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ORIGINAL RESEARCH ARTICLE

Virtual learning environments and digital twins: Enhancing accessibility, diversity, and flexibility in training secondary educational administrators

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ABSTRACT

This study investigates the potential of Virtual Learning Environments (VLEs) and digital twins to overcome geographical, scheduling, and diversity barriers in the training of secondary educational administrators. Recognizing the limitations in traditional in-person visits to schools-particularly for graduate students in rural areas and those working fulltime with dependents-and the current ethnic composition of educational administrators, where White individuals comprise 64.5% of the population in the US (71.01% for principals), this research explores how VLEs can democratize access and foster diversity in educational leadership training. Over the academic year 2022–2023, pre- and post-engagement surveys were administered to students in a Visionary and Innovative Leadership course that employed a digital twin of a middle school. The virtual environment allowed students to explore the school and interact with its mission and vision principles at their own pace, from any location, and as frequently as required. These digital tools not only offered a homogenous and repeatable experience but also enabled a deeper, self-directed investigation into how an institution's mission and vision are operationalized within its physical environment. Findings from the study indicate that VLEs and digital twins offer considerable potential in terms of accessibility, flexibility, and diversity in educational leadership training. Through the integration of these innovative technologies, future leaders can experience immersive, interactive, and inclusive learning environments, contributing to a more diverse and effective educational leadership landscape.

Keywords: Virtual Learning Environments (VLEs); digital twins; educational leadership; training; accessibility and diversity; mission and vision in education

1. Introduction

Educational equity remains a significant challenge in today's educational landscape, particularly when it comes to providing equitable experiences and training to working educators across different regions and districts[1]. In many instances, educators grapple with geographic, technical, and temporal constraints that limit their access to comprehensive and practical training opportunities[2]. This is particularly relevant in the field of educational administration, where first-hand understanding and exposure to different educational spaces are crucial[3]. With recent advancements in digital twin technology, however, the limitations of distance, physical constraints, and time are increasingly being overcome. Systems like Matterport now allow for the rapid capture of large interior spaces, transforming them into immersive virtual environments within a matter of hours[4].

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For example, in this study, a digital twin of a complete school serving 9,000 students was created, offering an unprecedented opportunity for experiential learning.

Despite these advancements, there has been limited research on the viability of digital twin technology for the training of educational administrators, particularly in graduate programs such as Master's in Educational Administration[5]. The potential benefits, such as flexible access, repeatable experiences, and an immersive understanding of physical space, are yet to be thoroughly explored and validated in academic contexts. In the program under consideration, is an advanced program aimed at individuals seeking certification at the superintendent level in the state of Missouri. The program provides the necessary skills and knowledge to effectively manage a school district, offer advice and recommendations to a board of education and the community, and tackle challenges in the ever-changing field of education. The coursework is carefully designed to align with the competencies and specific requirements set by the Missouri Department of Elementary and Secondary Education for certification in superintendent positions. The program provides aspiring educational administrators with the necessary qualifications and expertise to excel in leadership roles within school districts and equips students with the knowledge and skills to navigate the complexities of educational administration, make informed decisions, and contribute to the improvement of educational institutions.

Educational leadership training plays a crucial role in preparing aspiring administrators to navigate the complex challenges of the educational landscape[6]. Effective educational leaders must possess a diverse set of skills, including strategic planning, decision-making, communication, and problem-solving, to successfully lead schools and districts. The significance of educational leadership training cannot be overstated, as the quality of leadership directly impacts the overall success and performance of educational institutions[7]. Well-trained and competent educational leaders are essential for creating positive learning environments, promoting student achievement, and fostering a culture of continuous improvement[8].

In this context, the use of virtual reality (VR) and related technologies holds immense potential for enhancing the teaching quality in educational leadership training programs. VR technology provides a unique opportunity to create immersive and interactive learning experiences that simulate real-world scenarios, enabling aspiring leaders to develop their skills in a safe and controlled environment[9]. By leveraging VR, educational leadership training programs can offer realistic simulations of complex situations that educational leaders often encounter. For instance, VR can recreate challenging scenarios involving school management, community relations, budgeting, crisis response, and decision-making[10]. Through these immersive experiences, aspiring leaders can develop critical thinking skills, practice effective communication strategies, and learn how to make informed decisions in high-pressure situations.

The use of VR-related technologies in educational leadership training can also facilitate collaboration and networking among aspiring leaders. Virtual environments can be created where participants from different locations can come together, engage in discussions, and share experiences[11]. This fosters a sense of community and provides opportunities for collaborative problem-solving and knowledge exchange. Improving the teaching quality in educational leadership training with VR-related technologies has the potential to revolutionize the field. By providing realistic and experiential learning opportunities, VR can bridge the gap between theory and practice, equipping aspiring leaders with the skills and confidence they need to excel in their roles[12].

As such, this study bridges the research gap by exploring the application of digital twins and Virtual Learning Environments (VLEs) in a leadership course. Our focus is on how these emerging technologies aid in identifying and navigating physical spaces within an educational setting, particularly in operationalizing an institution's mission and vision[13]. Over the academic year 2022–2023, both pre- and post-engagement surveys were administered to students in a Visionary and Innovative Leadership course that employed a digital twin of a middle school. Students interacted with a school principal, conducted interviews regarding the school's mission and vision, and subsequently navigated the digital twin to see how these principles are manifested within the school's physical space.

The digital twin of the middle school in Saint Louis, MO was created using the Matterport System that allows for the precise capture and representation of physical spaces in a virtual format. This innovative system utilizes 3D scanning technology to create a highly accurate and immersive digital replica of the school building. To provide students with an immersive viewing experience, the Oculus Quest 2 headsets were employed. The Oculus Quest 2 is a standalone virtual reality headset that offers a high-quality and interactive virtual reality experience. By wearing the Oculus Quest 2 headsets, students were able to enter the digital twin of the middle school and explore its various rooms, hallways, and facilities as if they were physically present within the school.

The combination of the Matterport System and the Oculus Quest 2 headsets allowed students to engage with the virtual environment in a realistic and immersive manner. This technology facilitated a unique and interactive learning experience, enabling students to navigate through the school, observe its layout, and gain a deeper understanding of its physical spaces. By leveraging this digital twin technology and virtual reality headsets, students were able to explore the middle school in a way that transcended traditional photographs or videos. This immersive approach provided a valuable opportunity for students to familiarize themselves with the school's physical layout, aiding in their understanding of the school's facilities and enabling them to better connect with the educational environment.

The utilization of the Matterport System and Oculus Quest 2 headsets demonstrates the potential of virtual reality technology in education. It opens up new possibilities for interactive and experiential learning, allowing students to engage with educational content in a more immersive and meaningful way. The use of digital twins and virtual reality has the potential to revolutionize the educational landscape by offering enhanced visualization, experiential learning opportunities, and expanded access to educational environments[14]. Results of the study, gleaned from these surveys, demonstrate the viability of digital twin technology for educational administration training. We discovered a positive correlation between the use of digital twins for environmental training and students' learning outcomes, presenting compelling evidence for the potential of VLEs and digital twins as innovative tools for leadership training in education.

2. Literature review

Research on the educational potential of digital twins is emerging but remains largely focused on the training of undergraduate students, often within engineering and business disciplines[15–17]. The concept of the digital twin, derived from industrial applications and business processes, has gradually permeated educational spheres, yet its utilization for training in relation to the physical environment of schools and classrooms is scant[18]. Digital twins are virtual replicas of physical entities, interconnected with their real-world counterpart, enabling the simulation, prediction, and optimization of performance in a safe and controlled environment[19]. The industrial sector has leveraged these capabilities to enhance manufacturing processes, asset management, and product lifecycle management[20]. For instance, Tao et al.[21] highlighted the role of digital twins in Industry 4.0, where the fusion of digital and physical systems allows for improved decision-making, efficiency, and innovation.

However, despite their promising applications, the transfer of these technologies to the field of education, specifically to educational administration and the understanding of physical environments of schools, has been relatively unexplored[22]. Undergraduate education has seen some innovation in this regard, with studies exploring the use of digital twins for complex system comprehension in physics and engineering programs. In the wake of the fourth industrial revolution, also known as Industry 4.0, there has been a significant shift in the manufacturing sector from conventional automated systems to Internet of Things (IoT) and cloud computing-driven cyber physical systems[23]. Furthermore, as David et al.[24] posit, manufacturing pedagogy and training have not kept pace with these rapid advancements. Opoku et al.[25] propose that the use of digital twins of manufacturing processes to deliver effective learning experiences and note that their high-fidelity replication of physical systems supports detailed observation and fosters concrete learning. Despite learning factories' attempts to address these challenges, barriers such as limited mapping abilities, high cycle time products, space and cost issues, and fixed locations persist[26]. Digital twins, with pedagogic extensions, can aid pedagogy, validating learning outcomes against objectives and facilitating ontological reasoning. Vikhman and Romm[27] likewise examined the prospects and reality of "digital twins" in education. Their focus, however, was on understanding the process and outcomes of implementing digital twin methodologies in educational contexts.

In their 2019 study, David et al.[24] expanded on their previous research and noted that with the transformations brought by Industry 4.0, Internet of Things (IoT) and cloud computing also saw a change in teaching methods from traditional to more hands-on approaches, resulting in the development of learning factories designed for training and educating students in an academic setting. However, the researchers noted several limitations of existing learning factories, such as their limited mapping ability, space and cost issues, and fixed locations. Instead, the use of digital twins is proposed with high-fidelity virtual replicas of physical systems in order to address these limitations. By extending the use of digital twins to pedagogic contexts, these technologies can aid in mapping learning objectives, evaluating student performance, and guiding students towards desired skill levels, thus enhancing the learning process within manufacturing systems.

The use of digital twins in education and industry has been an area of significant research, with a multitude of studies shedding light on various aspects of this burgeoning field. In industry, the use of digital twins to develop a workforce and/or to maintain the physical plant is common. Pernelle et al.[28], for example, integrated digital twin and ecological transition in the training process. Their paper discussed the role of digital twins within the context of Industry 4.0 and the management of cyber-physical systems, thereby highlighting the industry-wide applications of this technology. At the same time, greater use in the education sector has been realized.

Sepasgozar[17] highlighted that while mixed reality technologies have experienced rapid growth, their application in the domains of architecture, engineering, and construction (AEC) education is still in its early stages. To remedy this, the study brought to light five groundbreaking digital technologies that make use of virtual and augmented reality and digital twins to boost the effectiveness of construction courses. Furthermore, Zacher[29] shed light on the utilization of digital twins in educating and studying engineering sciences. His emphasis was on how digital twins, serving as software replicas of industrial plants, could be virtually simulated and visually represented in ways that mirror their real-world counterparts closely.

In a similar vein, Johra et al.[30] showcased digital twins of experimental laboratory setups for building physics for enhanced e-learning. Their stance was that digital twins are not meant to replace physical experiments but to facilitate more flexible teaching methodologies and improve learning efficiency, all at a reduced cost. Further evidence of the growing prevalence and broad applications of digital twin technology comes from Flaga and Pacholczak[31], who presented a digital twin for educational and training purposes within a web application. Their discussion revealed an increase in tools being developed for the creation of digital twins, indicating the ever-expanding nature of this field. Lastly, Pajpach et al.[32] built an educational platform for digital twins employing the OPC UA and Unity

3D. They observed significant progress in the conception, realization, and application of digital twin technology in recent years, thus accentuating its current pertinence and future expansion possibilities.

Considering the study at hand, Sorochan et al.[33] explored the concept of a digital twin as an ecosystem for professional development, with a particular focus on postgraduate education. Their study highlighted the transition from traditional learning management systems to digital learning environments that promote efficient lifelong learning and professional development for teachers. However, the role of digital twins in leadership and administrative training, particularly in the context of spatial navigation and understanding within a school environment, is almost non-existent in the current literature[34]. This gap becomes more pronounced when considering the potential benefits that these technologies could offer in terms of accessibility, repeatability, and equity[35]. As digital twins allow for interaction with a virtual environment at any time and from any place, they could be a powerful tool to ensure all students, regardless of their geographical location or personal constraints, have equal access to comprehensive learning experiences[31,36].

These studies, along with others, demonstrate the diverse ways in which digital twins can be utilized in both educational and industrial contexts, and suggest a rich potential for further research and application. The potential of the technology for remote teaching demonstrates the ability of digital twins to provide experiential learning in a broader range of disciplines and at varying educational levels remains untapped. As a result, there is a clear need for research exploring the use and benefits of digital twins and Virtual Learning Environments (VLEs) for the training of educational administrators, specifically in relation to understanding and operationalizing the mission and vision within a school's physical environment. This study aims to contribute to this underexplored area, shedding light on the potential of digital twin technology to foster equitable, immersive, and innovative learning experiences in educational administration.

3. Methodology

In this longitudinal mixed-methods study, data was collected from pre- and post-assignment surveys administered to two different cohorts, instructor feedback, and artifacts (content generated within the Virtual Learning Environment, or VLE). The sample was drawn from two groups of educational administrators enrolled in a training program at a private, four-year, liberal arts institution located in the suburban region of St. Louis, Missouri. The Fall 2022 and Spring 2023 cohorts, each comprising educational administrators (n = 29), were the participants.

The study aimed to assess the efficacy of a new instructional approach that incorporates digital twins, an emerging technology, into the training of educational administrators. The technology and digital twin of a middle school in the St. Louis region (**Figure 1**) was introduced to the participants towards the end of the Fall 2022 term, and again in the Spring 2023 term. As a part of their training, the administrators were asked to navigate a digital twin of their respective educational institutions. They used this virtual model to understand and practice various administrative tasks, scenarios, and challenges in a risk-free environment. The digital twin technology was introduced via an accessible web application, important due to the decentralized nature of the program (**Figure 2**).

In order to measure the impact of the digital twin-based training approach, pre- and post-training surveys were administered to the administrators. The pre-training survey aimed to capture the administrators' expectations and perceptions regarding the use of digital twins in educational administration. The post-training survey, on the other hand, aimed to gauge the administrators' experiences, perceived challenges, and potential benefits of using digital twins (**Table 1**).

Figure 1. Digital twin of middle school.

Figure 2. Detail of classrooms in digital twin of middle school.

Table 1. Survey questions pre- and post-assignment

Survey question	Pre-survey	Post-survey
Q1-Comfort with technology	In general, how comfortable are you with technology?	-
Q2-Experience with virtual reality technology	Have you ever used virtual reality technology?	-
Q3-Experience with virtual environments	Have you ever viewed a virtual environment?	-
Q4-Virtual learning environment preferences	Rank the ways in which a VLE could assist learning.	-
Q5-Problems encountered during the assignment	Did you encounter any problems in completing the assignment?	-
Q6-Comparison to photographs of the location	Was the experience more useful than viewing photographs?	Was the experience more useful than viewing photographs?
Q7-Comparison to video walkthroughs of the location	Was the experience more useful than watching video walkthroughs?	Was the experience more useful than watching video walkthroughs?
Q8-Inhibition of learning due to technology issues	Did it inhibit your learning in any way?	-
Q9-Motion sickness experience	Did you suffer motion sickness due to the experience?	Did you suffer motion sickness due to the experience?

Table 1. (*Continued*).

Survey question	Pre-survey	Post-survey
Q10-Seated or standing during motion sickness	If you suffered motion sickness, were you seated or standing?	If you suffered motion sickness, were you seated or standing?
Q11-Duration of symptoms dissipation	Did the symptoms dissipate within minutes, hours, days, or weeks?	Did the symptoms dissipate within minutes, hours, days, or weeks?
Q12-Motion sickness in cars or boats	Do you generally experience motion sickness in cars or boats?	Do you generally experience motion sickness in cars or boats?
Q13-Frustration reduction suggestions	If frustrated, what could have been done to reduce or eliminate that frustration?	-
Q14-Frustration reduction suggestions	-	If frustrated, what could have been done to reduce or eliminate that frustration?

These questions were used to gather valuable insights and feedback from the participants regarding their comfort with technology, experiences with virtual reality, perception of the assignment, challenges encountered, and suggestions for improvement. The pre- and post-surveys allowed for a comprehensive assessment of the participants' perspectives before and after engaging with the virtual learning environment.

Data collection for this study involved a mixed-methods approach, which included both qualitative (open-ended responses) and quantitative (close-ended, multiple choice) survey data. The survey was designed to inform future pedagogical strategies for digital twin integration into educational administration training. The survey was administered at the beginning and end of each term, Fall 2022 and Spring 2023, using the Qualtrics platform to ensure the privacy and anonymity of the responses. The collected data were then sorted based on demographic information such as gender identity, age, and years of administrative experience.

Statistical analyses were carried out on the quantitative survey data, while a thematic analysis was conducted on the qualitative data. The results derived from these analyses, in conjunction with the feedback from the instructors and the administrators' performance within the VLE, provided valuable insights into the effectiveness of the digital twin-based training approach[17,31,32].

4. Results

4.1. Demographics

Fall 2022 cohort

The demographic overview of the Fall 2022 cohort provides insights into the age, gender, ethnicity, and race of the participants. In terms of age, none of the participants were in the 18–24 or 55–64 age brackets, nor were there any participants aged 65 or older. The majority of the cohort fell into the 35–44 age range (46.67%, n = 7), followed by participants aged between 25–34 and 45–54, each group comprising 26.67% (n = 4) of the total. Regarding gender identity, two-thirds of the participants identified as female (66.67%, n = 10), while the remaining one-third identified as male (33.33%, n = 5). There was no non-binary or third gender individuals in this particular cohort, and none of the participants preferred not to disclose their gender identity.

Concerning ethnicity, none of the participants in this cohort identified as Hispanic or LatinX. All of the participants (100%, n = 15) selected "No" for this question. Regarding race, the majority of the cohort identified as White/Caucasian (80%, n = 12). Meanwhile, 20% (n = 3) identified as Black or African-American. There were no participants identifying as American Indian or Alaskan Native, Asian, Native Hawaiian or Pacific Islander, or any other racial or ethnic heritage.

Spring 2023 cohort

Starting with age, none of the participants were between the ages of 18–24, or 65 and older. The majority of the participants fell within the 25–34 age bracket, representing 75% (n = 9) of the cohort. The remaining 25% (n = 3) was evenly divided among the age groups 35–44, 45–54, and 55–64, with each of these age groups comprising 8.33% (n = 1) of the total. Looking at gender identity, the cohort was two-thirds female (66.67%, n = 8), and one-third male (33.33%, n = 4). There were no participants who identified as non-binary or third gender, and none of the participants chose not to disclose their gender identity.

In relation to ethnicity, the majority of participants were not of Hispanic or LatinX descent (91.67%, n = 11), but there was a small representation of this ethnicity within the cohort, with one participant (8.33%) identifying as Hispanic or LatinX. Finally, the racial composition of the cohort was predominantly White/Caucasian, with 91.67% (n = 11) of participants identifying as such. There was one participant (8.33%) who identified as Black or African-American. No participants identified as American Indian or Alaskan Native, Asian, Native Hawaiian or Pacific Islander, or of any other racial or ethnic heritage.

4.2. Pre-Assignment surveys

Fall 2022 cohort

The pre-class survey results for the Fall 2022 cohort provided insights into the participant's general comfort with technology, their experience with virtual reality technology, and their perspectives on the potential benefits of a virtual learning environment (VLE). The majority of participants reported some degree of comfort with technology. On a scale of 1 (extremely uncomfortable) to 5 (extremely comfortable), the mean score was 3.6, indicating that participants tended to be somewhat comfortable with technology. 40% of participants (n = 6) indicated that they were somewhat comfortable with technology, while 20% (n = 3) reported being extremely comfortable. 26.67% (n = 4) felt neither comfortable nor uncomfortable, and a small proportion felt uncomfortable to some extent (13.34%, n = 2).

In terms of virtual reality technology usage, a slight majority of participants (53.33%, n = 8) reported never having used this type of technology. However, 40% (n = 6) had used it, and 6.67% (n = 1) were uncertain. When it came to viewing a virtual environment, such as with Google Street View or Google Earth, most participants had done so (86.67%, n = 13), while only 13.33% (n = 2) had not. Among those who had engaged with such technology, the majority (61.54%, n = 8) used a smartphone, 30.77% (n = 4) used a PC/Desktop computer, and a small fraction used a Virtual Reality headset (7.69%, n = 1).

Participants were asked to rank potential benefits of using a VLE in their learning for this class (**Table 2**). The ability to be immersed in an environment and engage in learning activities not possible otherwise both had a mean score of 1.92, suggesting they were viewed as the most beneficial aspects. Meanwhile, experiencing a wider range of examples than could be seen in person had a slightly higher mean score of 2.58, indicating it was seen as somewhat less beneficial. The ability to interact with a virtual environment and the ability to take time in a space at their own pace to learn had higher mean scores (4.25 and 5, respectively), suggesting these aspects were viewed as less beneficial. Understanding a physical space better had the highest mean score of 5.33, indicating it was perceived as the least beneficial aspect of VLE use in this context. It's noteworthy that even though the respondents had varying comfort levels with technology, they generally appreciated the potential benefits of a VLE, especially its immersive nature and the unique learning opportunities it could provide.

Table 2. Fall 2022 cohort ranking of potential benefits of using VLEs

Question	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6
Ability to be immersed in an environment	41.67% (5 participants)	25.00% (3 participants)	33.33% (4 participants)	0.00% (0 participants)	0.00% (0 participants)	0.00% (0 participants)
Engage in learning activities not possible otherwise	50.00% (6 participants)	25.00% (3 participants)	16.67% (2 participants)	0.00% (0 participants)	8.33% (1 participant)	0.00% (0 participants)
Experience a wider range of examples	8.33% (1 participant)	41.67% (5 participants)	33.33% (4 participants)	16.67% (2 participants)	0.00% (0 participants)	0.00% (0 participants)
Ability to interact with a virtual environment	0.00% (0 participants)	0.00% (0 participants)	8.33% (1 participant)	66.67% (8 participants)	16.67% (2 participants)	8.33% (1 participant)
Understanding a physical space better	0.00% (0 participants)	0.00% (0 participants)	0.00% (0 participants)	0.00% (0 participants)	66.67% (8 participants)	33.33% (4 participants)
Ability to take time in a space at my own pace	0.00% (0 participants)	8.33% (1 participant)	8.33% (1 participant)	16.67% (2 participants)	8.33% (1 participant)	58.33% (7 participants)

This table illustrates the distribution of rankings provided by the Fall 2022 cohort for the potential benefits of using a Virtual Learning Environment in their learning experience. The ability to be immersed in an environment and engaging in learning activities not possible otherwise were ranked as the top two potential benefits, followed by experiencing a wider range of examples and the ability to interact with a virtual environment. Understanding a physical space better and the ability to take time at their own pace received lower rankings overall. These rankings provide insights into the participants' perceptions of the value and potential advantages of using VLE in their learning.

Spring 2023 cohort

The pre-class survey results for the Spring 2023 cohort provided insights into participants' comfort with technology, their experience with virtual reality technology, and their perspectives on the potential benefits of a virtual learning environment (VLE). In general, the cohort was very comfortable with technology. On a scale of 1 (extremely uncomfortable) to 5 (extremely comfortable), the mean score was 4.17, indicating that participants were either somewhat comfortable or extremely comfortable with technology. In fact, 41.67% (n = 5) were extremely comfortable, and the same percentage was somewhat comfortable. Only 16.67% (n = 2) felt somewhat uncomfortable or neither comfortable nor uncomfortable.

Regarding virtual reality technology usage, 41.67% (n = 5) of the participants reported having used this type of technology, while 33.33% (n = 4) had not. The remaining 25.00% (n = 3) were uncertain. Interestingly, every participant (100%, n = 12) had viewed a virtual environment, such as Google Street View or Google Earth. Among them, 58.33% (n = 7) used a smartphone and 41.67% (n = 5) used a PC/Desktop computer for this purpose. None of the participants reported using a Virtual Reality headset.

The participants ranked potential benefits of using a VLE in their learning for this class (**Table 3**). The ability to be immersed in an environment and to engage in learning activities not possible otherwise were perceived as most beneficial, with mean scores of 2.18 and 2.27, respectively. The potential to experience a wider range of examples than could be seen in person, to interact with a virtual environment, and to take time in a space at their own pace to learn were seen as less beneficial, with mean scores of 3.36, 3.73, and 4.27, respectively. Understanding a physical space better had the highest mean score of 5.18, indicating it was perceived as the least beneficial aspect of VLE use in this context.

Table 3. Spring 2023 cohort ranking of potential benefits of using VLEs

Question	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6
Ability to be immersed in an environment	36.36% (4 participants)	27.27% (3 participants)	27.27% (3 participants)	0.00% (0 participants)	9.09% (1 participant)	0.00% (0 participants)
Engage in learning activities not possible otherwise	27.27% (3 participants)	18.18% (2 participants)	54.55% (6 participants)	0.00% (0 participants)	0.00% (0 participants)	0.00% (0 participants)
Experience a wider range of examples	9.09% (1 participant)	18.18% (2 participants)	18.18% (2 participants)	36.36% (4 participants)	18.18% (2 participants)	0.00% (0 participants)
Ability to interact with a virtual environment	18.18% (2 participants)	18.18% (2 participants)	0.00% (0 participants)	18.18% (2 participants)	27.27% (3 participants)	18.18% (2 participants)
Understanding a physical space better	0.00% (0 participants)	0.00% (0 participants)	0.00% (0 participants)	27.27% (3 participants)	27.27% (3 participants)	45.45% (5 participants)
Ability to take time in a space at my own pace	9.09% (1 participant)	18.18% (2 participants)	0.00% (0 participants)	18.18% (2 participants)	18.18% (2 participants)	36.36% (4 participants)

This table illustrates the distribution of rankings provided by the Spring 2023 cohort for the potential benefits of using a Virtual Learning Environment in their learning experience. The ability to engage in learning activities not possible otherwise ranked as the top potential benefit, followed by the ability to be immersed in an environment and experiencing a wider range of examples. The ability to interact with a virtual environment received mixed rankings, while understanding a physical space better was ranked higher by the participants. The ability to take time at their own pace received moderate rankings overall. These rankings provide insights into the participants' perceptions of the value and potential advantages of using VLE in their learning.

These results indicate that the Spring 2023 cohort was generally comfortable with technology and had a positive view of the potential benefits of VLEs, particularly their immersive nature and the unique learning opportunities they could offer. This comfort with technology and openness to VLEs may be beneficial for the implementation of technologically-advanced teaching methods.

4.3. Post-assignment surveys

Fall 2022 cohort

The post-assignment survey results for the Fall 2022 cohort provide valuable insights into participants' experiences with the virtual reality (VR) assignment.

Most participants (92.31%, n = 12) reported not encountering any problems in completing the assignment, suggesting the technology and processes involved were generally manageable and user-friendly. Only one participant (7.69%) reported having problems.

Participants generally found the VR experience to be more useful than viewing a series of photographs or watching a video walkthrough of the location. Specifically, the experience was deemed "extremely useful" by 23.08% (n = 3) and "very useful" by 46.15% (n = 6) of participants in both contexts. "Moderately useful" was the response given by 30.77% (n = 4). No participants found the experience to be only "slightly useful" or "not at all useful", suggesting that the VR environment added significant value to their learning experience.

In terms of the potential hindrance of the technology to the learning process, none of the participants (0.00%) reported that the technology inhibited their learning in any way. This implies that the VR experience was generally smooth and free from significant technological issues that could frustrate users or disrupt the learning process.

Concerning motion sickness, most participants (85.71%, n = 12) did not suffer from it. One participant (7.14%) reported experiencing motion sickness, while another one (7.14%) reported somewhat experiencing it. The one participant who did experience motion sickness was seated during the experience. Their symptoms dissipated within minutes, and this participant also reported experiencing motion sickness in cars or boats most of the time.

The overall findings from the post-assignment survey suggest a positive reception of the VR learning experience among the Fall 2022 cohort, with few problems reported, perceived value over traditional methods of representation (like photographs and videos), no reported hindrance to learning due to technology, and very limited instances of motion sickness.

Spring 2023 cohort

The post-assignment survey results for the Spring 2023 cohort provide insight into the participants' experiences with the virtual reality (VR) assignment. In this cohort, none of the participants (0.00%) encountered any problems in completing the assignment, indicating a seamless experience with the technology and procedures.

Participants in this cohort found the VR experience even more beneficial compared to the Fall 2022 cohort. Specifically, when compared to viewing a series of photographs of the location, 57.14% (*n* = 8) of the participants found the experience "extremely useful", while 42.86% (*n* = 6) found it "very useful". Similarly, when compared to watching a video walkthrough, 57.14% (*n* = 8) found the VR experience "extremely useful", 35.71% (*n* = 5) found it "very useful", and only 7.14% (*n* = 1) found it "moderately useful". No participants found the VR experience to be only "slightly useful" or "not at all useful" in both contexts, emphasizing that the VR environment added considerable value to their learning experience.

With regard to whether the technology was a hindrance to learning, most participants (85.71%, *n* = 12) reported that it did not inhibit their learning in any way. However, 7.14% (*n* = 1) indicated that it did, and another 7.14% (*n* = 1) said "maybe". This suggests a slight increase in technological difficulties compared to the Fall 2022 cohort.

Concerning motion sickness, most participants (78.57%, *n* = 11) did not suffer from it. However, a slightly higher proportion of participants compared to the Fall 2022 cohort reported either experiencing motion sickness (7.14%, *n* = 1) or somewhat experiencing it (14.29%, *n* = 2). All participants who experienced motion sickness were seated during the experience, and their symptoms dissipated within minutes. Among them, 66.67% (*n* = 2) generally experience motion sickness in cars or boats sometimes, and 33.33% (*n* = 1) about half the time.

These results suggest an overall improvement in the Spring 2023 cohort's experience with the VR assignment compared to the Fall 2022 cohort, with no reported problems in completing the assignment, a higher proportion finding the experience "extremely useful", and a similar proportion reporting no hindrance to learning. However, there was a slight increase in the occurrence of motion sickness.

4.4. Sentiment analysis of free responses

Pre-assignment responses

The sentiment analysis of the Fall 2022 pre-survey free responses reveals a mixture of neutral and positive sentiments, with a hint of skepticism regarding the role of a virtual learning environment for the class. Overall, the sentiment leans more towards the positive, reflecting curiosity and potential benefits of VR technology in educational settings. Some participants appear unsure about the value of VR, but still display an eagerness to explore its possibilities.

One participant showed enthusiasm about the ability of VR to expand the scope of learning, stating: "There are so many different schools and ways to do things right and wrong. VR could give us opportunities to look at way more examples than we could ever conquer in person!" This highlights the unique affordances of VR in providing diverse and extensive learning examples. Another participant perceived VR's potential in relation to safety procedures, stating: "I think virtual reality could help with beginning of the year procedures like where to go in the event of a fire or some other type of emergency event."

This suggests that VR could be instrumental in practicing and learning about safety protocols.

Meanwhile, a few participants expressed uncertainty or lack of prior experience with VR, as reflected in the statement: "I'm honestly not sure; I've never had to use VR in any classes, so I'm excited to see how it goes." This statement, along with others like it, demonstrates a sense of excitement, curiosity, and openness to the new experience, despite initial uncertainty.

Likewise, the sentiment analysis of the Spring 2023 Pre-Survey free responses also reveals a mix of sentiments from participants regarding the potential benefits and drawbacks of a virtual learning environment for the class. The overall sentiment appears to be primarily neutral, leaning towards positive. Several participants expressed uncertainty or a lack of experience with virtual reality (VR), but also expressed curiosity or a willingness to explore its potential.

One participant expressed a positive sentiment, saying: "If this includes other students at the same time, I would be able to interact and 'meet' other students in my program that I have only interacted with through discussion posts." This shows an appreciation for the interactive potential of VR. Another participant expressed potential benefits in terms of learning, stating: "It can help with multiple types of learning." This reflects the recognition of VR's capability to cater to different learning styles.

On the other hand, some participants expressed uncertainty, as reflected in the statement: "I am unsure if VR is necessary for this type of instruction, but am open to see how it is implemented." This shows a level of skepticism, albeit coupled with an openness to experiencing VR's potential benefits. Interestingly, one participant expressed surprise and intrigue about the idea of using VR in the class: "To be honest, I hadn't really thought this would be possible for this class. I am intrigued by what could be done in a virtual reality setting." This indicates a level of curiosity and potential excitement about the unique possibilities VR could offer in an educational setting.

Post-assignment responses

The sentiment analysis of the post-assignment responses for the Fall 2022 cohort suggests that students generally had a positive experience with the virtual reality component of the class. Notably, the feedback suggests increased familiarity and appreciation of the technology compared to the pre-survey responses. However, there are some mixed sentiments regarding the usability and ease of navigation in the VR environment. Several respondents found navigation to be tricky or challenging, with one student explaining that they "did not grow up playing 3-dimensional games", and thus initially found the VR environment difficult to navigate. Despite these challenges, most participants acknowledged the engaging and novel nature of the VR experience. For instance, one student described the experience as "cool", and another remarked that they "really enjoyed this assignment".

Improvements for future iterations of the class could involve clearer instructions for navigation in the VR environment, particularly for those unfamiliar with 3D gaming or similar technologies. This could help to mitigate frustration and improve the overall learning experience for all students. One interesting observation from the feedback is that the VR headset provided a better experience than the desktop platform, as stated by one respondent: "I was able to use the headset as well as the desktop platform and I found that the headset was significantly better." This suggests that the immersive nature of the VR headset may have contributed to a more engaging and effective learning experience.

Turning to the sentiment analysis of the post-assignment responses for the Spring 2023 cohort, there was a generally positive shift in attitudes towards the VR learning environment compared to the pre-survey responses. The students seem to value the immersive nature of the VR experience, and find it engaging, meaningful, and convenient. For example, one student mentioned: "I thoroughly enjoyed being able to see another school without having to take away time from my day to travel." This shows that the VR experience allowed students to explore environments in a time-efficient manner, saving travel time. Another student said: "I loved this assignment. I showed this assignment to multiple people and everyone was impressed. I wish I had more assignments like this!" This suggests that the VR assignment was not just appreciated by the student, but it also garnered positive feedback from others, demonstrating the potential wide-reaching appeal of such technology.

However, some students experienced challenges related to motion sickness and navigation. For example, one student described an unexpected sense of nausea, which they did not initially associate with the VR experience, demonstrating the importance of informing students about possible side effects. In terms of navigation, one student mentioned that clearer guidance about accessible areas within the VR environment could be beneficial.

Despite these minor issues, the general sentiment is overwhelmingly positive, with several students recommending continuation of such assignments and expressing a desire for more VR-based tasks. The enhanced depth of exploration was also highlighted, as exemplified by one student's comment: "This experience allowed me to see it at a deeper level." This reinforces the potential educational advantages of VR environments for comprehensive and focused learning experiences.

4.5. Instructor observations

Instructor observations for the same class with the same assignment revealed valuable insights regarding the use of VR in the educational administration master's program. The instructor noted that the second cohort performed better overall, with no questions or access issues reported. All students accessed the assignment using desktop computers, and the scores remained consistent across the cohorts. The assignment itself was the same for both cohorts and required students to look for evidence and justify how it demonstrated the mission and vision of the program. It was observed that it was difficult for students to lose points unless they missed a section of the assignment. Students enjoyed the change of pace compared to previous iterations conducted onsite. The VR assignment forced students to be more objective as they were not writing about their own school, thereby improving rigor.

From an instructor's standpoint, it was beneficial to have all students looking at the same VR environment, as it provided the ability to compare and critique their observations across the cohort. The instructor found it interesting to see how different students noticed various aspects of the virtual environment, with some being more observant than others.

For future research, the instructor plans to create a discussion post after the assignment submission, where students can discuss their observations and compare what they noticed with their colleagues. This will provide an opportunity for collaborative learning and a deeper understanding of the different perspectives within the cohort.

The instructor also received valuable feedback from the student responses. This feedback highlighted the need for training on how to navigate and manage movement through the VR space to address issues related to VR sickness. Furthermore, the instructor observed an increase in the demographic shift towards more female students, while a predominance of white students remained common.

Overall, the instructor observations indicated improved performance in the second cohort, positive student feedback regarding the assignment, and the benefit of having all students examine the same VR environment. The observations will inform future improvements, such as post-assignment discussions and training on VR navigation, to enhance the overall learning experience. The instructor also noted the demographic shift and will continue to monitor and address any potential disparities in student representation.

5. Conclusion

This study aimed to explore the use of virtual reality (VR) as a learning tool in the context of an educational administration master's program. The results shed light on the experiences and perceptions of students who engaged with a VR assignment and provided valuable insights from instructor observations. The relevance of this study lies in the growing interest in incorporating immersive technologies like VR into education. As technology continues to advance, it becomes crucial to understand its impact on teaching and learning. This study contributes to the existing literature by specifically examining the use of VR in an educational administration program, providing insights into its potential benefits and areas for improvement.

The results indicate that the second cohort of students performed better overall, demonstrating increased familiarity with VR technology. Students found the VR experience engaging, useful, and meaningful. The assignment allowed them to explore and evaluate a virtual learning environment, providing opportunities to apply their knowledge and critically analyze the alignment of the environment with the program's mission and vision. Instructor observations highlighted the advantages of having all students examine the same VR environment, facilitating comparisons and discussions.

The applicability of these findings extends beyond the educational administration program studied here. VR has the potential to enhance learning experiences in various disciplines and contexts. The ability to immerse oneself in virtual environments can provide unique opportunities for exploration, interaction, and the development of critical thinking skills. The positive feedback and insights gained from this study encourage the integration of VR into other courses and educational settings.

However, further research is needed to address the limitations and explore additional aspects. The study focused on a specific cohort and assignment, warranting exploration of the broader application of VR in different educational programs and topics. Future research should consider the efficacy of VR in enhancing student learning outcomes, the development of appropriate instructional strategies for VR implementation, and the impact of VR on students' engagement and motivation. Regardless, this study demonstrates the potential of VR as a valuable learning tool in an educational administration program. The results highlight the benefits of using VR to provide immersive and interactive experiences that align with the program's goals. The findings have broader implications for education, emphasizing the need to embrace emerging technologies and their potential to transform teaching and learning. Continued research and exploration of VR's effectiveness and best practices will contribute to the advancement of educational experiences and the optimization of student learning outcomes.

Conflict of interest

The authors declare no conflict of interest.

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