Virtual Reality in Connecticut Public High Schools: A Comprehensive Study

DECEMBER 20, 2024

Center for Connecticut
Education Research Collaboration

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CCERC

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About CCERC

The Center for Connecticut Education Research Collaboration (CCERC) is a research partnership between the Connecticut State Department of Education (CSDE) and institutions of higher education across Connecticut. CSDE sets the agenda, identifies projects, and allocates funding for CCERC. The University of Connecticut manages funding and provides an administrative team. A Steering Committee composed of researchers from various Connecticut institutions guides the administrative team in developing and approving research projects and reports. Researchers from Connecticut universities and colleges constitute the research teams. The mission of CCERC is to address pressing issues in the state's public schools through high quality evaluation and research that leverages the expertise of researchers from different institutions possessing varied methodological expertise and content knowledge.

CCERC was formed initially using federal relief funds to investigate the impact of the COVID-19 pandemic on learning and well-being and recovery efforts in the state's schools. The partnership was subsequently institutionalized to respond to ongoing evaluation and research needs of the CSDE, provide research opportunities for Connecticut researchers, and foster collaboration across the state's institutions of higher education.

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Executive Summary

The present study was commissioned by the Center for Connecticut Education Research Collaboration in response to a Connecticut State Legislative mandate calling for information about virtual reality (VR) use in Connecticut public high schools. The purpose of the study is to determine how many high schools in Connecticut are using VR, the purposes for which they are using them, the challenges and barriers to implementation they have faced, and the benefits they perceive. This report presents findings from a comprehensive study on the use of VR technologies in Connecticut public high schools. Data were collected in spring, summer and fall 2024 through an online survey of 181 schools, achieving a 60% response rate (n=109 schools), and follow-up interviews with 19 school administrative staff to contextualize and expand upon the survey results. The study revealed that 32% of schools in the sample are currently using VR technology, with educators expressing enthusiasm for its potential to augment teaching and learning.

Participants identified key perceived benefits of VR that make it an appealing tool for education. Specifically,

- VR was seen as highly effective in enhancing classroom engagement and participation by immersing students in interactive and captivating learning experiences.
- VR creates dynamic classroom environments where students can explore content in innovative ways, such as visiting historical sites or exploring complex three-dimensional models.
- Educators noted VR's ability to encourage creativity and innovation by providing students with tools to design, build, and problem-solve.
- VR was viewed as a means to foster the development of 21st-century skills, including critical thinking and technical expertise like coding.
- VR was described as a powerful motivator for students, sparking curiosity and inspiring deeper engagement with the curriculum.

Despite these benefits, significant barriers to VR integration remain pervasive across Connecticut public high schools. Barriers to VR adoption included:

- Budget constraints, which were cited as the top challenge, with many districts unable to afford the initial purchase of VR equipment or sustain its use over time.
- A lack of educator training was also a major obstacle, leaving educators feeling unprepared to implement VR effectively in their classrooms.
- Limited availability of VR headsets and ongoing technical challenges, such as maintaining devices and addressing connectivity issues, further hindered adoption.
- Equity concerns emerged as a critical issue, with under-resourced schools disproportionately affected by these challenges, resulting in uneven access to VR hardware and software.
- Suburban schools and rural schools reported significantly greater levels of student concerns (e.g., student frustration, lack of interest/motivation) in using VR than did urban schools.

The findings of this study highlight the urgent need to address these barriers to ensure equitable access to VR technology in Connecticut public high schools. Policy recommendations include equitable funding opportunities for under-resourced schools to address disparities in purchase, maintenance, and sustainability of VR technology. Professional development and training programs are needed to help educators effectively integrate VR into their classrooms, alongside the creation of a statewide repository of vetted content aligned with curriculum standards. Finally, pilot programs districts should be implemented to evaluate feasibility and refine strategies for potential broader adoption. With strategic planning, VR can serve as a powerful tool to enhance learning, promote equity, and prepare high school students for the future.

Benefits of VR in Education:

- Enhanced classroom engagement and participation by immersing students in interactive and captivating learning experiences.
- Creation of dynamic classroom environments where students can explore content in innovative ways.
- Ability to encourage creativity and innovation by providing students with tools to design, build, and problem-solve.
- Development of 21st-century skills, including critical thinking and technical expertise.
- A powerful motivator for students, sparking curiosity and inspiring deeper engagement with the curriculum.

Barriers to VR Adoption:

- Budget constraints, with many districts unable to afford the initial purchase of VR equipment or sustain its use over time.
- A lack of educator training, leaving educators feeling unprepared to implement VR effectively in their classrooms.
- Limited availability of VR headsets and ongoing technical challenges.
- Equity concerns, with under-resourced schools disproportionately affected, resulting in uneven access to VR hardware and software.
- Suburban schools and rural schools reported significantly greater levels of student concerns (e.g., student frustration, lack of interest/motivation) than urban schools.

Full Report

Introduction

Virtual reality (VR) is a technology that creates computer-generated, three-dimensional, immersive environments that allows the user to explore and manipulate digital spaces as if they were physically present. Using specialized hardware such as head-mounted displays and hand controllers, VR provides unique opportunities for experiential learning by enabling users to engage directly with abstract concepts, simulate real-world scenarios, and explore environments that would otherwise be inaccessible. In terms of education, VR has been applied across many K-12 subjects, including environmental science, biology, geology, health, mathematics, English language learning, social studies, and music (Pellas et al., 2021). VR has been shown to significantly improve student motivation and attention (Santos Garduño et al., 2021), as well as improve learning outcomes and knowledge retention (Merchant et al., 2014). Many educators view VR as a transformative tool for helping students grasp complex concepts, build essential communication and interpersonal skills, and foster deeper engagement through immersive, hands-on experiences (Khukalenko et al., 2022).

While the promise of VR in education is substantial, current research highlights persistent challenges to its adoption. These include high equipment costs, insufficient teacher training, and limited access to the technical infrastructure needed to implement VR effectively (Alalwan et al., 2020) (Bower et al., 2020). Teachers also express concerns about the alignment of VR content with existing curricula and the time required to incorporate new technologies into lesson plans (Bower et al., 2020). Despite these challenges, most teachers express a strong interest in implementing VR in their schools (Khukalenko et al., 2022).

As educational institutions increasingly explore the use of VR, it is critical to examine its integration in schools, where resources, training, and infrastructure may vary widely. This report seeks to address the extent of VR usage in Connecticut public high schools, identifying barriers and facilitators to its adoption, and exploring educator perceptions of this technology. By combining survey data with in-depth interviews, this study provides a comprehensive overview of how VR is currently used in Connecticut schools and what is needed to unlock its full potential. The findings of this report are intended to guide policymakers, educators, and stakeholders in making informed decisions about the future of VR in high school public education.

In terms of education, VR has been applied across many K-12 subjects, including environmental science, biology, geology, health, mathematics, English language learning, social studies, and music (Pellas et al., 2021). VR has been shown to significantly improve student motivation and attention (Santos Garduño et al., 2021), as well as improve learning outcomes and knowledge retention (Merchant et al., 2014). (Stock Photo)

LITERATURE REVIEW

Over the past forty years the integration of new technologies into the classroom has been rapidly accelerating, with schools embracing tools ranging from computers and interactive whiteboards to tablets and learning management systems. While each new technology promises to transform learning, its integration into schools is rarely seamless. As technology has become more widespread, it has brought many benefits, such as improved productivity, greater collaboration, and expanded learning opportunities. However, the advantages have been accompanied by inevitable challenges. These challenges, ranging from budgetary constraints to a lack of professional development, have remained persistent. As schools now consider the integration of virtual reality (VR) into classrooms, these historical patterns of technology adoption and implementation are important to recognize, as they can provide insight into both the potential benefits and the barriers VR may face.

Benefits of Technology Adoption

The integration of technology in classrooms can enhance both teaching and learning experiences when implemented effectively. Teachers and administrators widely recognize technology as a vital tool for improving access to information, enhancing instructional methods, and streamlining administrative tasks. Research consistently highlights how digital devices support collaboration and creative problem-solving. For example, according to the 2019 Gallup survey conducted for the report "Education Technology Use in Schools," which collected data from a nationally representative sample of 3,210 public school teachers and 1,163 public school principals, 83% of teachers and 93% of administrators strongly agree or agreed with the idea that digital learning tools can support instructional strategies to meet students' learning goals. The perceived benefits of technology integration were found across a wide variety of content areas, with 91% of English language learning teachers (n = 98), 81% of special education teachers, 85% of math teachers, 83% of science teachers, 83% of English language arts teachers, 81% of history/social studies teachers, and 78% of reading teachers agreeing that digital learning tools can support instructional strategies to meet students' learning needs (Gallup, 2019).

The implementation of technology in schools has also allowed students to develop the capabilities necessary to enter a technologically advanced world. To investigate these benefits, Grimes and Warschauer (2008) studied three schools in California – one largely Hispanic low socio-economic junior high school, one largely Asian-American high SES K-8 school, and one largely White gifted program in a medium-SES elementary school. Interviews, observations, surveys, and analysis of student work signified that laptop use promoted skills characterized as 21st-century literacies. Students can recognize the relevance of technology in their lives and the importance of technological expertise for their futures (Zheng et al., 2014). Thus, technology in education can be beneficial in the way that it prepares students for future schooling and occupations. Consequently, students' feelings of readiness were enhanced using technology.

But it is not just feelings of readiness and attitudes toward technology that are positively affected by implementation in the classroom. Technologies such as laptops, tablets, and educational software have been shown to significantly enhance learning outcomes, engagement, and collaboration. In 1:1 computing initiatives, where each student is equipped with a device, studies have reported increased motivation and higher test scores in subjects like English Language Arts (ELA) when compared to traditional classrooms (Bebell & O'Dwyer, 2010; Grimes & Warschauer, 2008; Shapley et al., 2011).

Furthermore, implementing technology has also aided schools in accommodating a broad spectrum of learners and providing for different students' needs. For instance, an analysis of statewide Colorado Student Assessment Program writing scores for third, fourth, and fifth grade students, showed improvement in scores for Hispanic students and learners from low-income families with the use of laptops (Zheng et al., 2013). In an effort to further understand the benefits of technology in education, McKnight et al. (2016) conducted a multisite case study using focus groups, interviews, classroom observations, and teacher interviews in seven schools across the U.S. Results from this study revealed five functions that technology plays in enriching education, one of which is its ability to improve access. Such access widens the range of learning resources which allows teachers to tailor their instruction to cater to different learning needs. This could have significant benefits for students with disabilities. Moreover, making technological devices accessible to students by offering them in classrooms creates opportunity for educational equity.

Challenges of Technology Adoption

Despite the many advantages of technology integration, it is also important to recognize the challenges that come with the introduction of technology in schools. Russell, Bebell, O'Dwyer, and O'Connor (2003) collected survey data from 2,894 teachers in 22 Massachusetts school districts and discovered that teachers' attitudes towards technology directly affect their ability to use it to benefit their students. Indeed, many educators expressed concerns surrounding their own abilities to utilize technology effectively and stated that to do so they would need to feel comfortable and have substantial training. Similarly, a recent study from the International Society for Technology in Education (2023) found that in a survey of 214 teachers in their first three years in the profession, more than half of teachers reported (56%) lacking confidence in using learning technology prior to entering the classroom.

While providing training may seem like a simple solution, there are many obstacles that prevent schools from being able to provide their teachers with the necessary skills to meaningfully implement technology into their lessons. Assessing these obstacles, a 3-year time-series survey study conducted in K-12 public schools in a North Midwestern US state (Francom, 2020), found limits on time to pose a considerable boundary for teachers working to implement technology. The

Benefits of Technology Adoption

- **Support instructional strategies to meet students' learning goals. (Gallup, 2019)**
- **Promotion of skills characterized as 21st-century literacies. (Grimes & Warschauer, 2008)**
- **Increased motivation and higher test scores in subjects like English Language Arts when compared to traditional classrooms (Bebell & O'Dwyer, 2010; Grimes & Warschauer, 2008; Shapley et al., 2011).**
- **Improvement in test scores for Hispanic students and learners from low-income families (Zheng et al., 2013).**
- **Access, which allows teachers to tailor instruction to cater to different learning needs. (McKnight et al., 2016)**

Challenges of Technology Adoption

- **Teachers' attitudes towards technology directly affect their ability to use it to benefit their students. (Russell et al., 2003)**
- **Teachers' lack of confidence in using learning technology prior to entering the classroom. (ISTE, 2023)**
- **Limits on teachers' time (Francom, 2020)**
- **Budget constraints and aging infrastructure (IncidentIQ, 2024)**
- **Inability to sustain devices (renewal of funding, software licenses, etc.) (CoSN, 2024)**
- **Ongoing expenses due to wear and technological obsolescence (Mayes et al., 2015)**
- **Lack of adequate technical infrastructure (Internet connections or speed) (Gray & Lewis, 2021)**

Purpose of the Present Study

- **Respond to a Connecticut State Legislative mandate calling for information about VR use in Connecticut high schools.**
- **Determine how many public high schools in Connecticut are using VR**
- **Determine the purposes for which public high schools in Connecticut are using them**
- **Determine the challenges and barriers to implementation public high schools in Connecticut have faced**
- **Determine the benefits public high schools in Connecticut perceive.**

teachers reported that they could not take full advantage of the benefits technology has to offer without proper time to test it out for themselves and create a plan.

Another significant barrier is the inability to fund technological initiatives. According to a 2024 survey by Incident IQ, over 60% of K-12 facilities managers identified budget constraints and aging infrastructure as their top concerns. Budget constraints have consistently posed significant challenges to the adoption of new technologies in schools. Educational institutions often struggle to secure sufficient funding for purchasing devices, upgrading infrastructure, and ensuring ongoing maintenance. The CoSN 2024 State of EdTech District Leadership Report collected survey data from 981 EdTech leaders in early 2024. The results of that study highlighted that 46% of EdTech Leaders reported concern about their ability to sustain classroom technology refreshes (other than devices) as federal emergency funding ends. However, 41% of respondents also reported that ability to sustain devices was also a concern. And just over one-third of participants (34%) were worried they would be unable to renew software licenses.

Ongoing expenses present additional challenges. Devices and systems often require regular updates, repairs, and replacements due to wear and technological obsolescence, creating a continuous financial burden (Mayes et al., 2015). Furthermore, schools in underfunded areas often struggle to maintain even basic technology infrastructure, leaving them at a disadvantage compared to wealthier districts. These disparities highlight the pressing need for more equitable funding solutions to ensure all students can benefit from modern educational tools.

In addition to financial constraints and the need for professional development, the lack of adequate technical infrastructure remains a significant hurdle for schools seeking to integrate advanced technologies like VR. A 2021 survey by the National Center for Education Statistics (NCES) (Gray & Lewis, 2021) found that 52% of schools experienced issues with internet connections or speed when large numbers of students were online. Without these infrastructure upgrades, schools risk technical glitches, lagging VR environments, or outright inaccessibility, which can disrupt learning and deter both teachers and students from embracing the technology.

Purpose of the Present Study

The present study was commissioned by the Center for Connecticut Education Research Collaboration in response to a Connecticut State Legislative mandate calling for information about VR use in Connecticut high schools. The purpose of the study is to determine how many public high schools in Connecticut are using VR, the purposes for which they are using them, the challenges and barriers to implementation they have faced, and the benefits they perceive.

Methods

This study utilized an explanatory sequential mixed-methods approach (Creswell & Plano Clark, 2018), which consisted of two distinct phases: a quantitative survey followed by qualitative interviews. The initial quantitative phase involved distributing a survey to public high schools across Connecticut to collect data on VR usage, teacher perceptions, and barriers to implementation. The survey findings were analyzed to identify trends and key challenges, which informed the development of the subsequent qualitative phase. The survey data were analyzed using descriptive statistics, including means and standard deviations, to identify patterns and trends. Factor analysis was employed to group challenges into themes. In the second phase, in-depth semi-structured interviews were conducted with a subset of school educators to further explore and contextualize the survey results.

This sequential design allowed the research team to use the qualitative data to elaborate on and provide deeper insights into the patterns and themes identified in the survey, particularly regarding educators' perceived benefits of VR and barriers related to successful implementation and sustainability of the technology. Thematic analysis was conducted to identify recurring themes, which were then integrated with the survey findings to provide a comprehensive picture of VR usage in Connecticut public high schools.

PARTICIPANTS AND RECRUITMENT

The sample for this study included all public high schools in Connecticut, identified through online records from the Connecticut State Department of Education's EdSight Database (https://public-edsight.ct.gov/?language=en_US) and the National Center for Education Statistics' Common Core of Data (CCD). In total, 181 public high schools were included in the study and consisted of traditional public schools, charter schools, and career technical education schools.

Once the full population of public schools had been identified, we located and merged into our database background information taken from the NCES Common Core of Data that corresponded to the following school-level variables: number of students enrolled, geographic locale of the school (e.g., urban, rural), percentage of students by gender, percentage of students by ethnicity, and percentage of students who are free and reduced-price lunch eligible. In addition, our team compiled contact information, namely email addresses and phone numbers, for the principal and vice principal at each school by searching the website for each individual school.

For the first phase of the study, school principals were targeted as the initial point of contact and were invited via email to complete an online survey or nominate an individual from their school to provide responses. Survey participants were offered a $30 Amazon gift card for their participation.

For the second phase of the study, participants who completed the online survey were contacted via email by a research team member to participate in a semi-structured interview online via a conferencing platform at a time that was convenient for them. Several schools were strategically chosen to reflect diversity in socioeconomic status, racial composition of the student body, and urbanicity. When interviewed, participants were asked to share their experiences, challenges, and successes related to VR integration, or, in schools without VR, their perspectives on barriers and potential facilitators. Each participant in this phase received a $30 gift card as compensation. By targeting all public high schools in the state and employing a purposeful selection strategy for several interviews, the study ensured a comprehensive understanding of VR use and attitudes in Connecticut schools.

QUANTITATIVE DATA COLLECTION

Survey Instrument

The survey instrument was developed specifically for this study to capture comprehensive data on VR usage, perceptions, and barriers within Connecticut public high schools. The initial structure and content of the survey were informed by a review of existing survey instruments available online and in relevant academic publications. These sources provided a foundation of validated questions that addressed technology use and adoption in educational contexts. To ensure the survey accurately reflected the study's objectives, additional questions were created to address specific aspects of VR implementation and teacher experiences that were not adequately covered in existing instruments. The survey was pilot tested with a small group of educators and administrators to assess clarity, relevance, and usability before being distributed statewide.

Survey Administration

The survey was administered online using Qualtrics, a secure and widely recognized platform for survey research. In May 2024, an invitation email containing a link to the Qualtrics survey was sent to the principal of each public high school in Connecticut. Principals were encouraged to either complete the survey themselves or nominate a relevant individual to provide responses on behalf of their school. The use of Qualtrics ensured data confidentiality and streamlined the response process. To maximize participation, follow-up emails were sent every other week to non-respondents through mid-October 2024. These reminders included the original survey link and emphasized the importance of our study in understanding VR use in education. This extended follow-up period facilitated a robust response rate and allowed for comprehensive data collection. The average time to complete the survey was 10-15 minutes.

Survey Sample and Results

PARTICIPANT CHARACTERISTICS

Of the 113 participants responding to the survey, 92% reported that they were currently in an Administrative Leadership position (e.g., principal, assistant principal) while 7% reported being either Teachers or Academic Staff. A total of 52% of participants identified as male, 46% female, and 2% preferred not to say. The ethnic composition of the sample was 95% White and 5% Black/African American.

As a group, the participants had extensive experience in the field of education, with 88% of participants reporting having worked in education for more than 15 years. Despite their long tenure in the field of education, however, the same participants reported very little experience using virtual reality, with 58% of the sample reporting having little to no experience and only 6% reporting that they had a great deal of experience using VR.

There were 4 participants out of 113 who were drawn from the same school. The data from all participants was used in subsequent analyses as the perspectives of the participants are what was deemed to be most important, and each participant was assumed to have their own unique set of attitudes, beliefs, and knowledge about VR. The only item on which one of the two participants from a school was excluded was on the item asking whether VR was currently being used in the school. In all but one instance the redundant cases were in agreement with their answers; however, in one case one of the participants reported that it was being used in the school and the other participant reported not knowing if it was being used. In that instance, we counted the school as using VR since one of the participants affirmed that it was, in fact, being used.

SCHOOL CHARACTERISTICS

In terms of the contextual characteristics of the 109 unique schools that are represented in the sample, the data reveal that 26% were classified as urban, 56% of the schools were classified as suburban, and 18% were classified as either rural or small town. School size varied substantially, ranging from a minimum of 18 students to a maximum of 3,590 students (Mean = 809, SD = 569). In terms of ethnic diversity, the schools in the sample exhibited a broad range in the ethnic composition of their students. As a crude measure, Figure 1 below shows a histogram of the percentage of White students at each school. Two things are noteworthy from the histogram. First, the range is substantial and includes a school in which only 2.5% of the student body identifies as White. On the other end of the spectrum, there is also a

Figure 1. Percentage of students identifying as White across all schools

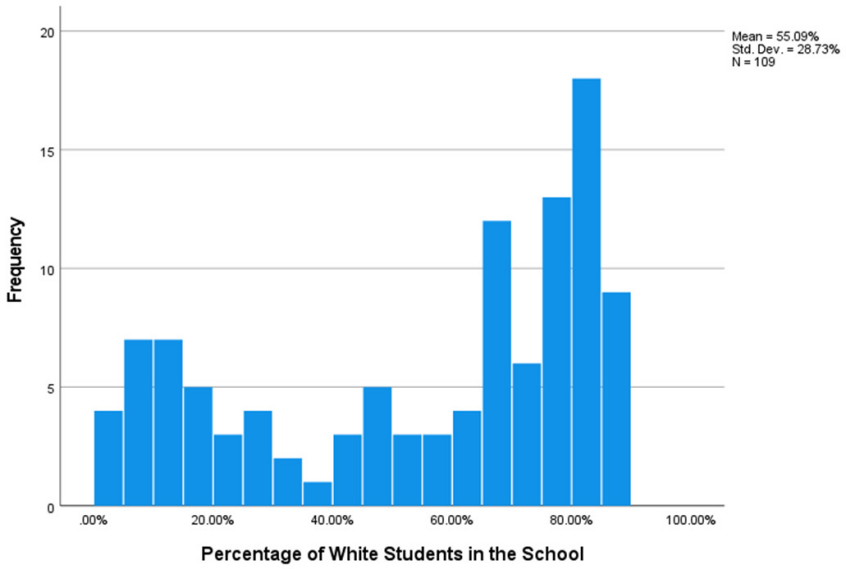


Table 1. Characteristics of Interview Participants: VR Use in Connecticut High Schools

Participant ID #	Role in School	VR Use (Yes/ No/Unsure)	Gender
1	Library Media Specialist	Yes	Female
2	Assistant Principal	Yes	Female
3	Assistant Principal	Unsure	Female
4	House Principal	Unsure	Male
5	Assistant Principal	Yes	Male
6	Assistant Principal	No	Male
7	Principal	Yes	Male
8	Administrative Leadership	Yes	Unknown
9	Teaching and Academic Staff	Yes	Male
10	Principal	No	Female
11	Teaching and Academic Staff	Yes	Male
12	Library Media Specialist	No	Female
13	Director of Technology	Yes	Female
14	Principal	Yes	Male
15	Technology Education	No	Male
16	Principal	Yes	Male
17	Library Media Specialist	Yes	Female
18	Librarian	No	Female
19	Principal	Yes	Male

school in the sample in which 90% of the student body identifies as White. Second, the distribution is somewhat, though not entirely, bimodal, with one large cluster of schools having more than 80% non-White students and a second, even larger cluster of schools, in which more than 70% of students identified as White.

QUALITATIVE DATA COLLECTION

Participant Characteristics

A total of 19 participants were interviewed for this study. Participant characteristics can be found in Table 1.

Semi-structured Interviews

A semi-structured interview guide was developed based on themes identified during the survey analysis. These interviews were designed to gather nuanced insights into school administrative staff's experiences with VR implementation, as well as to understand the real, or perceived, barriers and facilitators associated with its use in schools. Interviews were conducted via the online conferencing platform Zoom. Each session was recorded with participants' consent and subsequently transcribed using Zoom's automated transcription tool. A member of the research team reviewed all transcripts for accuracy before coding. Participants were asked open-ended questions, such as their perceptions of the challenges and benefits of using VR in school, concerns or reservations of using VR, and what resources or support would facilitate VR adoption and sustainability. Interviews lasted for an average of 20 minutes but ranged from 11 to 39 minutes and were conducted between June and November of 2024. Each participant received a $30 gift card as compensation for their time. This approach allowed the research team to capture contextual data that complemented the quantitative findings from the survey.

Data Analysis

Three research team members carried out the qualitative analysis using an iterative approach following the principles of thematic analysis outlined by Braun and Clarke (2006) which emphasize a systematic and collaborative process for identifying and organizing themes. Using a structured coding process, the researchers initially read a subset of transcripts independently and identified key themes. Initial codes were then generated inductively and deductively to capture key features of the data relevant to the study's research questions. Using an inductive approach, new themes emerged directly from the participants' responses, while deductive coding allowed the team to apply existing theoretical frameworks and concepts identified in the survey findings. The research team collaboratively developed a coding framework after reviewing a subset of transcripts, which was refined iteratively as new data were coded from subsequent transcripts.

Each interview was coded independently by two research members to ensure consistency. In instances where discrepancies arose, a third researcher reviewed the disagreements and facilitated a resolution through discussion. This process ensured that the coding was both reliable and reflective of the data. Final codes were entered into Dedoose, a qualitative management software application, which facilitated the organization of codes, themes, and relevant participant quotes.

A total of 19 participants were interviewed for this study. These interviews were designed to gather nuanced insights into school administrative staff's experiences with VR implementation. (Getty Images Signature)

Data Integration

Data integration in this study followed a triangulation approach to combine the quantitative survey findings with qualitative insights from the interviews (Patton, 1999). This approach increases the credibility and validity of research by combining multiple data sources, where the qualitative phase was explicitly designed to build upon and elaborate on the quantitative results.

Findings from the survey data informed the design of the semi-structured interviews, allowing the research team to explore specific themes and questions in greater depth during the qualitative phase. During the analysis phase, the qualitative data were systematically linked to the quantitative findings. Themes emerging from the interviews were compared against survey responses to identify areas of convergence, divergence, and complementarity (Creswell & Plano Clark, 2018). This triangulation of data ensured that the research questions were addressed comprehensively, with each method contributing unique insights that enriched the overall findings.

Results

Overall, we found that one-third of public high schools in Connecticut are currently using virtual reality in some way in their school. Schools reported a wide variety of uses for the technology (e.g., virtual field trips, teaching specific content in a domain) and participants reported that the use of VR enhanced student engagement and motivation and created a more dynamic classroom, among other benefits. Barriers to implementation generally fell into one of three categories: 1) Teacher concerns related to things such as a lack of knowledge/training related to VR and difficulty locating relevant content, 2) Administrative concerns related to issues such as budgeting and student safety, and 3) Student concerns related to motivation to use the technology.

SURVEY RESULTS

How Many Public High Schools in Connecticut are Currently Using Virtual Reality?

A total of 34 out of 109 unique schools reported that virtual reality was currently being used in their school (32%). The remainder of the participants either answered that it was not being used (35%) or that they were not sure whether virtual reality was being used in their school (33%).

How Are Schools Using Virtual Reality?

Of the 34 schools using VR, the majority (20/34 = 59%) of them report having between 1-5 devices in the school. Figure 2 shows a distribution of responses to the question of how many devices are currently in the school as compared to the number of devices those same participants feel would be ideal to have in the school. It is clear from this figure that participants feel that it would be desirable to have significantly more devices in schools with most (30/34 = 88%) responding that a minimum of 16 devices would be ideal. Interview responses noted that the rationale for this number is so that at least half of the class could be using a headset at the same time and they could then share with a partner. When there are fewer headsets, it is more difficult to fully engage the entire class of students.

In 79% of the schools, only 1-2 staff members currently use VR headsets and in the remaining 21% of schools that report using VR, there are 3-6 staff members using the headsets.

Figure 3 shows the ways in which participants reported using virtual reality in their school. A total of 14/34 schools (41%) reported using VR headsets for virtual field trips. Two other relatively common uses included teaching specific topics (35%) and for fun (35%). When asked to elaborate on the specific topics, survey respondents mentioned the following topics: collision repair, for history classes for students to visit historical sites virtually, for science classes to visit rain forests and other habitats, construction trade areas, aviation, auto/power transportation, animal science, earth science, and general topics related to science and technology. Physical health/prevention, mindfulness, and physical activity were less frequently cited uses of the devices.

When asked about the frequency with which the VR headsets are used, the largest group of participants (44%) reported that they were used less than once per month while only 3% reported using them every day. About a quarter of the participants reported that the VR headsets were used 1-2 times/week (24%) while the remaining 29% of participants reported that the VR headsets were used in their school 1-2 times/month.

In terms of the devices that are being used in schools, by far the most fre-

Figure 2. Number of devices currently in school versus ideal number of devices

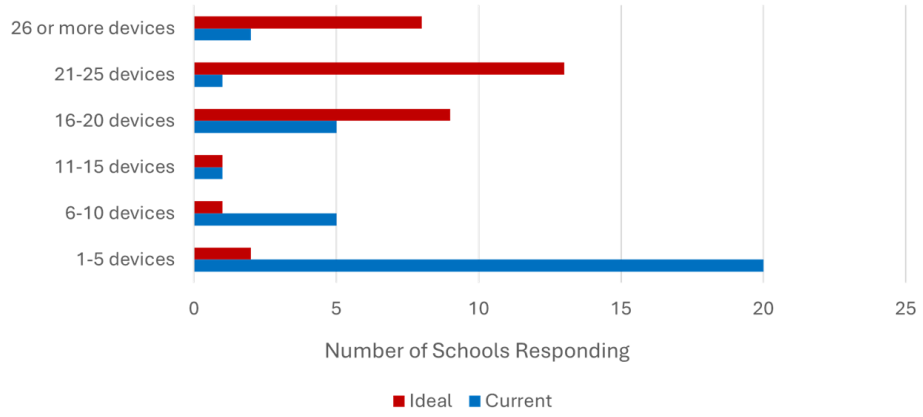
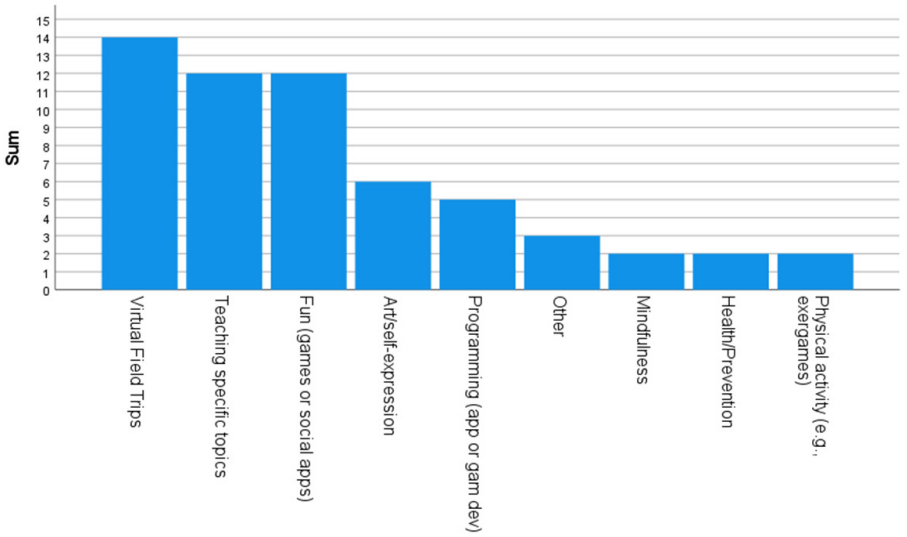


Figure 3. How virtual reality is currently used in schools



quently used device is the HTC Vine Pro 2, with 12 out of 34 participants (35%) citing its use in their school. Next, a total of 26% of schools report using Google Cardboard and only 12% of schools are currently using the Meta Quest 2 or 3 device. Figure 4 shows the distribution and frequency of use of other devices noted by participants.

To What Extent Does Using VR Enhance Diversity, Equity, and Inclusion?

Several items in the survey were designed to specifically ask about diversity, equity, and inclusion concerns as they pertain to the use of virtual reality in schools. Participants responded to a Likert scale in which 1 indicated strong agreement and 5 indicated strong disagreement with the prompt. The results in Table 2 show that participants felt very strongly that students with diverse learning needs had access to the devices (Mean = 1.82, SD = .94), that the accessibility features were effective in catering to students with diverse learning needs (Mean = 2.53, SD = .79), and that those same students found VR to be beneficial (Mean = 2.12, SD = .95). Participants generally agreed that the devices supported multiple languages and cultural contexts that were effective in promoting inclusivity (Mean = 2.91, SD = .93). Meanwhile, on average, participants noted that parents or guardians did not play a significant role in supporting the use of VR devices in school.

What are the Perceived Benefits Associated with the Use of Virtual Reality in Schools?

The full sample of 113 participants described what they perceived to be the benefits, or potential benefits, of using virtual reality in their schools. They were asked to rate the extent to which they agreed with 17 statements listed in Table 3 below, again using a Likert scale in which 1 = strongly agree and 5 = strongly disagree. The results show that overall, participants had a highly favorable view of the potential benefits of using VR in schools with the group, on average, in agreement with each of the 17 statements regarding potential benefits. However,

Figure 4. Types of VR devices used in schools

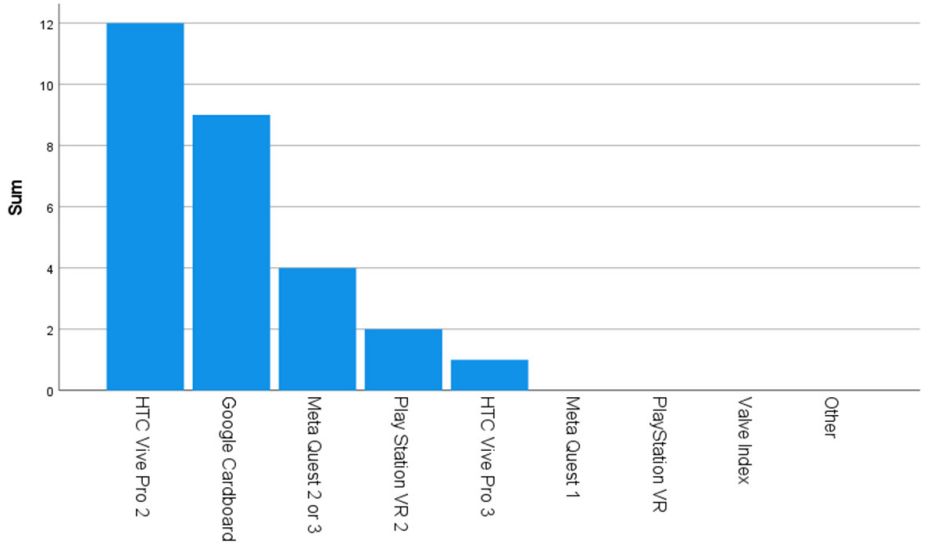


Table 2. Diversity, Equity, and Inclusion and Virtual Reality

Item	Mean	SD
Students with special needs have equal access to VR devices in my school	1.82	0.94
Students with diverse learning needs benefit from the use of VR technology in my school	2.12	0.95
The accessibility features on VR devices are effective in catering to students with diverse learning needs in my school	2.53	0.79
The VR devices in my school support multiple languages and cultural contexts to promote inclusivity	2.91	0.93
Parents or guardians play a significant role in supporting the use of VR devices in my school	3.32	0.88

N = 34; 1 = Strongly Agree, 5 = Strongly Disagree

in ordering them by strength of agreement, as is done in Table 3, we see that the participants felt most strongly in agreement with the idea that the use of VR enhances classroom engagement and participation (Mean = 1.77, SD = .81) and that it creates a more dynamic classroom (Mean = 1.90, SD = .81).

An exploratory factor analysis was run on the data using principal axis factoring with varimax rotation to determine if the items were multidimensional. The results revealed strong evidence for a single overarching factor accounting for 58% of the observed variance in the data. In addition, when run as a scale, the Cronbach's alpha of the 17 items was equal to .96, providing excellent evidence of unidimensionality.

What are the Perceived Challenges Related to the Use of Virtual Reality in Schools?

The full sample of 113 participants described what they perceived to be the major challenges associated with using virtual reality in their schools. They were asked to rate the extent to which they agreed with 15 statements listed in Table 4 below. On average, the biggest challenge associated with using VR in schools

Table 3. Perceived Benefits of Using VR in schools

Benefits or Potential Benefits of Using VR in Schools	Mean	SD
Enhances classroom engagement and participation	1.77	0.81
Creates a more dynamic classroom environment	1.90	0.81
Encourages student creativity and innovation	2.00	0.83
Fosters the development of 21st century skills (e.g., critical thinking, adaptability)	2.04	0.93
Improves student motivation for learning	2.04	0.80
Makes the curriculum seem more modern and up to date	2.07	0.88
Effectively supplements traditional learning methods in school	2.09	0.79
Enhances the ability of students to apply theoretical knowledge to real-world situations	2.12	0.81
Allows for more personalized and student-centered instruction	2.19	0.79
Effective means of preparing students for future careers	2.26	0.79
Provides opportunities for collaboration and teamwork	2.27	0.84
Enhances student retention of material	2.29	0.81
Application of health-related skills (mindfulness, anxiety reduction, emotion regulation)	2.33	0.83
Contributes to a positive school reputation and community perception	2.42	0.87
Enhances cultural competence	2.62	0.92
Helps faculty/staff to connect with students	2.65	0.94
Enhances social competence	2.77	0.92

Note: N = 113, 1 = Strongly Agree; 5 = Strongly Disagree

appear to be budget constraints (Mean = 1.78, SD = .90), lack of knowledge of how VR would be useful (Mean = 1.88, SD = .91), and lack of training or professional development opportunities (Mean = 1.98, SD = .89). By contrast, participants did not perceive student interest/motivation or student frustration with the technology as a meaningful challenge.

To ease interpretation, the 15-item scale inquiring about challenges faced using VR was factor analyzed using a principal axis factoring technique with varimax rotation. A three-factor solution explained a total of 44% of the variance in the data. The three factors and their associated amount of explained variance are listed below. The complete list of items and their factor loadings are listed in Table 5 below.

1. Teacher Concerns (21%): Lack of knowledge of how to use VR, lack of training and professional development, difficulty finding appropriate content, difficulty integrating VR into the lesson, insufficient technical support.
2. Administrative Concerns (14%): Things such as whether there is enough space in the building, whether there is sufficient funding in the budget to purchase equipment, concerns with student privacy/safety, concerns with student health, concerns with monitoring what students view.
3. Student Concerns (9%): Student frustration with the technology, lack of interest/motivation.

The factor scores were analyzed to determine if there were any significant differences in reported challenges based on participants' school type. A one-way ANOVA revealed a statistically significant difference on Factor 3 (Student Concerns) by school type; however, no differences by school type were found on the other two factors. Specifically, suburban schools and rural schools reported significantly greater levels of student concerns (e.g., student frustration, lack of interest/motivation) in using VR than did urban schools ($F(2, 106) = 5.8$, $p = .004$). No statistically significant relationships on any of the three factors were found between school size or ethnic composition of students in the school.

An additional set of questions was administered only to those schools currently using VR. Those questions asked about the level of training and support they were receiving with regard to using VR in schools. Table 6 reveals that, on average, participants felt they were not being provided with adequate training on how to use VR (Mode = 4.0, Mean = 4.0, SD = .78), they were not receiving sufficient support for challenges and questions arising using VR (Mode = 4.0, Mean = 3.79 SD = 1.04) and that they were not being provided with strategies for adapting VR applications to diverse student

learning needs (Mode = 4, Mean = 3.82, SD = 1.03). In short, training and support are areas in which participants felt there were significant opportunities for growth regarding using VR in schools.

QUALITATIVE FINDINGS

Interviews with educators provide a broad understanding of how VR is perceived and implemented in Connecticut public high schools. Participants shared their perspectives on the potential of VR, emphasizing its ability to enhance student engagement, foster creativity, and support the development of essential skills. However, they also highlighted significant barriers, including challenges related to funding, educator training, space constraints, and equitable access. These findings offer valuable insights into both the opportunities and challenges of integrating VR into educational settings.

What are the Perceived Benefits Associated with the Use of Virtual Reality in Schools?

Participants provided insights into the potential benefits of VR in educational settings, offering examples of how this technology can transform teaching and learning experiences. The top five perceived benefits from Table 3—1) Enhancing Classroom Engagement and Participation, 2) Creating a Dynamic Classroom Environment, 3) Encouraging Creativity and Innovation, 4) Fostering the Development of 21st Century Skills, and 5) Improving Student Motivation for Learning—were further explored in the qualitative data to gain deeper insights into participants' perceptions of these benefits, whether from direct implementation or their expectations of VR's potential impact.

ENHANCING CLASSROOM ENGAGEMENT AND PARTICIPATION

Interview participants frequently highlighted VR's ability to captivate students and foster participation in ways traditional tools often cannot. One participant, who had successfully integrated VR into their school, shared:

"There was a ton of interest. The students were really excited about using them. We had... we do like student choice with that. So we have students sign up ahead of time, and that was the most requested activity. More than half the school was like 'I want to do that all day.'" (Participant #17).

Another participant, who had not yet integrated VR into their school, remarked:

"The more tools that we have in our toolkit, the better. So, you know, when we're looking at, you know, how to better meet the needs of kids, get them engaged, get them interested in learning." (Participant #19).

CREATING A DYNAMIC CLASSROOM ENVIRONMENT

Participants emphasized how VR can transform traditional classrooms into immersive, interactive spaces where students engage with content in innovative ways. One participant described how VR had been used in their school's social

Table 4. Perceived Challenges Associated with Using VR in Schools

Challenges	Mean	SD
Budget constraints	1.78	0.90
Lack of knowledge as to how VR would be useful	1.88	0.91
Lack of training or professional development opportunities	1.98	0.89
Availability of VR headsets when needed	2.04	0.96
Lack of time to learn how best to integrate VR into school	2.04	0.85
Lack of technical support	2.42	1.02
Inability to monitor what students are viewing in the headset	2.50	1.04
Challenges with integrating VR applications into the lesson plan or program	2.58	0.86
Finding appropriate and relevant content	2.58	0.98
Concerns with student accessibility and equity	2.67	1.08
Concerns with student privacy/security	2.68	1.01
Insufficient space in the school	2.85	1.14
Concerns with student health/safety, such as eye strain or motion sickness	3.10	0.92
Student frustration	3.17	0.84
Lack of interest/motivation	3.19	0.98

**Note: N = 113; 1 = Strongly Agree, 5 = Strongly Disagree*

Table 5. Factor Analytic Results for Major Challenges to Using VR in School

Items	Factor 1	Factor 2	Factor 3
Lack of training or professional development opportunities	0.877		
Lack of knowledge as to how VR would be useful	0.778		
Lack of time to learn how best to integrate VR into school	0.618	0.338	
Finding appropriate and relevant content	0.575		
Lack of technical support	0.519		
Challenges with integrating VR applications into the lesson plan or program	0.466		
Inability to monitor what students are viewing in the headset		0.623	
Insufficient space in the school		0.548	
Budget constraints	0.412	0.517	
Concerns with student privacy/security		0.485	
Concerns with student health/safety, such as eye strain or motion sickness		0.442	
Availability of VR headsets when needed	0.394	0.437	
Concerns with student accessibility and equity	0.362	0.421	
Student frustration			0.845
Lack of interest/motivation			0.503

studies classes:

"Our social studies teachers use it probably the most. The ones that teach different regions in the world, because they're able to bring in different things that kids could never see or experience." (Participant #1).

Another participant highlighted the potential of VR to provide students with access to experiences that extend beyond the limitations of their physical environment:

"You're able to bridge the gap and give kids more access than what they would normally have. I mean, there's studies out there for kids who have never seen a beach or been, you know, they're landlocked. And they, you know, you can take them places. So I think if it's used right, you can access almost anything or give a kid exposure and experiences that they may not be able to get at this time or point in life." (Participant #8).

ENCOURAGING CREATIVITY AND INNOVATION

Several participants highlighted VR's ability to foster creativity by allowing students to design, build, and explore in ways that inspire critical thinking and innovation. One participant shared:

"They can actually showcase these things that they have designed. And of course, it didn't cost us anything beyond the goggles and the software packages to be able to build these items so that you know they could, you know, be reviewed and presented in the context that they're intended for." (Participant #7).

Another participant emphasized how VR can empower students with diverse needs to express their creativity in unique and impactful ways:

Table 6. Perceived Training and Support for VR Amongst Schools Currently Using VR

Item	Mean	Median	Mode	SD
My school provides adequate training on how to use VR	4.00	4.00	4	0.78
My school provides ongoing support to address any challenges or questions that arise when using VR technology	3.79	4.00	4	1.04
My school provides training that includes strategies for adapting VR applications to students with diverse learning needs	3.82	4.00	4	1.03

N = 34; 1 = Strongly Agree, 5 = Strongly Disagree

"I find some kids who are nonverbal - I have 3 students in class that are nonverbal - they are creating some of the most awesome artwork and three-dimensional designs and animations." (Participant #11)

Other participants recognized VR as a critical tool for equipping students with the skills needed for future careers and modern challenges. One participant observed:

"STEM is clearly a driver of graduation requirements for all high school students, no matter what school they go to in Connecticut. So, VR would definitely support opportunities for students to get involved with STEM and a technology that they're probably going to be using after that." (Participant #4).

Another participant highlighted the importance of VR in fostering technical skills, particularly in areas like coding, which are essential for preparing students for future careers:

"I think it's just really the coding part that they're learning, which I think is important. I'm a programmer—that was my degree was computer programming. So I get excited when a kid wants to learn how to program." (Participant #13).

IMPROVING STUDENT MOTIVATION FOR LEARNING

Educators noted that VR has the potential to encourage curiosity and significantly boost students' motivation to engage with learning. One participant reflected:

"Like I said to my class today, I said, I'm introducing this (VR) to you, and I expect you to teach me all about it. Because they'll spend more time digging deeper than I would in some of these software packages, and I learn from watching them. All I can do is light the fire." (Participant #11).

Another participant reflected on how VR can inspire students by giving them the sense that they are engaging with cutting-edge technology:

"It really would be a win...what a great way to help students feel like, oh, you're on the cutting edge of something. It's something that's new...They know it's new." (Participant #4).

What are the Perceived Challenges Related to the Use of Virtual Reality in Schools?

Our qualitative data revealed three overarching themes that reflect the perceived challenges of implementing VR into Connecticut public high schools – 1) educators face challenges in integrating VR into classrooms, 2) institutional barriers to VR adoption, and 3) challenges related to student engagement and equitable access. These themes echo the findings from the quantitative survey results reported previously in Table 4 (Factor Analysis). Within each theme, subthemes capture distinct aspects of these challenges, supported by quotes that illustrate the lived experiences or perceptions of participants.

> *"STEM is clearly a driver of graduation requirements for all high school students, no matter what school they go to in Connecticut. So, VR would definitely support opportunities for students to get involved with STEM and a technology that they're probably going to be using after that."*
>
> **– Participant #4**

> *"Our social studies teachers use it probably the most. The ones that teach different regions in the world, because they're able to bring in different things that kids could never see or experience."*
>
> **– Participant #1**

EDUCATORS FACE CHALLENGES IN INTEGRATING VR INTO CLASSROOMS

Educators described a variety of challenges that limited their ability to effectively adopt VR into their curriculum or program. These included: 1) limited knowledge about VR technology, 2) insufficient access to educator training related to VR, and 3) difficulty finding and aligning VR content with curricula.

LIMITED KNOWLEDGE ABOUT VR TECHNOLOGY

Educators' unfamiliarity with VR technology and its educational applications emerged as a significant barrier. Many participants noted that this lack of knowledge created hesitation and resistance, particularly among those with limited exposure to digital technology tools as a whole:

"I don't think most educators are super familiar with the technology, period. Never mind how they would integrate it in their classrooms." (Participant #14).

Another participant described how generational differences contributed to this gap:

"You have the older generation of people, they're like, 'Oh, I don't know about that,' you know. And they might not have ever put one on before. And so they're—or they don't need that, you know. So, I think that plays a role." (Participant #1).

Participants also expressed concerns that the growing demands placed on educators, particularly around adopting new technologies, could feel overwhelming to them. One participant reflected:

"A lot of these teachers that have been around for a long time, you know, they didn't even have email when they started teaching or barely had email. We're asking them to use smart boards and chrome books and Google classroom and Microsoft teams. They've already had to make a lot of changes. And I've seen people leave the profession as those changes have been necessary... So, I think if we really want VR to be successful, we have to support people, so they don't get pushed out. And give them some almost like a carrot at the end of a stick to try to lure them in, because to have to do it all on your own it can be a lot for someone who's not familiar with technology to try to bridge that gap."

(Participant #5).

INSUFFICIENT PROFESSIONAL TRAINING AND DEVELOPMENT

The lack of professional educator training was identified as another key barrier. Educators emphasized the need for training programs that not only explained how to use VR devices but also demonstrated how to integrate them effectively into their curricula or other school programs. As one participant described:

"Teacher training is always the critical piece. That is a slow process, and then not only just learning the product now, how do you integrate your lessons into the product and redesign your lessons so that these tools can be used by kids so that they're acquiring the skill sets. They need to be current in the marketplace. So that is a slow process." (Participant #7)

Another participant described what meaningful professional development might look like:

"We need professional development in terms of instructional support—not just, 'Here's how you use the device,' but actual models of how to use it in your class. We would need someone to go into classrooms and co-teach a lesson using VR, showing teachers how to integrate it into their existing curriculum rather than making it something extra. Because if there's one thing teachers hate, it's anything that feels extra. It has to replace something less effective." (Participant #18)

DIFFICULTY FINDING AND ALIGNING CONTENT

Educators also highlighted the difficulty of finding VR content that aligned with curriculum standards. The process of identifying and vetting educationally appropriate VR materials was described as time-consuming and overwhelming.

"It's hard to make 360-degree content. It's hard to find the good ones, because anyone can put stuff up, and so it takes a lot of time to go through and vet different things that we want to use" (Participant #1).

One participant shared their experience of piecing together content independently:

"I was using VR in a history classroom for a while. I had to search YouTube for things that were appropriate, educational, and still functioning. That it wasn't a broken link or something like that. It was time-consuming, and it wasn't always reliable." (Participant #5)

INSTITUTIONAL BARRIERS TO VR ADOPTION

At an institutional level, educators described logistical and structural challenges that impeded the adoption of VR. These included, 1) budget constraints, 2) space limitations, 3) concerns about monitoring and privacy, and 4) the lack of sufficient technical support.

BUDGET CONSTRAINTS

Funding for VR emerged as one of the most significant barriers, with participants emphasizing that school budgets often prioritized other essential needs, leaving little room for investment in new technologies. Participants highlighted that even schools with an interest in VR struggled to find the resources to purchase and sustain the necessary hardware, software, and infrastructure. One participant described how funding for VR was low on their school's priority list:

"Most school districts are struggling to just keep up with payroll. For schools to really implement this, the funding is going to be a huge thing, especially in middle, working-class communities where budgets reflect what's needed, not what's desired." (Participant #5).

Another participant noted:

"I think a lot of school districts, especially ours, are in a budget crunch. A lot of the (funding) after the COVID pandemic has run out. So, we're having to adjust some staffing issues. And I think for schools…I think we look at staffing first. When it comes to integrating technology or any new initiative or anything. So I think people are what drive a lot of our budget decisions, often at the expense of facilities and materials and things like that." (Participant #4)

Participants also expressed concerns about the long-term sustainability of VR programs in districts with limited funding. One participant explained:

"Something I worry about with new technology is that it can be expensive to maintain or replace. So having that be a part of the programming for it, the funding for it, to make sure that you're not going to have them one year, and then five years later you're down to half the amount of units you had before. Students can't really access it, you know, things like that. It needs to have a longevity piece tied to it" (Participant #5).

SPACE LIMITATIONS

Schools also faced challenges in finding physical space to implement VR activities. VR setups often require open areas to allow safe and unrestricted movement, further complicating space constraints in already crowded school environments. Many buildings were not designed with the infrastructure needed to support VR, creating logistical hurdles for educators. One participant described their concern with finding space:

"Space is an issue, because schools were not designed to accommodate it. Allocating a multi-use area so multiple classes could use it poses a burden." (Participant #5).

MONITORING AND PRIVACY CONCERNS

The ability to monitor students while using VR devices and concerns about privacy and data security were significant barriers. Participants expressed uncertainty about how to ensure that students stayed on task and used VR for appropriate educational purposes. One participant emphasized the concern with supervising what high school students

"We have to control what it is that they're doing under our supervision. Parameters are necessary, especially with high school kids." (Participant #12).

Another raised concerns about data privacy, stating:

"We always have concerns about privacy and how student information is shared. Some tech companies don't follow U.S. regulations, and we need to whitelist software to ensure its FERPA-compliant. Monitoring what students access is a big issue for us." (Participant #4).

LACK OF TECHNICAL SUPPORT

Even when schools had access to VR

hardware and software, the lack of technical support created significant barriers to implementation. Participants described challenges with maintaining equipment, resolving technical issues, and ensuring reliable connectivity. As one participant described:

"We definitely have the infrastructure. The technical support…a lot of them are great on hardware, not software. And if we had a tech integrator—someone who could focus on being there when teachers needed it—that would be huge. But we don't have the budget for that right now." (Participant #13).

Another participant described issues related to integrating VR with school networks:

"So even with the Wi-fi, if you don't have a Wi-fi access point in your room that's set up to your school network, which typically is restricted, it's slow. Students are complaining when they're trying to set up the goggles because the bandwidth on our open network has been throttled" (Participant #11).

Some participants expressed frustration with bureaucratic hurdles in receiving IT support. One participant described their experience with their IT department:

"To get our IT Department to install software is like getting a bill passed in Congress." (Participant #11)

BARRIERS TO STUDENT ENGAGEMENT AND ACCESSIBILITY

Participants described two major challenges related to student engagement and accessibility to VR integration in schools. These challenges included 1) student motivation and familiarity, and 2) equity and sustainability.

STUDENT MOTIVATION AND FAMILIARITY

Educators perceived that while some students were enthusiastic about VR, others approached it with skepticism or viewed it as purely recreational. Educators highlighted how students' familiarity with using technology for entertainment, such as gaming or social media, sometimes made it difficult to shift their mindset toward using VR as an educational tool:

"It's not because the technology doesn't hold promise. It's so foreign to so many of our kids. They either come in with the 'wow factor' or expect it to be like a video game. I think that mindset can limit how they engage with it in a learning setting" (Participant #14).

Educators also noted that when VR wasn't well-integrated into the curriculum, it risked becoming a novelty. One participant explained:

"My fear would be that to just have them without that kind of structure would lead to a lot of, for lack of a better word, teachers using them as gimmicks. Yes, it's cool, it's fun, the kids are engaged—but to what end? How is the VR headset really doing something with student learning that couldn't have been done with more traditional tools?" (Participant #14).

> *"I think schools in wealthier districts might have more freedom to explore innovative tools like VR, but for districts like ours, we're just trying to keep the basics running. It's frustrating because you know the potential is there, but it feels out of reach."*
>
> **– Participant #16**

EQUITY AND SUSTAINABILITY

The disparity in access to VR technology between schools in higher- and lower-income districts was a central concern. Participants repeatedly emphasized how funding inequities left under-resourced schools unable to adopt or sustain VR programs. As one participant described:

"Sometimes state initiatives and state programs are awesome to drive something. But then, sometimes it creates equity issues…we live in a segregated state, for lack of a better word, in terms of funding for schools. You have some schools that are very highly funded and some schools that are very low funded. It's tough for all schools to figure out how to manage programs after a grant expires or after a state initiative expires" (Participant #4).

One participant reflected on how grant funding often fails to create long-term change for underfunded districts:

"When a grant comes in or a big state program comes in for the underrepresented schools, it's great for the couple of years that the money is there. But then when it gets pushed back on districts, it's difficult for some districts to keep those programs going. So it works for a while, but then there's no sustainability. The schools that need it most are the ones that can't keep it running" (Participant #4).

One participant also stressed the importance of addressing access gaps as a prerequisite for meaningful implementation:

"If we truly believe in equity, we need to figure out a way to make sure that all districts have access. Without access, you have no steps forward," one participant argued (Participant #7).

Another participant highlighted how this inequity perpetuates disparities in educational opportunities:

"I think schools in wealthier districts might have more freedom to explore innovative tools like VR, but for districts like ours, we're just trying to keep the basics running. It's frustrating because you know the potential is there, but it feels out of reach" (Participant #16).

Summary

Our qualitative findings highlight both the potential and significant challenges of integrating VR into Connecticut public high schools. Educators emphasized VR's ability to enhance student engagement, foster creativity, and support the development of critical skills for the future. However, barriers such as insufficient funding, limited training, space constraints, and concerns about equity and sustainability hinder its broader adoption. Addressing these challenges is essential to unlock the full educational potential of VR while ensuring equitable access for all students.

Discussion

This study contributes to the growing body of literature on integrating virtual reality (VR) technology into K-12 education by examining its use in Connecticut public high schools. Consistent with prior research, our findings indicate that while the promise of VR is substantial, significant barriers impede its widespread adoption. Previous studies have similarly highlighted the challenges of integrating new technologies into schools, such as budget constraints, lack of training, and difficulty aligning content with existing curricula (Bower et al., 2020; Harrell & Bynum, 2018; Pellas et al., 2021). For instance, the need for professional development and training opportunities for educators to effectively incorporate VR into their teaching practices was highly emphasized as a major barrier to the successful implementation of the technology in both our quantitative and qualitative findings.

However, this study highlights unique contextual insights specific to Connecticut public high schools. For instance, equity emerged as a particularly salient issue, with participants repeatedly stressing how disparities in funding between districts limit access to VR technology. This aligns with recent findings that identified systemic inequities in technology access as a critical challenge in underserved communities (Hill & Reimer, 2023). A recent report from the Connecticut Commission for Educational Technology (2024) reports that the average staff-to-device ratio of 1 to 670 and staff-to-device support ratio of 1 to 1,008, further highlighting the systemic barriers CT schools face in providing adequate technical support for implementing and maintaining VR technology. The equity issues raised in this study suggest that targeted funding and resource allocation are critical to ensuring VR's potential is accessible to all students, regardless of socioeconomic background. Additionally, the need for ongoing funding, as opposed to one-time funding opportunities for schools, is essential to sustain the maintenance, updates in VR software and hardware, and continued training required for the effective and long-term integration of VR technology in schools.

Consistent with prior research, our findings indicate that while the promise of VR integration into K-12 education is substantial, significant barriers impede its widespread adoption. (Stock Photo)

In our study, suburban schools and rural schools reported significantly greater levels of student concerns such as student frustration and lack of interest/motivation in using VR than did urban schools. This finding aligns with a recent Pew Research Center report (2021) which shows overall higher technology adoption rates in urban areas compared to rural areas, with urban households generally have greater access to broadband, smartphones, and other devices. This may translate into students having higher familiarity and comfort with advanced technologies like VR in urban schools, suggesting that differences in exposure and access to technology could influence students' experiences and attitudes toward VR in educational settings.

Data collection and student protection were mentioned in both the quantitative and qualitative interviews as a concern to adopting virtual reality (VR) in educational settings. The Family Educational Rights and Privacy Act (FERPA) mandates the protection of student data and integrating VR technologies may introduce complexities in maintaining compliance. For instance, VR systems often collect extensive biometric data, such as head and hand movements, which can uniquely identify individuals and reveal sensitive information (Brehm & Shvartzshnaider, 2024). To address these issues, it is crucial to develop clear guidelines and best practices for the use of VR in schools, ensuring that data collection is minimized and that robust security measures are in place. Collaborations between educators, policymakers, and technology developers are essential to create VR platforms that prioritize data privacy and comply with educational privacy laws.

This study also emphasizes the gap between the perceived benefits of VR and its actual implementation in classrooms. While many participants recognized VR's potential to engage students, foster creativity, and develop 21st-century skills, only a minority of schools had integrated VR into their curricula. This gap is con-

sistent with research on other educational technologies, which often encounter a lag between initial enthusiasm and widespread adoption due to logistical and systemic challenges (Merchant et al., 2014; Shifflet & Weilbacher, 2015). Yet, when integrated properly, technology does not detract from class time, but instead provides new material for students to enjoy (Shifflet & Weilbacher, 2015). Technology offers a new side to course content and student engagement. Often, it supports creative, student lead learning and opportunities beyond the scope of the average classroom.

In comparing these findings to research on other educational technologies, it is evident that the trajectory of VR integration mirrors that of earlier technologies integrated into schools in the past, like Smartboards and Chromebooks. While initial excitement may be tempered by logistical challenges, adoption can grow over time with proper support and infrastructure (Merchant et al., 2014). This study adds to the discourse by highlighting the specific needs and perceptions of educators at a pivotal time for VR adoption.

Despite its contributions, this study has several limitations. First, the study sample is limited to Connecticut public high schools and excludes private schools, thus narrowing the generalizability of our findings to other educational contexts, particularly schools that are privately funded and may have greater access to resources such as VR technology. Second, the response rate to the survey was approximately 60%, which, while substantial, means that the perspectives of 40% of the schools were not captured. This non-response could skew the findings if non-responding schools had systematically different experiences or perceptions regarding VR use. Future research should aim for broader inclusion of schools and higher response rates to provide a more comprehensive understanding of VR adoption across all high school settings. Third, the cross-sectional nature of this study does not capture the evolution of VR use over time, particularly as new technologies and resources become available.

Overall, this study provides critical insights into the perceived benefits and barriers of VR in K-12 education, with particular relevance to Connecticut's public schools. By identifying the key challenges educators face and offering policy recommendations to address these obstacles, this research lays the groundwork for more equitable and effective integration of VR into classrooms. As VR technology continues to evolve, future research should explore longitudinal outcomes and strategies for adoption and sustainability to ensure that its potential can be fully realized across diverse educational settings. With thoughtful investment and ongoing support, VR has the potential to transform the way students learn and interact with their world, driving innovation and promoting equity in education.

In some ways, the challenges faced in adopting VR in education are not fundamentally different from those encountered when introducing other technological innovations in the past. Whether it's financial constraints, the need for professional development, or the technical infrastructure required to support new tools, these barriers have long been part of the process of integrating technology into classrooms. Just as schools once struggled with the adoption of computers, interactive whiteboards, and digital learning platforms, the same issues persist with VR. However, history has shown that with strategic investments in training, infrastructure, and support, educational technologies can eventually be normalized and become integral to the learning experience. The key lies in overcoming these challenges with a comprehensive approach, ensuring that VR, like any other technology, can fulfill its transformative potential in education.

Policy Recommendations

Based on the findings of this study, several policy recommendations and changes may assist with the successful integration of VR into Connecticut public high schools. First, there is a critical need to increase funding for technology in under-resourced schools to address disparities in access. Targeted funding programs should focus on equity and ensure that resources are allocated not only for the initial purchase of VR hardware and software, but also for ongoing maintenance, updates, and potential replacements. Additionally, comprehensive professional development programs must be created to support educators in effectively incorporating VR into their teaching practices. These programs should include hands-on workshops and practical examples of how VR applications can be aligned with the current state curriculum standards.

Another recommendation is to establish a statewide repository of vetted VR content and lesson plans for educators. This resource would provide access to high-quality, pre-approved materials that are aligned with educational standards and designed to be culturally responsive and accessible to all students. Expanding technical support infrastructure is also crucial, as schools need adequate IT personnel to assist with troubleshooting and training related to VR equipment and software.

Finally, we recommend implementing pilot programs across diverse high schools in CT to test and refine best practices for VR adoption. These programs would allow for the evaluation of student outcomes, technology acceptability and usability among educators and students, feasibility of VR integration, and cost-effectiveness. Collection of this data, especially over time, could provide valuable data to inform broader implementation efforts. By addressing the most prominent challenges to VR adoption, policymakers can create an environment where the potential benefits of VR can be fully realized, ensuring that all students have equal opportunity to engage with this evolving technology.

References

Alalwan, N., Cheng, L., Al-Samarraie, H., Yousef, R., Ibrahim Alzahrani, A., & Sarsam, S. M. (2020). Challenges and Prospects of Virtual Reality and Augmented Reality Utilization among Primary School Teachers: A Developing Country Perspective. *Studies in Educational Evaluation, 66,* 100876. https://doi.org/https://doi.org/10.1016/j.stueduc.2020.100876

Bebell, D., & O'Dwyer. (2010). Educational Outcomes and Research From 1:1 Computing Settings. *Journal of Technology, Learning and Assessment, 9*(1), 1-15.

Bower, M., DeWitt, D., & Lai, J. W. M. (2020). Reasons associated with preservice teachers' intention to use immersive virtual reality in education. *British Journal of Educational Technology, 51*(6), 2215-2233. https://doi.org/https://doi.org/10.1111/bjet.13009

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp0630a

Brehm, K., & Shvartzshnaider, Y. (2024). Understanding Privacy in Virtual Reality Classrooms: A Contextual Integrity Perspective. *IEEE Security & Privacy, 22*(1), 53-62. Accessed 12.03.24 via: https://ieeexplore.ieee.org/abstract/document/10352441

Connecticut Commission for Educational Technology (2024). 2024 K-12 Technology Staffing and Devices. Accessed 12.01.24 at: https://portal.ct.gov/das/-/media/das/ctedtech/publications/2024/cet2024k12staffdevices.pdf

CoSN. (2024). *2024 State of EdTech District Leadership*. *Consortium for School Networking (CoSN)*. https://www.cosn.org/wp-content/uploads/2024/05/2024_CoSN_LeadershipSurvey_Report_F2.pdf

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Francom, G. M. (2020). Barriers to technology integration: A time-series survey study. J*ournal of Research on Technology in Education, 52*(1), 1-16. https://doi.org/10.1080/15391523.2019.1679055

Gallup. (2019). *Education technology use in schools*. Gallup. https://www.newschools.org/wp-content/uploads/2019/09/Gallup-EdTech-Use-in-Schools-2.pdf

Gray, L., & Lewis, L. (2021). Use of Educational Technology for Instruction in Public Schools: 2019-20. First Look--Summary. NCES 2021-017. National Center for Education Statistics. Accessed 11/30/24 at: https://nces.ed.gov/pubs2021/2021017Summary.pdf

Grimes, D., & Warschauer, M. (2008). Learning with Laptops: A Multi-Method Case Study. *Journal of Educational Computing Research, 38*(3), 305-332. https://doi.org/10.2190/EC.38.3.d

Harrell, S., & Bynum, Y. (2018). Factors affecting technology integration in the classroom. *Alabama Journal of Educational Leadership, 5,* 12-18.

Hill, J., & Reimer, T. (2023). Technology as a tool to address educational inequities: practices implemented during the COVID-19 pandemic that have been sustained. E*ducation and Information Technologies, 29*(9), 10879–10898. https://doi.org/10.1007/s10639-023-12236-z

Incident IQ (2024). *2024 K-12 facilities management survey*. https://www.incidentiq.com/blog/2024-2025-k12-facilities-management-survey

International Society for Technology in Education (2023). *ISTE report: Survey on teacher technology proficiency and confidence*. *International Society for Technology in Education*. https://iste.org/news/new-research-study-from-iste-examines-educator-preparation-landscape

Khukalenko, I. S., Kaplan-Rakowski, R., An, Y., & Iushina, V. D. (2022). Teachers' perceptions of using virtual reality technology in classrooms: A large-scale survey. *Educ Inf Technol (Dordr), 27*(8), 11591-11613. https://doi.org/10.1007/s10639-022-11061-0

Mayes, R., Natividad, G., & Spector, J. M. (2015). Challenges for Educational Technologists in the 21st Century. *Education Sciences, 5*(3), 221-237. https://www.mdpi.com/2227-7102/5/3/221

McKnight, K., O'Malley, K., Ruzic, R., Horsley, M. K., Franey, J. J., & Bassett, K. (2016). Teaching in a Digital Age: How Educators Use Technology to Improve Student Learning. *Journal of Research on Technology in Education, 48*(3), 194-211. https://doi.org/10.1080/15391523.2016.1175856

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education, 70,* 29-40. https://doi.org/https://doi.org/10.1016/j.compedu.2013.07.033

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health Serv Res, 34*(5 Pt 2), 1189-1208.

Pellas, N., Mystakidis, S., & Kazanidis, I. (2021). Immersive Virtual Reality in K-12 and Higher Education: A systematic review of the last decade scientific literature. *Virtual Reality, 25*(3), 835-861. https://doi.org/10.1007/s10055-020-00489-9

Pew Research Center (2021). *Some digital divides persist between rural, urban and suburban America.* Retrieved December 13, 2024 from https://www.pewresearch.org/short-reads/2021/08/19/some-digital-divides-persist-between-rural-urban-and-suburban-america/

Russell, M., Bebell, D., O'Dwyer, L., & O'Connor, K. (2003). Examining Teacher Technology Use:Implications for Preservice and Inservice Teacher Preparation. *Journal of Teacher Education, 54*(4), 297-310. https://doi.org/10.1177/0022487103255985

Santos Garduño, H. A., Esparza Martínez, M. I., & Portuguez Castro, M. (2021). Impact of Virtual Reality on Student Motivation in a High School Science Course. *Applied Sciences, 11*(20), 9516. https://www.mdpi.com/2076-3417/11/20/9516

Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2011). Effects of Technology Immersion on Middle School Students' Learning Opportunities and Achievement. *The Journal of Educational Research, 104*(5), 299-315. https://doi.org/10.1080/00220671003767615

Shifflet, R., & Weilbacher, G. (2015). Teacher beliefs and their influence on technology use: A case study. *Contemporary Issues in Technology and Teacher Education, 15*(3), 368-394.

Zheng, B., Arada, K., Niiya, M., & Warschauer, M. (2014). One-to-one laptops in K-12 classrooms: voices of students. *Pedagogies: An International Journal, 9*(4), 279-299. https://doi.org/10.1080/1554480X.2014.955499

Zheng, B., Warschauer, M., & Farkas, G. (2013). Digital Writing and Diversity: The Effects of School Laptop Programs on Literacy Processes and Outcomes. *Journal of Educational Computing Research, 48*(3), 267-299. https://doi.org/10.2190/EC.48.3.a

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