excluded during the selection phase. Those research papers that do not match the inclusion criteria as indicated previously, have poor quality, or lack of references stated will be disqualified from the consideration. In addition, since the AR intervention in the experiment is one of the inclusion criteria, studies that have no control group and merely evaluate the usability of AR technologies will not be taken into the consideration as well. Thus, this eliminates a total of 240 research studies as illustrated in Figure 1 below.

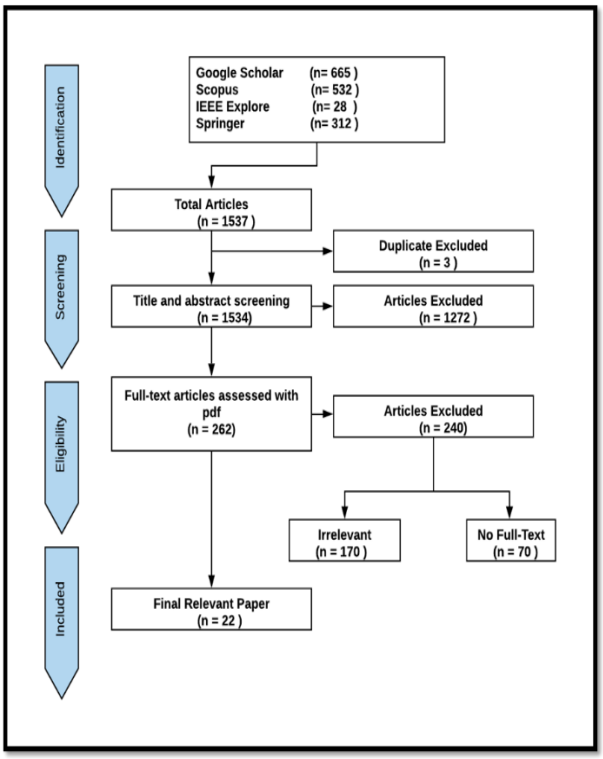

Figure 1 PRISMA-based selection flowchart

RESULT

In this section, the methodology or process used to perform the systematic review will be presented and discussed in detail. This explanation includes the search approach used to identify all the relevant previous studies and, their eligibility criteria up until the total number of relevant studies that will be utilised to assess the result at the conclusion

Instructional Design (ID) used for AR (RQ1: Which is the instructional design model used most for augmented reality development?)

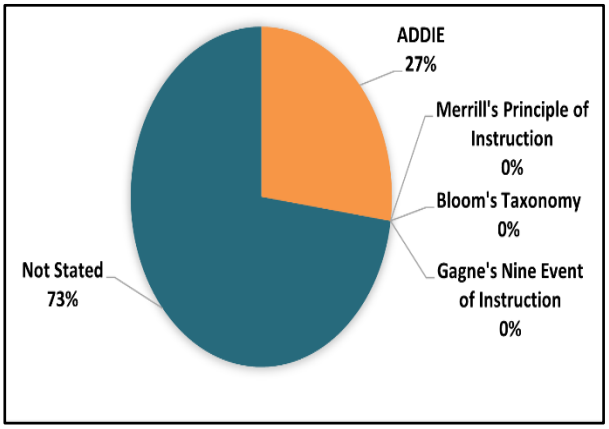

Figure 2 The most Instructional Design used in AR

As illustrated in Figure 2, none of the articles reviewed discussed IDs used in AR development such as Merrill's Principle of Instruction, Bloom's Taxonomy, and Gagne's Nine Event of Instruction. However, findings indicate that 27% of the publications implemented ADDIE as the selected ID when designing AR applications. Moreover, from this value, none of the papers mentioned the ID used in constructing AR applications related to PE, sports, or physical activity context. These articles discussed the use of ADDIE in the development of AR application in science subjects such as Astronomy [13], Physics [26], as well as Bahasa [27], English [28], business [29], and educational technologies [30].

Two points can be deduced from this data. To begin, the ADDIE paradigm is the most frequently used ID for creating augmented reality instructional products. This is because ADDIE is straightforward to implement and has a structure that applies to a wide variety of learning contexts [30]. Secondly, there is still a lack of research examining the IDs used in augmented reality applications, particularly those on PE, sports, or physical activity rather than IDs in AR applied to other subjects, especially related to science. It shows that the implementation of AR in PE learning still has less interest among the researchers.

To conclude, among four the most popular IDs as stated previously, ADDIE, Bloom's Taxonomy, Gagne's Nine Events of Instruction, and Merrill's Principles of Instruction, ADDIE is most frequently used as a systematic guideline in designing an AR learning material.

AR-based for undergraduates (RQ 2: Is AR-based application an option for undergraduates?)

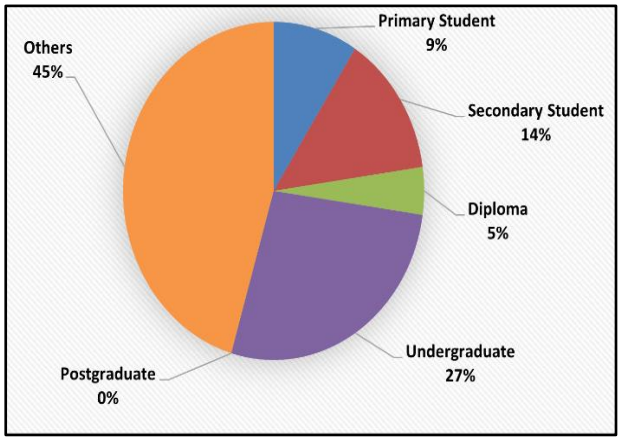

Figure 3 Population in AR application

Figure 3 demonstrates an illustration of a pie chart that depicts the overall outcomes of studies conducted on the sampling population that contributes to AR intervention. This sampling population varies from different educational backgrounds ranging from elementary and secondary schools to diploma programs, undergraduates, and even postgraduates students.

According to Figure 3, of the various types of sampling populations mentioned before, 27% of the research chose undergraduate students as their sampling population, resulting in a total of six articles with a range of ages from 18 to 24 years [29]–[34]. This followed by 14% for secondary students with ages ranging from 13 to 17 in three articles [12], [26], [35], and 9% for primary school students aged 7 to 12 years in two articles [27], [28]. Moreover, there is an article that combines both samplings of undergraduate and diploma program students, which consists of 387 undergraduates and 36 diploma students where in this article, an AR game, Pokemon Go, was used to test the effect of physical exercise on the level of physical activity among university students [36]. *Another* category in ten articles used other types of sampling population without specifically narrowing down its selected population group such as [13], [37]–[45].

Thus, Table 1 below shows the summary.

No.	*Sampling Population for AR*	*No of Papers Discussed*	*Percentage*
1	Primary Student	2	9%
2	Secondary Student	3	14%
3	Diploma	1	5%
4	Undergraduate	6	27%
5	Postgraduate	0	0%
6	Others	10	45%

Table 1 Summary of Sampling Population for AR

Essentially, the data does not support a statistically significant conclusion on whether augmented reality apps are a viable option for undergraduate students or not. This is due to the fact that there are numerous other sorts of educational technology that can be employed or are already being used by university students, particularly for undergraduates, such as learning management systems (LMS) like Google Classroom and interactive whiteboards like Google Jamboard which are commonly used in teaching and learning. It is supported by the statements made in research by researcher Saez-Lopez [46] which underlined that university students do not typically use this AR technology at the university.

To conclude, an AR-based application is not the only option to be used by undergraduate students. However, to produce educated graduates who have intelligence and various experience in using advanced digital technologies, emerging technologies for educational purposes need to be done. Therefore, many studies implement this AR intervention among undergraduates as visualized in Table 1.

DISCUSSION

This systematic review aimed to reveal the instructional design (ID) used most to develop an AR and to determine either AR technology is an option for undergraduates in PE or not for the last 5 years (2017-2021) and clarify the future of AR in PE. Overall, between the four IDs, there is no significant declaration on the best models since they are all present. All of them have their focuses, strengths, and weaknesses. As for ADDIE, the focus is more towards the course structure, Gagne's focuses on learning through behaviourism, while Bloom's and Merril's emphasise memory's role in learning and activating numerous intelligence [20], [21]. According to the study's findings, the ADDIE model is the most common ID that most of the researchers used to develop AR for learning materials. This may be due to its adaptability and simplicity as well as its reliance on the course structure rather than the learning process of the learners. However, from these findings, none of them were found embedding IDs to develop AR related to PE. It shows that the topics on instructional design for PE were not popular compared to other subjects such as science.

Besides that, AR is not the only option for undergraduates. According to research question 2's outcome, it shows that undergraduates are the most popular sampling population. Even though it is the highest sampling option, AR is still not an option for them. This is because, in university, the undergraduates had currently used a variety of digital technologies such as e-Learn as their additional materials for their learning but as stated by researcher Saez-Lopez [46], AR was not habitually embedded in university's teaching and learning. Therefore, to keep pace with digital transformation and produce a good quality of graduates with full experience and knowledge in digital technologies, the implementation of AR technology towards undergraduate education is recommended.

Thus, for the future of augmented reality in physical education, this study advises utilising the benefits promoted by augmented reality technology and implementing them specifically in the context of physical education, physical activity, or sports. This is because there is a scarcity of research examining the usage of AR in PE. Apart from that, rather than building AR only through the use of ADDIE, which focuses on course structure, working on developing AR through the use of alternative models is also encouraged.

CONCLUSION

In this work, a systematic review study was carried out, with the focus being on the implementation of AR in the context of physical education. According to the findings, the data reveal that the number of research associated with PE has increased over the past five years, from 2017 to 2021. The debut of an augmented reality game, Pokemon-Go, has become one of the starting points that may pique the curiosity of academics who wish to learn more about the game's impact on one's level of physical activity. Thus, these trends also make the study related to PE and sports, which had also become their new interest. Aside from that, the statistics on the variables, which are frequently employed by researchers, also contribute to the development of new ideas in this study. Future studies can make use of these findings to pique their interest in conducting research using variables that were rarely employed in the prior studies. Although the data shows that an AR application is not an option for undergraduates, integrating their learning with contemporary technologies is crucial. Therefore, in developing an AR application that focuses on course structure, researchers can utilise the ADDIE as their ID

in their development process. Thus, future study regarding the implementation of AR in PE needs to be done.

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