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Exploring the intersections of TAM and TRI models in middle school VR technology acceptance

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Background: In recent years, the attitudes of middle school principals toward virtual reality (VR) have received much attention from the educational technology community. As VR continues to gain popularity in education, researchers have begun to explore middle school principals' perceptions of VR using the Technology Acceptance Model (TAM) (perceived usefulness, and perceived ease of use) and Technology Readiness Index (TRI) (optimism, innovativeness, discomfort, and insecurity) models to explore middle school principals' perceptions of VR. This helps to reveal the influencing factors of middle school principals' acceptance of VR, which in turn provides theoretical support and guidance for promoting the application of VR in education.

Methods: To explore the factors influencing the acceptance of VR by middle school principals. We searched several databases such as Google, Scopus, and Elsevier. We focused on peer-reviewed English-language publications on VR, TAM, TRI, and middle school education from 2013 to 2023.

Results: Through the literature review, we found that middle school principals' intention to use VR was significantly influenced by the TAM (perceived usefulness, perceived ease of use) and TRI (optimism, innovation, discomfort, and insecurity) models. In addition, there was some degree of intersection between the dimensions of the TRI and TAM models.

Conclusion: VR has been widely recognized by middle school principals as an educational tool. By providing an immersive and interactive experience, VR can be effective in improving the efficiency of school operations to a great extent.

KEYWORDS

technology acceptance model (TAM), technology readiness index (TRI), virtual reality technology, middle school principals, educational leadership

Introduction

In recent years, there has been a growing interest in research on principals' acceptance of VR (Liou and Chang, 2018; Huang et al., 2020; Makransky and Mayer, 2022). This trend seems to reflect the desire in education to utilize emerging technologies to improve the learning experience. However, the existing literature does reveal a distinct research gap regarding an in-depth exploration of the factors influencing VR acceptance from a principals' perspective. This article will critically analyze the literature from different countries and regions to explore the multifaceted factors that contribute to the acceptance of VR by middle school principals.

Much current research on this topic has explored VR acceptance primarily from the perspectives of teachers and students (Merchant et al., 2014; Radianti et al., 2020). For example, a study by Radianti et al. (2020) found that students were more willing to use VR when they felt VR provided an immersive learning experience. Similarly, Merchant et al. (2014) indicated that teachers were more willing to use VR when they saw VR combined with instructional goals to personalize instruction. However, principals play a crucial role in the decision to introduce VR. In this context, Militello et al. (2021) study provides insights into the practicalities of principals' use of VR platforms to observe classroom scenarios and provide personalized feedback to teachers to improve instruction and student achievement. This perspective helps to deepen our understanding of principals' acceptance of VR technology, thereby providing theoretical and practical guidance for principal decision-making.

Nonetheless, there is a relative dearth of existing research focusing on VR acceptance factors at the principal level, which provides an unprecedented research opportunity for this paper. In exploring the factors influencing principals' acceptance of VR technology, Okafor (2023) mentioned high cost as a reason for low VR usage among principals. However, whether this observation is generalizable and holds in specific contexts in different countries and regions needs to be further explored. There is a need for a clearer definition of costs, including hardware costs, software costs, training costs, and maintenance costs (Ogheneovo, 2014).

In addition, Storey and Cox (2015) suggested that VR can enhance student engagement and interest in learning, prompting principals to have a positive attitude toward using VR. However, we also need to carefully consider the learning experience and learning effectiveness of VR for students. Although VR may have advantages in enhancing student engagement and interest in learning. However, whether VR can sustain a positive effect on long-term learning outcomes, and whether it applies to various educational contents and learning objectives, also needs to be thoroughly considered and investigated. The study by Liu et al. (2020) found that VR can improve academic performance to a certain extent, but more long-term empirical studies are still needed to validate this view. In particular, there is a need to examine students' memory and application of VR learning content over a longer period, as well as the effects of long-term VR use on students' motivation and behavior (Makransky et al., 2019). Furthermore, Fowler (2015) noted that different disciplines and learning objectives may require different types and levels of VR course design. Therefore, it is necessary to conduct research in different subject areas to verify the applicability and effectiveness of VR in different subjects and learning objectives.

Research from Ridenour et al. (2005) provided new perspectives in terms of a comprehensive understanding of the factors influencing principals' acceptance of VR. They pointed out that principals are happy to use VR because of its ability to provide personalized instruction to meet the diverse learning needs of students. This perspective bridges with existing research and also expands our understanding of the importance of integrating instructional methods and technology in principals' decision-making. However, Prestridge (2019) mentioned that personalized instruction is not only dependent on technology but also on teachers' expertise and teaching philosophy. This means that although VR can provide more flexible learning styles, truly effective personalized instruction requires teachers to play an active role in instructional design and implementation.

Notably, Lege and Bonner (2020) pointed out that not all educational institutions and students will be able to fully benefit from VR for principals' decision-making. Santamaría-Bonfil et al. (2020) further explained that with limited resources, principals need to weigh the pros and cons and take into account the balance between VR inputs and teaching effectiveness. That is, although personalized instruction is one of the important advantages of VR applications in education. However, various factors such as the actual situation of education, technology investment, and teachers' professional development need to be considered in principals' decision-making to ensure that VR can truly enhance the quality of teaching and learning.

To summarize, the existing literature has yet to draw comprehensive and universally applicable conclusions when examining the factors influencing the acceptance of VR by middle school principals. This article critically analyzes the complex impact that different factors have on middle school principals' attitudes toward VR and calls for future research to explore this topic in greater depth.

Method

Searching strategy

In our methods, we used critical review. According to Grant and Booth (2009) "an effective critical review presents, analyzes and synthesizes material from diverse sources"(p.93). The purpose of this mini-review was to present the literature related to influencing principals' acceptance of VR. Therefore, this article summarized the previous studies as follows. First, information was obtained from Google, Scopus, and Elsevier databases by searching for "virtual reality," "Technology Acceptance Model," and "Technology Readiness Index." The search was limited to articles published between January 2013 and August 2023 in English. The first search used all combinations of the above keywords and, after an initial review, produced 430 potentially relevant articles (Google: 312, Scopus: 107, ScienceDirect: 11).

In the second stage, secondary terms, "principal," "acceptance," and "education," were added, which reduced the number of studies to 74 (Google: 69, Scopus: 2, Elsevier: 3). Of these, 356 did not meet the criteria and were excluded. They were excluded because they targeted an audience of teachers and did not address the factors influencing principals' acceptance of VR from a leaders' perspective. In the final stage, another 64 articles were excluded because they were duplicates or designed to study either technology leadership, or both. Ultimately, the full text of their work was reviewed to determine if their work fit the focus of this study. Ten articles (Google: 9, Scopus: 1) qualified for the final review, covering a sample of studies on factors influencing principals' acceptance of VR, and were included in the analysis.

Inclusion and exclusion criteria

To ensure the caliber of the literature, we only chose peer-reviewed journal papers written in English and published within the previous 10 years. We mainly chose research papers on the characteristics in the educational context that impact principals' acceptance of VR since the major goal of this study was to analyze the factors that affect middle school principals' acceptance of VR. Studies not written in English,

studies that did not explore factors influencing VR acceptance from the perspective of principals, and studies published beyond the previously established time and language were excluded. In addition, selected articles were identified and evaluated by manually searching for references to topic-related articles, of which 22 met the eligibility criteria. As a result, 22 additional articles were added to the 10 identified. In total, 32 studies that met these eligibility criteria were included and reviewed here. The detailed inclusion criteria are shown in Table 1.

Result

The review found that the number of publications increased each year from 2014 to 2023, demonstrating the continued interest of researchers in exploring the factors influencing middle school principals' use of VR (see Figure 1). The most used factors in studying the influence of VR on user acceptance are Davis et al. (1989) TAM and Parasuraman's (2000) TRI. Davis et al. (1989) article was cited the most, 37,919 times, indicating that the study was highly influential in

TABLE 1 Publications reviewed in full text with reasons for inclusion.

First author	Title	Year	Reason for inclusion
Au	VR in education.	2017	Describes how virtual reality can support learner learning.
Abd Majid	TAM-based VR acceptance factors.	2019	Introduction to TAM and VR.
Buttussi	VR training impact.	2018	The application of head-mounted displays VR is evaluated.
Blut	TRI impact on technology use.	2020	Compares the advantages and disadvantages of TRI and TAM.
Boel	Principals' acceptance of VR.	2021	TAM-based exploration of middle school principals' acceptance of VR.
Chen	The impact of VR on students.	2016	The impact of VR on student learning is described.
Cook	VR challenge.	2019	Describes the challenges principals face when using VR.
Cunningham	Principal leadership challenge.	2022	Explores VR education to enhance principals' cross-cultural leadership.
Dhiman	VR enhanced empathy.	2023	The use of VR to enhance leaders' empathy is presented.
García-Vandewalle García	Technology in disadvantaged educational settings.	2022	Analyzes the challenges of principals using VR in deprived areas.
Huang	VR in the classroom.	2019	Compares traditional technology and VR technology in the classroom to help enhance student learning.
Holly	VR teaching	2021	The potential of VR for use in teaching and learning environments is explored.
Hamilton	VR learning.	2021	Highlights the advantages of head-mounted displays VR for student learning.
Joshi	TAM and TRI explanatory learning.	2023	TAM and TRI are analyzed against each other.
Jiang	Impact of educational technology.	2023	Comparative analysis of the advantages and disadvantages of traditional teaching methods and VR teaching.
Keane	Innovative principal leadership.	2020	The advantages of principals using VR in the classroom are discussed.
Liou	VR in the classroom.	2018	The study explores the positive effects of VR on the academic performance and motivation of middle school students.
Marangunić	TAM literature review.	2015	Introduction to TAM.
Mawela	Digital skills.	2020	Introduction to VR and TAM.
Militello	VR improves leadership.	2021	VR is studied to improve principal leadership.
McNamara	TRI improvements.	2022	The relationship between TAM and TRI is explored.
Makransky	VR learning benefits.	2022	The benefits of head-mounted displays VR for learning are explored.
Okafor	VR integration in schools.	2023	Discussed how principals can integrate VR into their schools.
Rauniar	Use of TAM.	2014	Introduction to TAM.
Radiant	VR in education.	2020	The benefits of head-mounted displays VR for use in education are discussed.
Rodríguez-Espíndola	VR management.	2022	The advantages and disadvantages of VR, as well as the challenges of managing VR, are introduced.
Storey	VR builds leadership.	2015	The role of VR in leadership enhancement is highlighted.
Slater	VR improves lives.	2016	Head-mounted displays VR is highlighted.
Stavroulia	VR training.	2016	The challenges of using VR are analyzed.
Shin	VR teaching.	2022	Introduces the challenges leaders will face using VR for different scenarios.
Zhang	VR safety.	2017	Introduce the VR experience in different scenarios.
Zuo	TAM influences principals' attitudes.	2021	Explore factors influencing principal technology acceptance.

the field of users' acceptance of VR. Parasuraman's (2000) article has been cited 4,112 times and has also had a significant impact on the research community. Most articles have 10 or fewer citations, which may indicate that these studies are relatively new or have less impact in the field. It was important to note that recently published articles such as Joshi and Sondhi (2023) did not have as much time to accumulate citations, so their impact on the field may not have been fully reflected in current citations.

To summarize, the differences in the number of citations of these articles highlight their different levels of influence in the area of factors influencing VR acceptance among middle school principals. However, there are some limitations to the research methods. For example, some articles may not yet fully reflect their impact on the domain in current citations due to their short time frame, which may result in less comprehensive findings. The literature included was small, and in the future, we will consider expanding the search of literature and databases, such as PubMed and the EBSCO database, as well as expanding the search with keywords, such as "principals' attitudes toward VR." In addition, the inclusion and exclusion criteria may have limited the generalizability of the findings, and therefore more caution is needed when generalizing the findings.

Technology Acceptance Model and Technology Readiness Index

Davis developed TAM in 1986 as an adaptation of Ajzen and Fishbein's (1975) Theory of Reasoned Action (TRA). TRA assumes that human beings are rational and consider the implications and consequences of their actions by combining various pieces of information before engaging in a particular behavior (Ajzen and Fishbein, 1975). Davis builds on this foundation by proposing the Technology Acceptance Model, identifying Perceived Usefulness (PU) and Perceived Ease of Use (PEU) (Davis, 1989). PU refers to "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p.320). PEU refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p.320). That is, when people perceive a new technology to be more useful and easier to master, they are more inclined to adopt it.

TAM provides an easy-to-understand framework for research in a variety of technologies, including VR (Szajna, 1994; Rauniar et al., 2014; Marangunić and Granić, 2015). For example, teachers' attitudes toward VR may be influenced by whether VR improves pedagogical effectiveness and user-friendly interfaces (Abd Majid and Mohd Shamsudin, 2019). Students' attitudes toward VR may be influenced by the effectiveness of VR in understanding complex concepts and the comfort level while wearing the VR device (AlYoussef, 2020). In addition, principals' attitudes toward VR may be influenced by whether VR improves the efficiency of school operations and compatibility with existing computing systems (Gefen and Straub, 2000; Huang et al., 2019; Zuo et al., 2021; Rodríguez-Espíndola et al., 2022; Jiang, 2023). These studies demonstrate that TAM is a reliable model for understanding user acceptance.

At the same time, we need to recognize that TAM is not without its limitations. First, the TAM has limited coverage and cannot take into account additional factors. For example, Srite and Karahanna (2006) noted the TAM for focusing primarily on individual-level factors that did not capture broader organizational, such as "national culture and values factors" (p. 679) that influenced technology acceptance. Similarly, Teo et al. (2008) noted the TAM for not explicitly considering "external variables such as technological infrastructure or social influences" (p. 131). The consequences of not taking these factors into account result in a narrow view of the user that does not reflect the full range of factors affecting technology acceptance. Here, the question arises: are there other factors besides PU and PUE? To better answer this question, considering other models such as the TRI may be useful to help us better understand the other factors that influence middle school principals to reject or adopt VR.

Parasuraman first proposed the TRI in 2000, referring to the "peoples' propensity to embrace and use new technologies for accomplishing goals in home life and at work" (Parasuraman, 2000, p.308). TRI consists of four dimensions: "optimism, innovativeness, discomfort, and insecurity" (Parasuraman, 2000, p.38). The first two are incentives that increase peoples' intention to use the new technology, and the second two are disincentives that decrease people's intention to use the new technology (Parasuraman, 2000). A study applying TRI to VR reveals that principals using VR may consider optimism (expectations of the benefits of VR on student outcomes) and insecurity (uncertainty about the long-term effectiveness of VR) (Storey and Cox, 2015). Teachers adopting VR may consider optimism (positive expectations of VR's impact on instructional outcomes) and innovation (teachers' openness to exploring and adopting VR) (Radianti et al., 2020). In addition, students adopting VR may consider optimism (VR enhances the learning experience) and discomfort (VR causes eye strain) (AlYoussef, 2020).

The TRI combines multiple dimensions more comprehensively than the TAM to provide an assessment of user acceptance of the technology (Blut and Wang, 2020). Moreover, TRI also synthesizes the external environmental factors that influence technology acceptance (Hung and Cheng, 2013). Of course, it is important to recognize that TRI is not without its limitations. According to McNamara et al. (2022), the TRI involved more "complex questionnaires" (p.11) than the TAM, which could be challenging to administer in some research contexts. In addition, Blut and Wang (2020) also noted that TRI may not have gained insight into the nuances of technology use because it was based on "an individuals' general inclination toward technology" (p. 652). Instead, TAM focuses on two specific factors (PE and PEU) that reflect technology-specific perceptions.

To summarize, the available literature shows that TAM and TRI have their strengths and limitations. Strengths include the simplicity and ease of use of TAM and the integration of personal attributes and external factors in TRI. Limitations are that TAM may ignore external factors such as technological infrastructure or societal influences, and TRI complexity may limit understanding of nuances. Considering these dimensions together in an educational context provides a better understanding of the attitudes and perceptions of teachers, students, and principals regarding the adoption of VR. The next section will use the different dimensions of the TAM and TRI to explore the factors that influence middle school principals' acceptance of VR.

Middle school principals' perception of VR

This section explores the factors that influence the adoption or rejection of VR by middle school principals based on the different

dimensions of TAM and TRI. There are several main reasons for the latest research on this topic. As the introduction mentions, current research on the use of VR factors focuses on teachers and students, with fewer studies specific to middle school principals (Merchant et al., 2014; Chen, 2016; Radianti et al., 2020). Although some studies investigate the attitudes of middle school principals toward VR use, the scope is broad, mixing the perspectives of elementary school and university principals. For example, Hamilton et al. (2021) recognized that "they do not restrict their analysis to exclusively one domain of education" (p. 4). It is worth noting that the perspectives of principals at different educational levels may vary due to factors such as the age of the students, their level of education, and the curriculum (Morris et al., 2012; Tarhini et al., 2015; Maponya, 2020). This review focuses on middle school principals' perceptions of VR. The literature included in this section reflects the following knowledge claims about the relationship between middle school principals and VR:

(1) It is a fact that principals' use of VR is influenced by PU and PUE.
(2) Similarly, the principal use of VR is influenced by the four TRI dimensions.
(3) There is some degree of intersection between the dimensions of the TRI and TAM.

We illustrate these claims by citing articles from a variety of contexts and focusing on the factors that influence the adoption or rejection of VR by middle school principals.

In regards to the first claim, Militello et al. (2021) and Cunningham et al. (2022) all noted that principals' perceptions of VR are determined by how useful they believe VR is to the efficiency of school operations and how easy to use is. For example, Militello et al. (2021) noted that "school leaders used VR to build their classroom observation and analysis skills to prepare to have more effective post-observation conversations with teachers" (p.286). In addition, Cunningham et al. (2022) found that principals found it easier to embrace VR if they perceived VR to be user-friendly, intuitive, and requiring minimal technical expertise to implement. To summarize, the views of these authors exemplify the fact that principals' use of VR is influenced by PU and PUE.

In regards to the second claim, García-Vandewalle García et al. (2022) and Militello et al. (2021) found that principals who were optimistic about the potential of VR to improve student classroom engagement, academic achievement, and classroom management effectiveness were more inclined to adopt VR. This finding reflects the optimism of middle school principals' attitudes toward VR. Similarly, Keane et al. (2020) and Zhang et al. (2017) illustrated that VR can change traditional didactic classrooms into experiential real-world simulations for education, and this innovativeness may attract middle school principals to VR. This finding reflects the innovativeness of middle school principals' attitudes toward VR.

In addition, according to Brown and Jacobsen (2016) and Boel et al. (2021), principals were discomforted by the fact that prolonged wearing of head-mounted displays may cause eye fatigue for students. This discomfort may be related to the time and light settings of the VR devices used. This finding echoes the discomfort of middle school principals with VR. Similarly, Jiang (2023) mentioned that principals were discomforted that schools in deprived areas may not have enough funds to purchase and maintain VR equipment. This means that students in deprived areas may not be able to get equal access to education. In sum, these studies reflect principals' discomfort with VR, which may limit principals' adoption of VR.

Finally, Peled et al. (2011) noted that there may be insecurity on the part of principals about the use of VR leading to the disclosure of students' personal information (such as name and age). Shin and Kim's (2022) study also noted principals' insecurity about the use of VR in small classrooms that could trigger limited student movement and instructional accidents such as collisions or accidental falls. These findings suggest that principals may have some concerns about student privacy and safety when introducing VR, leading to a more cautious adoption of VR. In sum, these authors' perspectives exemplify that principals' use of VR is also influenced by the four TRI dimensions.

Regarding the third claim, Svendsen et al. (2013) demonstrated that "optimism had significant relations to PU, PEU, or both" (p. 324). Their study recruited 30,000 Norwegians from a web panel at the Statistical Office, from which 1,004 participants (505 females and 499 males) aged 15 years or older were randomly selected. Their research results revealed that "the 'optimism' dimension of the TRI had the strongest impact on technology adoption through its positive impact on PU and PEU"(p.324). In addition, Agarwal and Prasad (1997) found that the "technology acceptance model attempts to explain and predict individual behavior toward an innovation, manifest through innovation utilization or system use" (p. 560). This literature seems to respond to our view that there is some degree of intersection between the dimensions of the TRI and TAM models.

To summarize, we illustrate our three claims by citing these articles with some new findings. For example, principals' acceptance of VR is influenced by a variety of factors, including TAM, TRI, school resources, culture, location, and more. In addition, due to factors such as the age, education level, and curriculum of students, direct transfer of the attitudes of principals at different education levels to middle school principals may not be appropriate. Therefore, there is a need to examine the unique factors that influence the attitudes of middle school principals in adopting VR to understand the advantages and disadvantages of VR in middle school education.

Advantages and disadvantages of VR for future schools

There are currently four types of VR in the market: desktop virtual reality, immersive virtual reality, augmented reality virtual reality, and distributed virtual reality (Buttussi and Chittaro, 2018). This section mainly focuses on immersive virtual reality. Immersive VR provides a fully immersive experience that gives the user the feeling of being completely immersed in a virtual world (Slater and Sanchez-Vives, 2016). Immersive VR typically uses head-mounted display devices to provide a virtual sensory space in which the user is immersed (Slater and Sanchez-Vives, 2016).

Immersive VR, as an innovative technology, has multiple advantages but also presents challenges for the future of schooling (Cook et al., 2019). In terms of advantages, immersive VR education provides an opportunity for middle school principals to improve their Scientific and Technological Literacy (STL) (Au and Lee, 2017). Scientific and Technological Literacy (STL) is not only

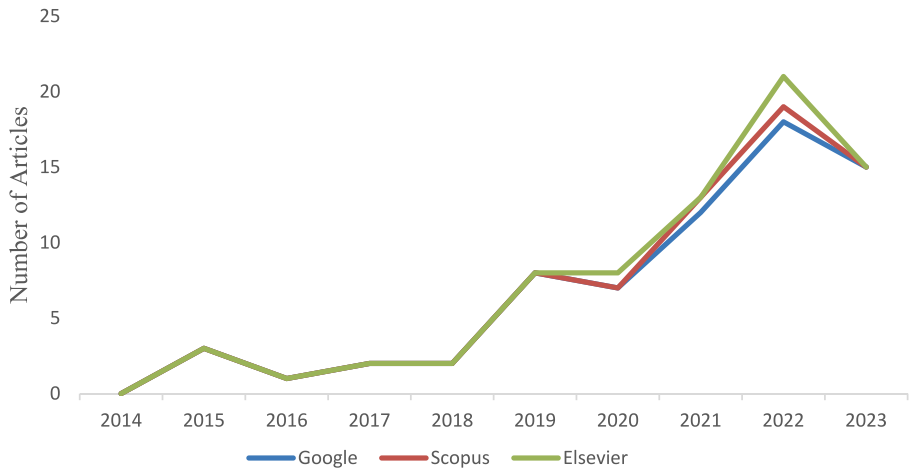

FIGURE 1
Number of publications in different databases.

about people having knowledge and skills related to science and technology, such as information and communication, but also "a cultural practice that involves values, ethics, and rules" (DiGironimo, 2011, p. 1339). For example, through the use of VR, middle school principals can simulate various scenarios by playing the role of a teacher dealing with problematic student behavior (such as bullying, or smoking) or coping with instructional stress (Dhiman, 2023). In this way, VR can evoke empathy in principals, thereby promoting greater consideration of moral and ethical norms in decision-making. Similarly, Johnson and Luo (2012) examined the role played by VR in cross-cultural communication. They selected a school with students from 140 countries and territories for a case study. Johnson and Luo's (2012) research found that VR can help principals and international students communicate effectively and enhance principals' cross-cultural understanding of cross-cultural leadership.

In a further example, the study by Peled et al. (2011) aimed to understand the optimal learning experience and safety of students when using VR. The researchers contacted and interviewed 14 principals about the effectiveness of principals' use of VR to simulate actual student experiences and address technology issues that students may encounter. Peled et al. (2011) suggested that principals could use VR to model the challenges that students face when using school equipment or accessing websites, and thus develop more effective rules to govern VR use. In short, using VR for education, principals can gain a deeper understanding of how to consider ethics, values, and rules when making decisions, thus promoting STL among middle school principals.

While the use of VR education can enhance the STL of middle school principals, there are some challenges. For example, Brown and Jacobsen (2016) mentioned that the complex technology and software involved in VR education, require middle school principals to have a certain level of technological knowledge and skills to operate and manage VR equipment. Holly et al. (2021) study explored a range of potential challenges in the design, usability, and pedagogical application of VR experiences. The study was conducted with 26 practicing teachers and 59 students and focused on identifying and discussing the challenges of teaching with VR. Holly et al. (2021) findings suggested that VR was better suited to subjects that required immersive experiences or simulation of specific environments. Whereas, subjects that require interpersonal interaction, cooperation, and social skill development may be more suited to traditional teaching methods. That is, not all educational content is suitable for VR, and middle school principals need to judge when to use VR for education to ensure the suitability and educational value of VR.

Furthermore, the aim of Stavroulia et al. (2016) study was to investigate the usefulness of principals' use of VR for training teachers on bullying. Stavroulia et al. (2016) findings suggested that specialized VR training sessions and support from principals for teachers could be particularly useful in educating teachers about bullying. In summary, although VR education can enhance STL, ethical decision-making, and pluralistic values in middle school principals. However, principals also need to be aware of the challenges of technical difficulty, applicability, and teacher training when using VR education.

Conclusion

This article explores the factors influencing middle school principals' acceptance of VR based on different dimensions of TAM and TRI and considers the advantages and disadvantages of VR in educational settings. In general, middle school principals' use of VR is influenced by both TAM and TRI. There is also some degree of intersection between the dimensions of the TRI and TAM models. This finding helps us understand the concerns and considerations of middle school principals when evaluating immersive VR integration into their schools.

However, we also recognize the following limitations of the study that warrant caution about the conclusions and results. First, the small sample limits the generalizability of the results. Second, regional and individual differences may have influenced principals' attitudes. In addition, limitations of the study methods such as inclusion and exclusion criteria lead to more cautious generalization of the results. Finally, this article overly relied on TAM and TRI while ignoring the influence of other theories on middle school principals' acceptance of

VR, such as Rogers (2003) Diffusion of Innovations theory. Future research could use larger samples, consider regional diversity, synthesize other theories (for example, diffusion of innovations), and employ mixed research methods (such as questionnaire surveys and focus group discussions) to enhance the credibility and applicability of the study.

Author contributions

XL: Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. BL: Conceptualization, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. MZ: Funding acquisition, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. ZY: Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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