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Immersive Learning Research Network

Work-in-Progress—VR Implementation in Classrooms: A TPACK Perspective

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Abstract. Research studies have generally focused only on VR learning's advantages and the introduction of learning content through VR, rather than providing useful information to support educators in integrating VR into their classrooms. In this work-in-progress paper, we aim to determine what preparations should be considered and organized as a VR-based learning arrangement. The Technological Pedagogical Content Knowledge (TPACK) framework is a useful lens that provides insight on how to successfully implement VR in the classroom. Through a literature review of research studies, we identify considerations teachers and instructors should consider before implementing VR in their classrooms. Aligned with the TPACK framework's Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK) areas, VR features such as demanding a high quantity of data and enough space require teachers and instructors to prepare sufficient internet connection, batteries, individual physical spaces and prior experience as TK components. Similarly, VR experiences depend on personal activities, and the arrangement of educational goals, assessment systems and applications for the classroom's diversity is crucial.

Keywords: Virtual Reality (VR), Technological Pedagogical Content Knowledge (TPACK), Arrangement.

1 Introduction

Due to the adverse effects of COVID-19, teachers and instructors had to seek a replacement of the traditional learning system with alternative new technologies. Virtual Reality (VR) - based instruction is a nascent area with tremendous growth in recent years; Huawei's Intelligent World 2030 report predicted that the number of VR and AR users will reach 1 billion by 2030 [1]. VR has recently been applied to teaching several subjects, such as astronomy [2], art history [3], and language learning [4].

To implement VR for students' learning, teachers and instructors must conduct significant preparations before their students' usage. The previous research illustrates that teachers with knowledge of AR/VR-based instruction are highly aware of the usefulness and ease of AR/VR use in teaching and learning [5]. Compared to AR and VR, although AR usually requires smartphones as the device, VR contains various devices. Hayes, Daughrity, & Meng [6] illustrates different VR devices' utilization respectively; thus, preparations for VR are more complicated than AR. On the other hand, many previous kinds of research focused only on VR learning's advantages and the learning through VR [2-4, 7]. In fact, teachers have some concerns about the application of VR in their instruction, especially operational factors and technical support pre-instruction phase and during students' VR play session [8]. Therefore, in this article we aim to determine what preparation should be considered for VR-based learning arrangement. The goal of this review of research also includes support for teachers and instructors' knowledge about VR learning for future integration of VR into their instruction.

2 Methods

VR-based education contains many differences from traditional technological media because of its intrinsic characteristics. As aforementioned, past research analyzed the effects of educational VR, but most studies did not mention or provide considerations regarding the practical implementation of VR; hence, organized illustration of educational VR preparation helps improve our understanding. To identify various practices and arrangements for VR learning, a useful perspective is provided through a well-known framework: Technological Pedagogical Content Knowledge (TPACK).

2.1. Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) has been described as a framework for teacher knowledge for technology integration [9]. It consists of three main components of a teacher's knowledge: content, pedagogy, and technology.

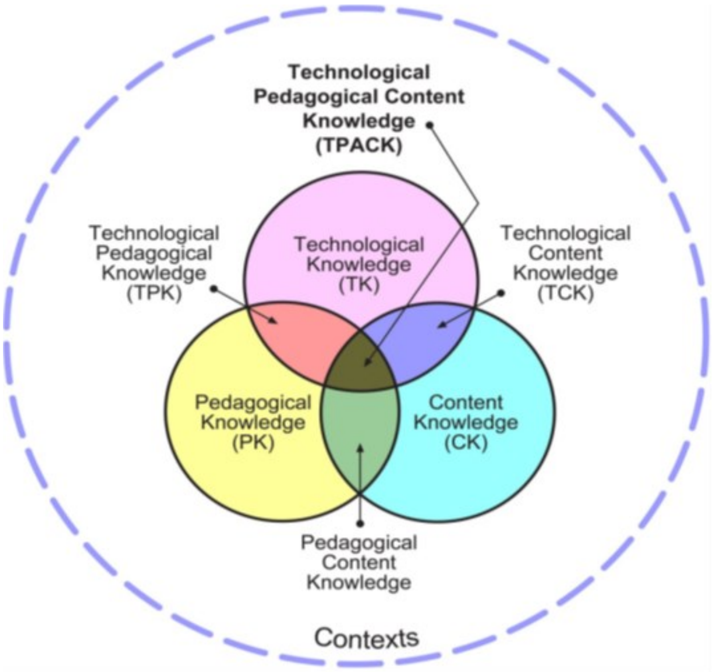

Fig. 1. The knowledge components of the TPACK framework [9].

One of the most significant advantages of this framework is that it highlights the interactions between and among the three components. It allows instructors to understand diverse contexts and integrate educational technology into classroom instructions [9]. Some research revealed the possibilities of application of the TPACK framework for practical situations and classrooms [10-12]. In addition, the research on K-16 lesson plans through Virtual Reality (VR) illustrated the effectiveness of the TPACK framework [13]. It suggested an integration strategy of VR in the classroom of tying course learning outcomes with the integrated VR experiences. This research focuses on illustrating the preparation of VR learning, including technological and pedagogical factors; thus, TPACK is suitable.

2.2. Related Components of TPACK to VR Implementation

In the context of VR learning preparation, the following two pieces of knowledge should be considered.

- Technological Knowledge (TK)
- Technological Pedagogical Knowledge (TPK)

At first, TK is knowledge about certain ways of thinking about, and working with technology, tools and resources [8]. The primary usage of VR tools like headsets and knowledge of VR's advantages and disadvantages can be included in this component. Furthermore, TPK is an understanding of how teaching and learning can change when specific technologies are used in particular ways. VR learning's advantages and disadvantages might change the teaching procedure. For instance, it is necessary to keep adequate physical space for experiencing VR applications, and this limitation will make instructors iterate the methods of instructional transfer.

Although Technological and instructional media shifts also influence technological Content Knowledge (TCK), our review of the literature does not include TCK perspectives. According to Koehler and Mishra, teachers need to understand which specific technologies are best suited for addressing subject-matter learning in their domains and how the content dictates or perhaps even changes the technology [9]. TCK highly relies on different subjects, and we do not profoundly delve into this area in this article. We aim to support teachers and instructors in improving their understanding of educational VR implementation; thus recognition of VR content is excluded from this study.

2.3. Search Strategy and Selection Process

This research was conducted through the following procedure to identify the arrangement and preparation of VR learning.

To detect relevant research results about essential preparations and arrangements for educational VR in the classroom, we searched with the following keywords through SCOPUS.

("virtual reality" OR "VR") AND ("education" OR "learning")

At the same time, these results were limited to studies that had been published since 1 January 2018. The reason why this condition was applied is based on the invention of standalone VR headsets. The device entails several characteristics especially suitable for the classroom, such as relatively low price and portability, and these features allow users to experience VR in a much more accessible way than previous VR devices [14]. These developments also affected VR learning situations; hence, this limitation was applied. In addition, only results in the U.S. were selected for inclusion. Each country has completely different contexts associated with unique cultural factors and politics; therefore, we decided to narrow our scope. The search generated 3661 references to journal articles, conference papers, and book chapters (see Fig. 2).

Furthermore, the keyword "school" was added because these results included various experiments, such as in universities and vocational training. This addition to the keyword search produced 276 references, many of which were excluded from this research because of the inconsistency of VR devices; these types of study did not utilize standalone VR headsets (see Fig. 2).

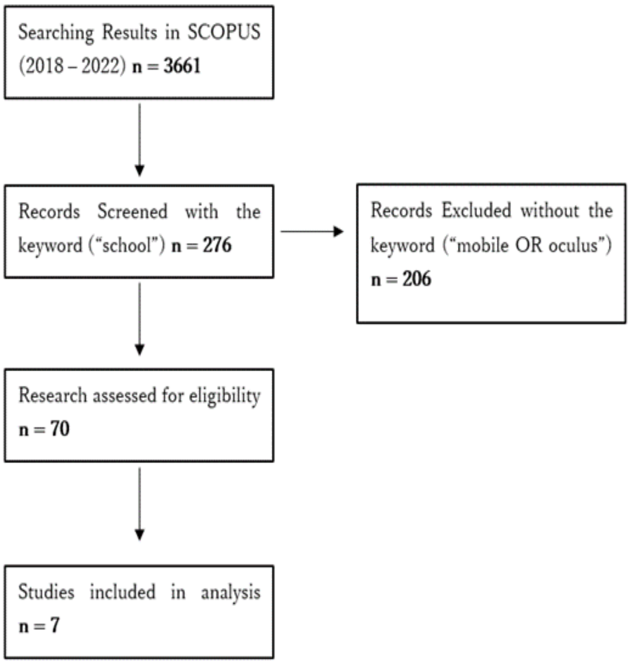

Fig. 2. Selection Process Flowchart.

Finally, the remaining 70 articles were analyzed to identify only relevant research focused on practical usage or experiments in classrooms from elementary to high school. 17 studies targeted undergraduate, graduate or vocational school students. Fifteen studies focused primarily on augmented reality or mixed reality; similarly, five studies did not focus on VR-based learning, and the other two applied Google cardboard for their experiments. Although these tools can be utilized for education, we did not include them in order to reduce the scope and narrow our focus. Seven papers described results in foreign countries, not the U.S., and five studies described the progress of creating VR content. Finally, eight studies did not include any empirical findings but were constructed as general commentary articles, and four articles were not accessible, so they were also excluded from our sample.

Consequently, seven studies met the exclusion criteria. These studies contain positive experiment results, limitations of VR as the media, and the necessary preparation or arrangements for conducting VR learning in the classroom. Technological limitations of VR are associated with Technological Knowledge (TK), and the necessary conditions for teachers to deliver VR learning are linked with Technological Pedagogical Knowledge (TPK). Thus, these perspectives were identified in this research result.

3 Findings

Before diving into deeper analysis to identify arrangements of educational VR in the classroom, we provide participant information and key findings of seven relevant studies were illustrated in Table 1 below. These studies found two distinct findings; essential components for most instructional media and particular conditions for VR. For instance, arrangements of assessments, the importance of prior knowledge, and consideration of diverse ethnicity and ages are standard requirements for every instruction [16, 18-20, 22]. On the other hand, VR has many specific characteristics, such as time limitation of experiencing content, the necessity of a stable connection to the Internet, and attention to motion sickness [17-19, 22].

Table 1. Key Findings of Relevant Studies.

ID	Authors	Participants	Key findings relevant to this research
1	L. M. Castaneda, S. W. Bindman,	277 students (14 - 17 years old)	・Derailing pedagogical goals ・Detracting assessments

	and R. A. Divanji		
2	R. M. Araujo-Junior and A. M. Bodzin	35 middle school students (10 - 14 years old)	・Time limitation (50-minute class period) ・Technical issues
3	E. Nersesian, M. Vinnikov, J. Ross-Nersesian, A. Spryszynski, and M. J. Lee	34 middle school students (5th - 8th grade)	・Preference to play VR more than maximum play time of 20 minutes ・Some cases of motion sickness and eye strain ・Gender-specific tendency
4	M. Thompson, A. Wang, C. Bilgin, M. Anteneh, D. Roy, P. Tan, R. Eberhart, and E. Klopfer	111 students (14 - 19 years old)	・Relationship between pre knowledge and gain from VR experience
5	I. Kuznetcova, M. Glassman, S. Tilak, Z. Wen, M. Evans, L. Pelfrey, and T.-J. Lin	169 students (12 - 14 years old)	・Impact of age differences, prior game experiences and ethnicity
6	A. Bodzin, R. A. Junior, T. Hammond, and D. Anastasio	57 students (16 - 18 years old)	・Difficulty of reading text ・Some cases of motion sickness
7	E. Ebrahimi, B. Morago, J. Stocker, A. Moody, A. Taylor, T. Pence, M. Jarrett, and B. Blackport	4 students (4th, 5th, 5th, 10th grade)	・Necessity of sufficient instruction, time of practice ・Difficulty of some tasks (holding objects, teleporting) ・Connection to the Internet

Based on the findings of Table I, it is necessary to interpret some of them into practical preparations and arrangements of VR learning in the classroom. For example, teachers and instructors must arrange an adequate schedule of students' educational VR experiences to ensure the time limitation of a class period. The following results explain the identification of necessary preparations and arrangements for them to conduct educational VR experiences aligned with the segmentation of TK and TPK. This identification includes essential components for most instructional media and particular conditions for VR.

A) Technological Knowledge (TK)

- Sufficient internet connections
- Plentiful batteries or charges for VR device
- Enough lesson times for experiencing VR learning
- Prior instructions and training about VR
- Technical support for students' unintentional problem
- Determination of physical spaces for each student

B) Technological Pedagogical Knowledge (TPK)

- Goal settings of the educational VR experience
- Assessment plans
- Classroom Management
- Suitable lesson plans for classroom diversity
- Blueprints of the whole progress

According to the literature review, TK includes six necessary arrangements to execute VR learning in the classroom, and TPK contains five components.

At first, teachers and instructors should consider fundamental technical preparations, such as the internet and batteries. VR needs many quantities of data to depict the entire immersive world, so usage of the internet and batteries are much higher than other instructional devices. Similarly, the VR experience is far from different media experiences, and users sometimes struggle to continue playing because of the originality of the control system and motion sickness [22]. Therefore, teachers and instructors should arrange multiple schedules of educational VR experiences and enough time for students' experience. Finally, they must figure out how many physical spaces are available in reality for individual students' educational VR experiences. Some VR contents allow users to go around in the immersive environment associated with their actual movements. With students' safety and better experiences with educational VR, it is necessary for teachers and instructors to identify this point.

Considering the perspective of TPK, delivering educational VR needs to be planned based on VR's technological features. Although all instructions must design pedagogical plans, the technological characteristics of VR make VR learning different from other instructional tools. One of the features of VR is that users experience content individually. In the educational situation, teachers and instructors cannot control what students experience in the VR environment. Therefore, arranging educational goals, assessment systems and applications for their classrooms' diversity is crucial. In addition, the limitation of the number of VR headsets also should be considered. It may be necessary to separate their classrooms into some groups, so the management plan of the classroom is another essential viewpoint that teachers and instructors should predict before VR instructions.

4 Discussion and Conclusion

As research studies about VR for classroom usage have proliferated in recent years, most focus only on VR learning's advantages and the introduction of educational VR content. Teachers and instructors also need practical information so that they can integrate VR learning into their classrooms. The purpose of this paper was to identify the necessary preparations and arrangements for integrating educational VR into the classroom. In particular, we hope that teachers and instructors would utilize the findings of this paper to improve their understanding of educational VR implementation.

In this paper, we illustrated some arrangements teachers and instructors should consider before coordinating VR learning in their classrooms. Aligned with the TPACK framework's Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK) areas, eleven factors were identified as significant for implementing educational VR. VR demands a high quantity of data in a short time and enough space for each player; thus, they must arrange sufficient internet connection, power management and individual physical spaces as TK components. It also requires several prior experiences for students related to the singularity of VR systems. In addition, they should recognize that VR learning also needs special essential preparations as TPK components. VR experiences rely on individual activities, so they must arrange educational goals, assessment systems and applications for their classrooms' diversity. This aspect also requires them to manage their classrooms more efficiently.

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