ilset 2024
April 16-19
San Francisco, CA
USA

Proceedings of International Conference on Life Sciences, Engineering and Technology

April 16-19, 2024 San Francisco, CA, USA

Editors

Mack Shelley

Yasemin Bertiz

Erdinc Cakir

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Volume 1, Pages 1-148

Proceedings of International Conference on Life Sciences, Engineering and Technology

ISBN: 978-1-952092-66-4

Editors: Mack Shelley, Yasemin Bertiz, & Erdinc Cakir

Articles: 1-14

Conference: International Conference on Life Sciences, Engineering and Technology (iLSET)

Dates: April 16-19, 2024

Publication Date: December 01, 2024

Location: San Francisco, CA, USA

Conference Chair(s):

Mack Shelley, Iowa State University, United States

Stephen Jackowicz, University of Bridgeport, United States

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Virtual Reality as a Teaching Aid for Medical Professionals: A Transformative Approach to Healthcare Training

Amaka Ojieh, Sri Mettu, Jahnavi Balaji, Dr. Brian Warren, Dr. Ratana Warren, Dr. Temitope Olokunde, Dr. Opeyemi Ojajuni, Deidre Street, Dr. Michael Stubblefield, Mussie Samuel, Devender Rapolu

Southern University and A&M College, U.S.A

Abstract: In modern times, daily activities would be limited without computers, virtual environments and related technologies. Over time, various sectors have found a way to easily operate with the inculcation of virtual reality and these technologies in carrying out their operations. This has broadly included the health care sector as it has its applications in areas as surgical procedures (remote surgery, augmented surgery, and simulation planning of procedures before surgery), medical therapy, preventive medicine, medical education and training, visualization of massive medical databases, skill enhancement and rehabilitation and architectural design for health-care facilities. Till now these applications have improved the quality of health care and medical trainings and in the future, they will result in substantial cost savings, safer medical practices and limited surgical errors. As of now, tools that respond to the needs of present virtual environment systems are being refined and developed for teaching and research basis. These advanced research projects with the aid of Virtual Reality (VR) brings to light the highest level of technological advancement in medical training and education allowing for better teaching and learning practices and advancement in practical learning. As technology continues to evolve, virtual reality stands poised to revolutionize how medical professionals are trained, collaborate, and deliver enhanced care to patients, ultimately shaping the future landscape of healthcare. The central research question that guides this study is; How can VR help aspiring medical professionals visualize and simulate real life medical situations for practice? To answer this question, this research paper focuses on the development of VR infused curriculum that contributes to the training of aspiring medical professionals using Anatomage technology. The Anatomage provides a unique anatomy learning experience for students using virtual reality. The lessons learned towards implementing and integrating virtual reality in medical science curriculum using Anatomage technology will be discussed.

Keywords: Virtual Reality, Healthcare, Education, Anatomage.

Citation: Ojieh, A., Mettu, S., Balaji, J., Warren, B., Warren, R., Olokunde, T., Ojajuni, O., Street, D., Stubblefield, M., Samuel, M., & Rapolu, D. (2024). Virtual Reality as a Teaching Aid for Medical Professionals: A Transformative Approach to Healthcare Training. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024 -- International Conference on Life Sciences, Engineering and Technology*, (pp. 1-12), San Francisco, CA, USA. ISTES.

Introduction

Virtual Reality is a "computer generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment such as a helmet with a screen inside or gloves fitted with sensors" according to the Oxford online dictionary.Virtual reality (VR) involves the use of computing technology to create interactive, immersive simulations replicating true or non-existent surroundings and situations. It offers users sensorial experiences involving audio, visual and haptic feedback which makes them perceive and interact with virtual objects as if they were tangible objects in real life (Cipresso, 2018).

VR systems rely on various hardware components such as head-mounted displays (HMDs), motion tracking devices and haptic interfaces to provide an elaborate sense of presence and immersion in the virtual world. The scope for application of VR has widened across different areas like gaming, education, healthcare, military training among others (Alexandra D Kaplan, 2021)

In education field VR has been seen as one powerful tool that can improve learning experience through realistic simulations and interactive visualizations about complex concepts and procedures (Freina L, 2015). It allows learners to repeatedly practice their skills within safe environment while considering different scenarios hence improving instant transfer into long-term memory (Gerup, 2020).

The use of VR in medical education includes medical training simulators; pain management; phobias' exposure therapy; rehabilitation from cognitive impairments; rehabilitation from physical impairments. In this case healthcare providers learn how to handle different situations through simulated scenarios without endangering patients' lives (Freeman, 2017).

Nonetheless, adopting VR into other sectors faces issues regarding technological constraints, expenses incurred during implementation user experience and effective deployment strategies for instruction design purposes among others things (Jensen 2018). Ongoing researches along with developments in technology are meant to address these challenges further expanding the potentialities and applications of VR in different areas.

Literature Review/Background of Study

The advent of Virtual Reality (VR) technology has heralded a new era in medical education, offering immersive, interactive experiences that traditional methods cannot match. VR's application in healthcare training is rapidly gaining traction due to its ability to simulate complex medical scenarios and procedures, allowing learners to practice and hone their skills in a risk-free environment. Recent studies highlight VR's effectiveness in improving knowledge retention, technical skills, and procedural confidence among medical students and professionals.

The Gap in Current Research

The study on virtual reality (VR) in medical training, especially in relation to complex skill development and integration of VR into nursing curricula has shown promise but also has some gaps. Though effective on theoretical knowledge improvement among learners undertaking medical courses, its effect on practical skills, satisfaction, confidence and performance time remains unknown. A few researches argue that using traditional methods is not different from using VR in these areas because no significant advantage was found by them over the others hence suggesting further studies should be carried out to determine how this can be achieved. (Cheng FQ et al., 2020).

Another area that needs more comprehensive investigation is about integrating VR into nursing curricula. It involves such things as systematically incorporating it into educational programs; usability and effectiveness in terms of how students perceive it together with educators. (Liu, K et al., 2023)

Virtual Reality in Nursing Education

VR is highly applicable in nursing education especially when simulating processes related to patient care and clinical procedures. For example, nursing students are taught through VR how to give injections, handle patient care scenarios and respond in emergency cases among others. Furthermore, such an approach is essential because it allows learners make mistakes that they can learn from without endangering patients' well being thus creating a safe practice area.

Moreover, VR may simulate environments difficult or even impossible for students to access in practical reality like disaster zones (Verkuyl et al., 2018). This helps them adapt themselves with different kinds of patients as well as other people who may be hard to find elsewhere. Therefore, using such learning devices creates flexibility among individuals thus making them stronger than before.

However promising Virtual Reality (VR) seems regarding its use in nursing education numerous gaps exist regarding quantitative evidence for fully embracing its potential within this framework. It is important therefore, to note these areas of research need further investigation if we are going to improve VR technologies and nursing educational practices.

Studies on Long-term Impact

A major limitation found within literature is that there are no longitudinal studies in place for assessing the long-term impact of VR training on nursing students' skills, knowledge retention and clinical performance. However, to comprehensively evaluate the underlying benefits thereof, it is important to establish potential long-term competencies or patient care outcomes as well (Padilha et al., 2019).

Various Clinical Situations and Areas of Expertise

On another note, there is need for exploration into other areas where VR can be used broadly in terms of different clinical scenarios and specialties within nursing circles. Most of such researches have been limited to general nursing skills as well as rudimentary clinical procedures. But a study focused on mental health nursing might produce findings that differ from those about pediatric or geriatric ones.

Cost-benefit Analysis

The cost implications associated with the integration of VR technology in nursing education have significantly been discussed. It however lacks comprehensive cost benefit analysis that takes into account costs involved during initial purchase of VR equipment and software and instead factors such as improved clinical competency, shorter training period among others (Padilha J.M., 2019). Consequently, this would then give more grounds that could be used by learning institutions and other medical facilities to improve their teaching standards through the use of virtual reality devices.

Cultural and Socioeconomic Factors

Most of the research on VR in nursing education has failed to consider how cultural and socioeconomic dynamics affect the effectiveness and availability of VR training. Understanding the impact of these factors on students' interactions with VR can provide important insights for designing and implementing inclusive, fair VR simulations.

Integration Strategies and Best Practices

However, there is limited guidance on how to effectively integrate VR into existing curricula, despite the fact that the advantages of VR in nursing education are increasingly becoming evident. If future research can aim at developing and assessing strategies for a seamless integration of VR training including faculty training, student orientation to VR technologies, and aligning VR simulations with learning objectives as well as assessment methods. By so doing we will fill these gaps thereby making sure that VR does not only promote theoretical understanding but also enhance cost-effective clinical decision making skills among nurses. Additionally, such findings may contribute towards creating more engaging educational background for trainees who are taking up nursing professionally.

Objective of the Current Study

This research aims to identify the primary gaps that investigates how VR technology can be more effectively used to improve not just theoretical knowledge but also practical nursing skills which are crucial for clinical practice. It also explores how VR can be systematically integrated into nursing education programs and assesses

its usability and perceived effectiveness among nursing educators and students.

Contribution to the Field

The study's focus on the integration of VR into nursing curricula could yield insights into best practices for incorporating innovative technologies in educational settings. By evaluating the effectiveness of VR in improving both theoretical knowledge and practical skills, this research provides evidence-based recommendations for how VR can be employed to enhance nursing education. The findings from this research could influence policy decisions and curriculum development within nursing education by providing a data-driven basis for incorporating VR technologies and ultimately encourage more widespread adoption and optimized use of VR in nursing training programs globally.

Furthermore, it would add to the growing bodcy of literature on the use of VR in education, particularly in the healthcare domain, by addressing some of the less explored aspects such as practical skills enhancement and economic evaluations. This could spur further studies and innovations in this area into the advantages and challenges of implementing primary VR tool in healthcare training. By documenting its impact on learners' outcomes, the research will inform educators, curriculum developers, and policymakers about the value of integrating advanced VR tools like Anatomage in medical training programs, potentially shaping future educational strategies and improving patient care quality.

Methodology Overview

The introduction of Virtual Reality (VR) in nursing education has changed the way nurses' students gain knowledge, skills alongside empathy required for their demanding role within healthcare settings. This technological revolution involves immersive simulations and interactive learning scenarios that offer students an opportunity to practice clinical skills and make decisions without any consequences. The development of virtual reality technologies and their incorporation into nursing curricula have been widely studied to establish whether they are efficient, feasible or affects learning outcomes.

This overview examines methodologies adopted by researchers when exploring multidimensional aspects of using VR in nursing education. Dean et al.'s (2020) study among others reveals the complexities involved with introducing VR simulations while suggesting evaluation frameworks that combines both quantitative measures and qualitative measures. In these studies, so much emphasis is put on investigating pedagogical bases upon which applications of VR can be seen to enhance clinical competencies; foster empathy; increase learner engagement (Nelson, 2016).

This analysis also takes account of different research designs like random controlled trials versus mixed method approaches indicating how diverse educational applications are (Dean, 2020); (Nelson, 2016) With this view in mind it seeks to unpack the methodological rigor as well as creative inquiry underpinning work in the domain

thus provide a comprehensive understanding about how nursing science moves forward thanks to these approaches.

Herein lies an examination of various methodologies used by researchers regarding virtual reality use in education allied health care article aims at appreciating pioneers in this field and the technology can change medical careers in future.

Clinical Virtual Simulation in Nursing Education by Padilha et al. (2018)

- Study Design: A quantitative approach was employed in this exploratory, descriptive, cross-sectional study.
- Sample: An unrepresentative sample of 426 pregraduate nursing students from Portuguese School of Nursing was used.
- Data Collection: Employed a questionnaire that is rooted in Technology Acceptance Model (TAM), with particular emphasis on ease of use, perceived usefulness and intention to use Clinical Virtual Simulation (CVS).
- Analysis: Descriptive and inferential statistics were done, with non-parametric tests due to violations of normality assumptions. To present results more succinctly, Exploratory Factor Analysis (EFA) was performed.

Augmented Reality, Virtual Reality, and Gaming: An Integral Part of Nursing by Ferguson et al. (2016)

- This article provides an overview for potential uses and advantages of AR technology VR technology &gaming in the field of nursing education describes how it can be added to enhance learning experience at schools and colleges when students are engaged in their studies as well as improve patients' clinical care outcomes; also it says that these technologies can change learning opportunities for nurses students along with patient interaction improvement alongside healthcare support.

A Literature Review on Immersive Virtual Reality in Education by Freina and Ott(2015).

-Study Design: Conducted a literature review focusing on the advantages and potentials of using Immersive Virtual Reality in Education especially between the years 2013 – 2014
- Content: Differentiated between non-immersive and immersive VR elaborating about evolution, applications including potential benefits of immersive VR such as its limitations and means for confirmation.

Commonalities and Unique Aspects

-Padilha et al. Cross-Sectional Surveys: This is centered on direct assessment of students' perceptions about the use of CVS using TAM as a theoretical framework to understand acceptance and intention to use VR technologies in nursing education.

-Freina and Ott Literature Review: The article gives a broader view on the field by synthesizing recent

researches related to immersive VR's application in education, stating potential benefits followed by identifying gaps in present knowledge and practice.

-Ferguson et al. (2017) Discussion on AR, VR, and Gaming in Nursing: Though not strictly speaking methodology, this discussion points out the increasing interests towards gaming based, AR/VR based teaching among nurses for better learning experiences as well as improved health care outcomes.

In general, these methodologies provide insights into how VR/IVR can be brought into nursing education to enrich learning experiences among students, improve clinical skills and prepare them for challenges faced in real world healthcare system.

Results

The results demonstrate the perceived efficacy, usability, and possible advantages of Virtual Reality (VR) technology alongside Immersive Virtual Reality (IVR) in relation to nursing education. A summary of key findings from each paper is given below;

Clinical Virtual Simulation in Nursing Education by Padilha et al. (2018):

The study found high levels of perceived ease, usefulness, and intention to use Clinical Virtual Simulation (CVS) among nursing students. On a 10-point Likert scale the simulator had an average usability rating of 8.99 while perceived usefulness scored even higher at about 9.60 with some averages slightly exceeding the figures mentioned above thus indicating that all nursing students are ready and willing to accept CVS into their learning experience because it adds value to their educational process. The study also noted that students without any clinical exposure regarded CVS more useful compared with those with clinical experience (Padilha J.M., 2018).

Augmented Reality, Virtual Reality, and Gaming: An Integral Part of Nursing by Ferguson et al.:

This article discussed the potential of AR, VR, and gaming to significantly impact nursing education and patient care. Quantitative findings were not reported specifically but the narrative review emphasized that these technologies could be applied across different learning environments to improve students' experience in healthcare training as well as enhance clinical skills development. According to the authors, these technology-mediated interventions are capable of yielding better health outcomes, more engaging learning spaces and increased self-management for individuals (Ferguson C.D., 2016).

A Literature Review on Immersive Virtual Reality in Education by Freina and Ott:

Freina and Ott's literature review highlights the changing role of immersive VR in education with respect to

making learning more motivating and engaging. Though this was a broad perspective of education rather than focusing exclusively on nursing it seems that adult training /university education has been identified as one area where immersive VR had greatest application due to historical cost issues and usability limitations. The review underscores the importance of immersive VR in simulating experiences that are otherwise inaccessible, providing safe training environments, and potentially enhancing learner engagement and motivation across various educational levels and settings (Freina, 2015).

Collectively, these findings indicate a favourable reception as well as validation of potential role played by VR/IVR technologies towards improving nursing education thus portending an era where such devices could become inherent parts of healthcare training regimens or strategies.

Summary of Key Findings from Quantitative Research

The results of quantitative research on the incorporation of Virtual Reality (VR) into nursing education have shown many significant findings that underscore its benefits and challenges. These findings, drawn from various studies, provide valuable information on how VR technology can be used to improve nursing training and education.

Enhanced Clinical Skills and Knowledge Retention

Several quantitative research studies have shown that VR simulation training in nursing education significantly augments clinical skills and knowledge retention among students. In a study by Padilha et al. (2019), there was significant improvement in clinical reasoning skills and knowledge application among nursing students who engaged in VR simulation specifically towards emergency care procedures. It is also evident that VR training enhanced learner proficiency on precise clinical tasks, for example, venipuncture thus emphasizing the role played by VR in skill acquisition and maintenance. (Padilha J. M., 2019)

Increased Student Engagement and Satisfaction

VR simulations are associated with higher student engagement levels and increased satisfaction as observed from quantitative research studies too. Kleinert et al., (2020) carried out a quantitative assessment of student satisfaction using VR training showed that there were higher levels of satisfaction among those who did Vr compared to traditional forms of learning thus indicating better perceived learning effectiveness Moreover, this suggests that immersive interactive experience through virtual reality plays an important role in engaging students during their entire educational journey.(Kleinert, 2020)

Improved Self-confidence and Reduced Anxiety

VR's positive impact among nursing students includes improved self confidence and lower anxiety as indicated

by a number of quantitive researches. Åkerberg et al.(2020) showed the reduction of anxiety levels while boosting self confidence amongst student nurses undertaking VR simulation training according to their own self-reports. The effect was highly notable particularly when it came to high stakes patient scenarios hence indicating that the use of these simulations can be deployed as tools that reduce anxiety besides building cognitive capacity for eventual real-life situations (Åkerberg, 2020).

Challenges and Considerations

Apart from all these positive results, quantitative research has also pointed out some issues concerning implementing VR into nursing education.Due to high costs involved in procuring virtual technology equipment, technical support including teaching is required, while digital content quality can differ a lot. Moreover, Forssén and Boyle (2020) indicate that more comprehensive research is needed as to whether large samples sizes and longitudinal studies are necessary for better understanding of the long term consequences of VR training on nursing competences and patient care outcomes. (Forssén, 2020). In sum, quantitative studies on the efficacy of using VR in nursing education have shown that it has potential to enhance clinical skills, knowledge retention, student engagement, self-confidence and addressed challenges that need to be tackled to ensure its maximum benefits.

Discussion

The results from the studies and literature review on the use of Virtual Reality (VR) and Immersive Virtual Reality (IVR) in nursing education, as presented by Padilha et al. (2018), Ferguson et al. (2016), and Freina and Ott offer compelling insights into the current and potential impact of these technologies on the field of nursing education. Here's a discussion of these findings:

Enhanced Learning Experiences and Engagement

One primary outcome across all the studies was a high perceived ease of use, usefulness; intention to use VR & IVR among nursing students suggesting that not only are VR technologies accessible but also beneficial to students looking forward towards enhancing their learning experience.Virtual reality creates an immersive environment whereby complex clinical scenarios can be simulated while ensuring safety thus allowing more practice opportunities for students leading to increased confidence without any real-life healthcare risks involved. This aligns with a growing expectation within nursing education for innovative solutions that respond digitally native students' needs.

Potential for Broader Educational Applications

Through the years, VR and IVR have been mostly used in adult training and university education because

historically it was quite expensive to purchase these systems and they had a lot of problems related with usability. However, there is a wider recognition that it can be applied for different levels of education and even various educational scenarios. As technology becomes more cost-effective and easier for people to adopt, it presents opportunities for integration into nursing education at all stages including initial training through to ongoing professional development. This has the potential to make nursing education more accessible and of higher quality, thus making post-graduate programs available to more students.

Improving Patient Care and Outcomes

Furthermore, VR/IVR integration is not limited to class scenarios, but also offer a chance for patient education and care. For instance, Ferguson et al. (2016) indicate that these solutions are media through which patients can be educated in an exciting and interactive manner in order to improve their health outcomes by increasing understanding of self-management related issues. In relation to this, it becomes applicable when it comes to handling chronic illnesses as well as recovery where patient engagement and adherence to treatment is vital.

Challenges and Future Directions

Despite these advantages, there are still hurdles that have prevented the widespread use of VR/IVR in nursing education. Other barriers include hefty investments in equipment and training for educators so they can successfully integrate these technologies into their curriculum. Moreover, there is little knowledge about the long-term impact of VR/IVR on learning outcomes and patient care practices.

The results demonstrated positive acceptance rates towards the implementation of Virtual Reality (VR) as well as Immersive Virtual Reality (IVR) technologies as ways of improving nursing education and patient health care respectively. As they keep changing with time and being integrated within school settings together with healthcare institutions, they give room for better training towards nursing professions. However, it will be important in future researches addressing challenges associated with implementing them while exploring fully what benefits do they bring along in addition to nursing courses.

Conclusion

The incorporation of Virtual Reality (VR) along with Immersive Virtual Reality (IVR) into nursing courses has marked a significant change from traditional teaching techniques that were used before today's complex world of medicine emerged. Padilha et al., 2018; Ferguson et al., 2016; Freina & Ott's literature review vests similarly inclined hope in this form of technology to improve learning experiences, involve students in immersive education and thus lead to better patient care.

The findings indicated that most nursing students accepted the implementation of VR/IVR which implied that

they believe it is easy to use, helpful and meant their future courses will feature these technologies. Such a positive reception is crucial for the introduction and integration of VR technologies into nursing curricula since it suggests that college learners are ready to accept new approaches with a view of matching present generations' digital literacy levels.

Furthermore, application possibilities for VR/IVR go beyond education services where they offer innovative solutions for patient education as well as care management. Hence, these technologies through simulated games can be extremely useful tools for patients' understanding enhancement; self-care enhancing through increasing knowledge about how people live in situations requiring complex care such as recovery from chronic ailments. However, there are still some challenges including the need for funding in terms of technology acquisition costs along with training educators while persistently investigating what will make VR/IVR work best in learning nursing. These challenges should be addressed fully so that nurses can maximize the benefits of using virtual reality techniques while preparing themselves.

Summing up, the introduction of VR and IVR into nursing programs indicates a radical revolution in teaching and learning methods. In the end, virtual reality (VR) and immersive virtual reality (IVR) technologies have created possibilities for improving quality of nursing education as well as making students more prepared for their clinical practice and also ensuring that there is patient care enhancement. In order not to be left behind in terms of educational innovation and health care excellence, it will be necessary to employ them as needed in this dynamic field of nursing education.

References

Åkerberg, A. W. (2020). The impact of virtual reality on nursing students' anxiety and self-confidence: A quasi-experimental study. *Clinical Simulation in Nursing*, 48,55-62.

Alexandra D Kaplan, J. C. (2021, June). The effects of virtual reality, augmented reality, and mixed reality as training enhancement methods: A Meta-Analysis.

Chen FQ, Leng YF, Ge JF, Wang DW, Li C, Chen B, Sun ZL (2020). Effectiveness of Virtual Reality in Nursing Education: Meta-Analysis. J Med Internet Res 22(9):e18290, doi: 10.2196/18290PMID: 32930664PMCID: 7525398d

Cipresso, P. G. (2018). The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. *Frontiers in Psychology*,, 9,2086.

Dean, S. H. (2020). Nursing education, virtual reality, and empathy? . *Nursing Open*, 2056-2059.

Ferguson, C. D. (n.d.). Augmented reality, virtual reality, and gaming: An integral part of nursing. . *Contemporary Nurse*.

Ferguson, C. D. (2016). Augmented reality, virtual reality, and gaming: An integral part of nursing. .

Contemporary Nurse.

Forssén, M. &. (2020). The efficacy of virtual reality in nursing education: A meta-analysis. . *Nursing Education Perspectives*, 41(30, 144-150.

Freeman, D. R. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine*, 47(14), 2393-2400.

Freina L, O. M. (2015). A Literature review on immersive virtual reality in Education: state of the art and perspectives. *Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. In Proceedings of eLearning and Software for Edu*, p133-141.

Freina, L. &. (2015). A Literature Review on Immersive Virtual Reality in Education: State Of The Art and Perspectives. . *Institute for Educational Technology*.

Gerup, J. S. (2020). *ugmented reality and mixed reality for healthcare education beyond surgery: An integrative review*. Retrieved from Online Learning: https://doi.org/10.24059/olj.v24i1.2002.

Jensen, L. &. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies*, 23(4) 1515-1529.

Kleinert, R. H. (2020). Immersive virtual reality in medical education and training: A narrative review. . *Journal of Surgical Education 77(4), 833-84*, 77(4), 833-84.

Liu, K., Zhang, W., Li, W. *et al.* Effectiveness of virtual reality in nursing education: a systematic review and meta-analysis. *BMC Med Educ* **23**, 710 (2023). https://doi.org/10.1186/s12909-023-04662-x.

Nelson, R. (2016). Replicating Real Life: Simulation in Nursing Education and Practic. *The American Journal of Nursing*, 116(5),20-21.

Padilha, J. M. (2018). Clinical virtual simulation in nursing education.. *Clinical Simulation in Nursing*, 15*,13-18.

Padilha, J. M. (2019). Clinical virtual reality simulation in nursing education: A randomized controlled trial. *Journal of Medical Internet Research*, 21(3), e11529.

Verkuyl, M. A. (2018). Virtual gaming simulation for nursing education: An experiment. *Clinical Simulation in Nursing*, pp. 17,7-15.

The Use of Toothpicks as a Tool to Stimulate the Development of Logical Reasoning

Elisiê Pialarissi
Universidade Tecnológica Federal do Paraná-UTFPR, Brazil, https://orcid.org/0000-0001-7547-4532

Lucas Alves Beatriz
Universidade Tecnológica Federal do Paraná-UTFPR, Brazil, https://orcid.org/0009-0009-8917-6275

Rhyanne Vitoria Leal Lourenço
Universidade Tecnológica Federal do Paraná-UTFPR, Brazil, https://orcid.org/0009-0009-8517-6091

Danielle Gonçalves de Oliveira Prado
Universidade Tecnológica Federal do Paraná-UTFPR, Brazil, https://orcid.org/0000-0003-2802-6037

Simone Garbelini Parro Pialarissi
Universidade Estadual de Londrina -UEL, Brazil, https://orcid.org/0000-0003-2181-3310

Isabelle Gonçalves de Oliveira Prado
Universidade Federal de Viçosa-UFV, Brazil, https://orcid.org/0000-0003-4456-8303

Abstract: Even with so much technology that we face today, the easy access to information, and the speed at which it reaches people, it is still a challenge when we face situations in which it is necessary to use logical reasoning to solve problems. Therefore, it is of great importance to develop this skill from childhood, especially in primary schools. To achieve this, we propose to use different methods that involve questions that work the mind. Furthermore, it is important to expand the exchange of knowledge and experiences between teacher and student, strengthening the relationship between them and providing a more dynamic, enjoyable teaching methodology that builds up better personal, social, and cultural relationships. Another point to be mentioned is that logical reasoning helps people make quick decisions to solve problems every day, thus contributing to their physical and mental health. Based on this assumption, in this work something very simple was used: ice cream sticks, as a teaching-learning tool for children from the 5th to the 7th year of elementary school. A healthy competition was held among the children. In addition to becoming an attractive activity, it escapes the formal reality of a conventional classroom. During the proposal, it was possible to identify an improvement in communication between students, and also, different strategies for solving questions involving elementary operations were presented, fulfilling the main objective of the dynamics. Due to the excellent performance of those involved, we intend to apply this and other activities with the same principle to other classes, always respecting the students' level of knowledge.

Keywords: Logical reasoning, toothpicks, teaching and learning.

Citation: Pialarissi, E., Beatriz, L. A. Prado, D.G.O., Lourenço, R.V. L., Pialarissi, S. G. P., & Prado, I.G.O. (2024). The use of toothpicks as a tool to simulate the development of logical reasoning. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024 -- International Conference on Life Sciences, Engineering and Technology*, (pp. 13-25), San Francisco, CA, USA. ISTES.

Introduction

We can see that the world is evolving more and more quickly and that advances in the use of technology are invading the homes and lives of the entire population, regardless of social class, gender, race, or ethnicity. Without a doubt, this evolution is reflected on children's learning and cognitive development, especially in schools. However, not all institutions are able to offer education that keeps up with this evolution, often making teaching and learning tedious and tiring, especially for children who are part of a generation that has skills with electronic devices and feels more comfortable with new technologies than with games, such as board games. This led us to think: How can we attract the attention of these children at school with playful activities using few resources? What types of activities could we use? What material is accessible to everyone?

These questions have led us to reflect on the need to transform teaching practices, using the resources available at school, to attract students' attention and bring them to more meaningful learning, which stimulates the development of reasoning and new skills. From this perspective, we believe in the appropriate use of play in basic education as a strategy that awakens enthusiasm for knowledge in students, aiming for critical enjoyment and the well-being of those involved (DOS SANTOS SILVA et al, 2022, p. 248). And the use of games in the classroom, as found by DOS SANTOS SILVA et al. (2022) provokes in the student a natural encouragement and a desire to discover ways that can establish relationships between real and imaginary situations. Furthermore, it allows students to expand their logical reasoning and creativity when solving problems.

First of all, we need to stop and think about how logical reasoning is present in our daily activities, from the simplest to the most complex, and how people, in general, have difficulty or even fear to talk about some school subjects, such as mathematics, when its use is so common and ordinary in our lives. Hence the importance of developing work from an early age that stimulates children's cognitive development, with school being an ideal place for this. In the words of Scolari, Bernardi, and Cordenonsi (2007), the development of logical reasoning in students is a necessity to make them think more critically about the content of different subjects, making them more argumentative based on criteria and logically validated principles, achieving true knowledge.

With this in mind, we understand the importance of working on logical reasoning from an early age, because as Silva (2006) highlights, learning begins in childhood so that it is possible to fix what is being studied and so that it is not easily forgotten. Based on this assumption, we aim to use games with popsicle sticks as a playful

teaching tool, practically and dynamically, engaging in logical and mathematical challenges with elementary school students from 5th to 7th grade, highlighting their relevance and demonstrating that all of this can result of an exchange of teachings between students and teachers in a simple, healthy and efficient way.

Method

Thinking about how to work on logical reasoning with elementary school children without using many resources and less technology, we decided to work on mathematical games using popsicle sticks, wich are a low-cost, accessible and, easy-to-use resource. In this proposal, we worked with an average of 20 wooden popsicle sticks, which were distributed among the students according to the proposal for each activity. The age range of the students who participated in the activities ranged from 10 to 12 years old. Among them there were four girls and one boy from different schools, so the activities were separated according to school age to determine the level of difficulty of each challenge. Each student solved their challenge individually.

For a month, once a week, the students met in a room at a private educational institution called Colégio São José, with meetings lasting one hour and twenty minutes to carry out these activities. The meetings took place on different days and times according to each person's needs and availability, working individually. As a result, we introduced the content in a theoretical way and thus worked on some exercises that were developed with popsicle sticks, forming figures, equations, or even logical sequences, in which it was necessary to move a certain amount of sticks to obtain the expected answer.

There were 4 lessons in total.The first lesson with an introduction to the content, two other lessons with exercises, and the last lesson with questions on the same subject, but using activities from competitive exams such as FUNDEP- Fundação de Desenvolvimento da Pesquisa.(Gestão de Concursos - 2021), VUNESP – Fundação para o Vestibular da Universidade Estadual Paulista (2016), FCC -Fundação Carlos Chagas (2017, SABESP -Companhia de Saneamento Básico do Estado de São Paulo - Internário Ensino Médio Regular), among others.

To develop the content, we took as inspiration the book "Raciocínio Lógico” (Logical Reasoning) as shown in Figure 1 and Figure 2, written by Artur Ataíde, from Artus Editora, in its various editions and volumes, exploring the needs of each student. We work with Omega (Θ) volume for the 4th and 5th year of elementary school, the Alpha (α) volume for the 6th year of elementary school, the Beta (β) volume for the 7th year of elementary school, the Omega (Ω) for the 8th year of elementary school and the Gamma (γ) for the 9th year of elementary school.

The book has an introductory theoretical part as shown in Figure 3, which highlights the importance of toothpicks and logical reasoning as a tool in teaching learning using strategy, logic and geometric shapes to unlock problems. Next, some dynamic work and resolved challenges are presented to serve as an example of

resolution for other problems that will appear in the fixing exercises and challenges setting part.

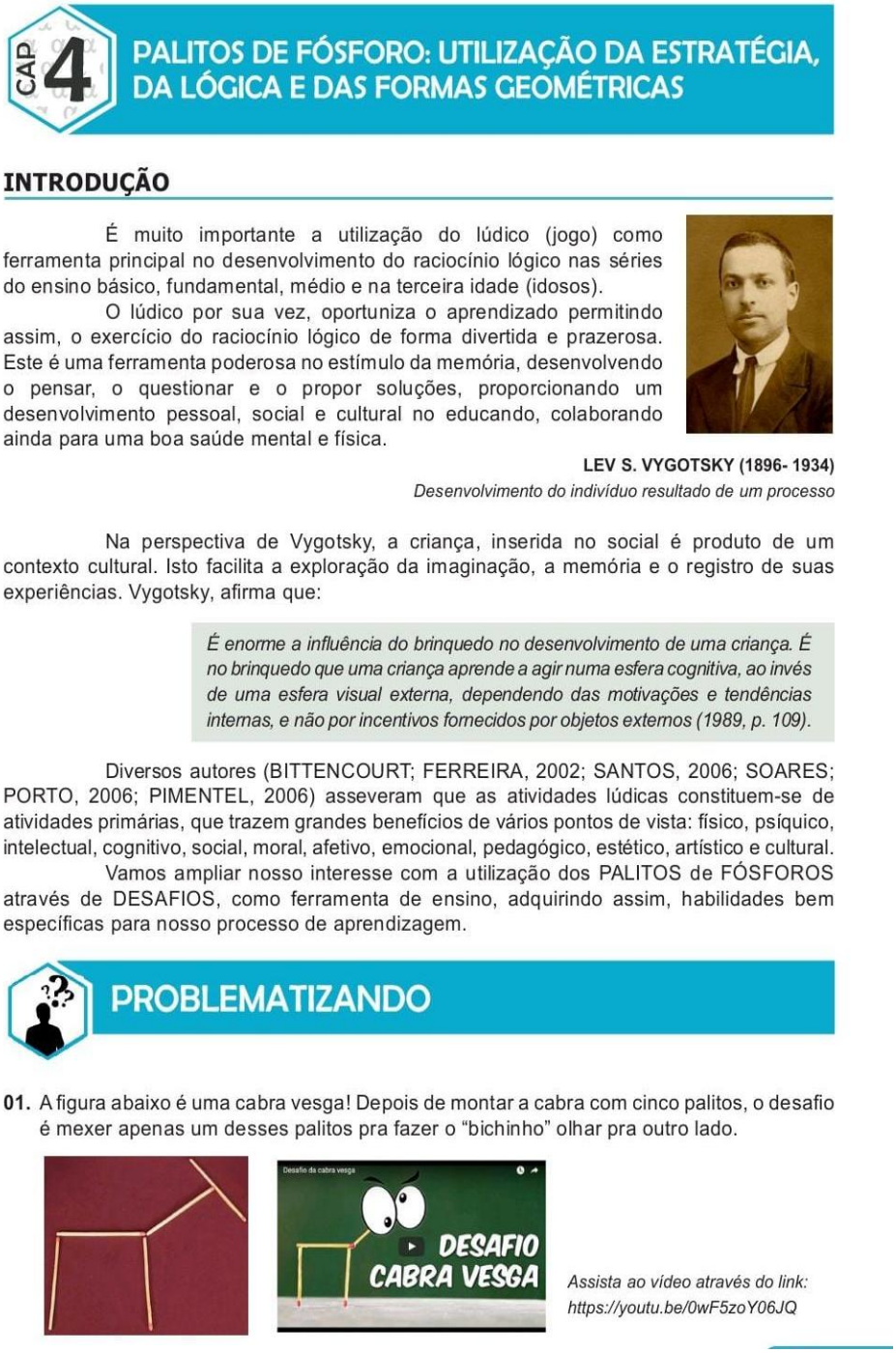
Figure 1. The books used to work on content in elementary school.

Source: author.

Figure 2. The books used to work on content in elementary school.

Source: author.

In addition to the book, we have had the support of numerous exercises created and also researched on the internet, in order to add content and challenges for students, always respecting - as mentioned - the level of development of each one.



CAP 4

PALITOS DE FÓSFORO: UTILIZAÇÃO DA ESTRATÉGIA, DA LÓGICA E DAS FORMAS GEOMÉTRICAS

INTRODUÇÃO

É muito importante a utilização do lúdico (jogo) como ferramenta principal no desenvolvimento do raciocínio lógico nas séries do ensino básico, fundamental, médio e na terceira idade (idosos).

O lúdico por sua vez, oportuniza o aprendizado permitindo assim, o exercício do raciocínio lógico de forma divertida e prazerosa. Este é uma ferramenta poderosa no estímulo da memória, desenvolvendo o pensar, o questionar e o propor soluções, proporcionando um desenvolvimento pessoal, social e cultural no educando, colaborando ainda para uma boa saúde mental e física.

LEV S. VYGOTSKY (1896- 1934)

Desenvolvimento do indivíduo resultado de um processo

Na perspectiva de Vygotsky, a criança, inserida no social é produto de um contexto cultural. Isto facilita a exploração da imaginação, a memória e o registro de suas experiências. Vygotsky, afirma que:

> *É enorme a influência do brinquedo no desenvolvimento de uma criança. É no brinquedo que uma criança aprende a agir numa esfera cognitiva, ao invés de uma esfera visual externa, dependendo das motivações e tendências internas, e não por incentivos fornecidos por objetos externos (1989, p. 109).*

Diversos autores (BITTENCOURT; FERREIRA, 2002; SANTOS, 2006; SOARES; PORTO, 2006; PIMENTEL, 2006) asseveram que as atividades lúdicas constituem-se de atividades primárias, que trazem grandes benefícios de vários pontos de vista: físico, psíquico, intelectual, cognitivo, social, moral, afetivo, emocional, pedagógico, estético, artístico e cultural.

Vamos ampliar nosso interesse com a utilização dos PALITOS de FÓSFOROS através de DESAFIOS, como ferramenta de ensino, adquirindo assim, habilidades bem específicas para nosso processo de aprendizagem.

PROBLEMATIZANDO

01. A figura abaixo é uma cabra vesga! Depois de montar a cabra com cinco palitos, o desafio é mexer apenas um desses palitos pra fazer o "bichinho" olhar pra outro lado.

Assista ao vídeo através do link: https://youtu.be/0wF5zoY06JQ

Figure 3. Book chapter from the 6th grade used to work on the content of the sticks

Source: Ataíde, Artur, 1981 - Logical Reasoning: Volume Alpha / Artur Ataíde. 6 .ed - Recife: Artus Editora, 2017 .116 p.43.

All children participated in the activities continuously, throughout the four lessons. The children were very insistently, without giving up on the challenges proposed to them. At all times, we were side by side with them to analyze each step and decision taken, as well as constantly supporting and encouraging them so that they wouldn't get discouraged by the requested activities. Each student showed difficulty in a particular exercise without maintaining any pattern, just as they showed extreme ease in some exercises individually.

At each class, the students arrived even more enthusiastic and determined to take on new challenges, even bringing some inspiration that they had developed or searched on the internet, based on the exercises worked on during the meetings. We clearly observe a personal evolution in each student.

Results

During the teaching process, it was possible to notice that progress was gradual with each lesson. During the resolution of the exercises that were proposed, the students achieved an excellent result, going beyond expectations and the proposed goals.

For example, we have a challenge presented in Figure 4, where it is necessary to move just two sticks to correct the equation, thus solving the problem shown in Figure 5.

Figure 4. Equation using ice cream sticks

Source: author.

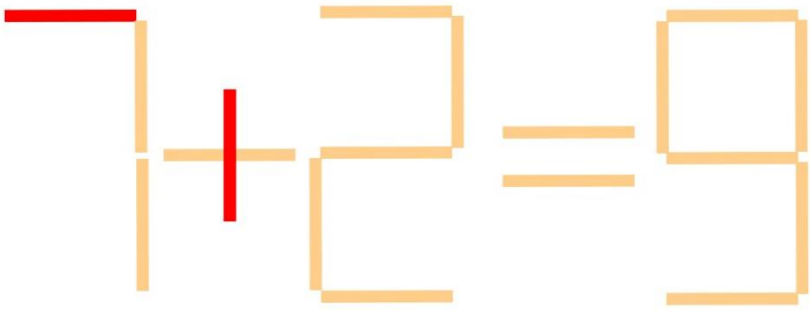


Figure 5. Resolution of the challenge presented in Figure 1.

Source: author.

In image 3 we can see an example of the incorrectly written equation: 4 - 2 = 9. The challenge is to write it correctly by moving only two of the sticks, as shown in Figure 5 where the correct equation obtained, 7 + 2 = 9. Another style of exercise that we can mention using sticks is shown below in figures 6 and 7.

Figure 6. Challenge using sticks.

Source: author.

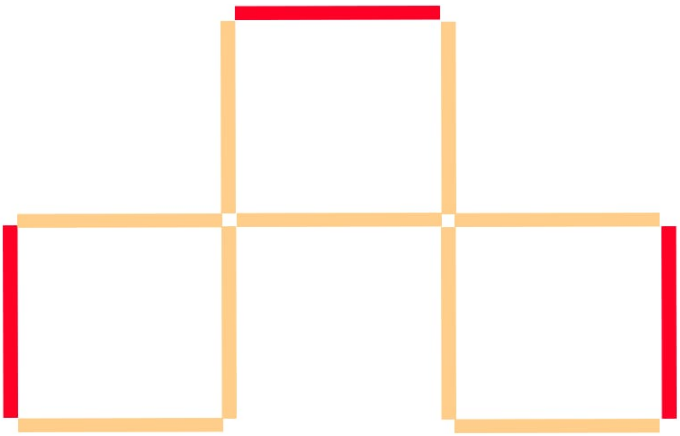


Figure 7. Solving the challenge using sticks from Figure 6.

Source: author.

In Figure 6, we can see a tic-tac-toe-shaped figure, with a closed square in the middle with eight more open squares around it. The problem says that we should build three different closed squares by changing the position of just three ice-cream sticks, which leads us to the correct answer, shown in Figure 7.

In the same line of exercises, we also have activities with animals, such as Figure 8 and Figure 9, where the aim

is to move just three sticks to change the direction of the fish.

Figure 8. Challenge using ice cream sticks - fish.

Source: author.

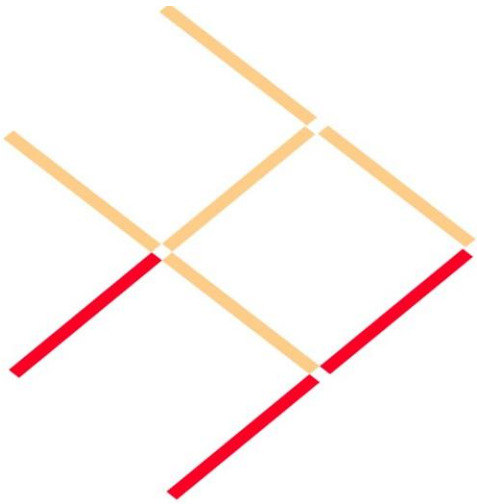


Figure 9. Resolution of the challenge in Figure 8.

Source: author.

This, like other exercises, was worked on at different levels of difficulty, according to the the students' age group, using beads, animals and well-known geometric shapes as figures for the exercises. We should also highlight that even if there is a known answer, some students end up achieving the same goal in a different way to the known one, thus showing that each one sees and deals with problems in an individual way, often surprising with the results in logical reasoning.

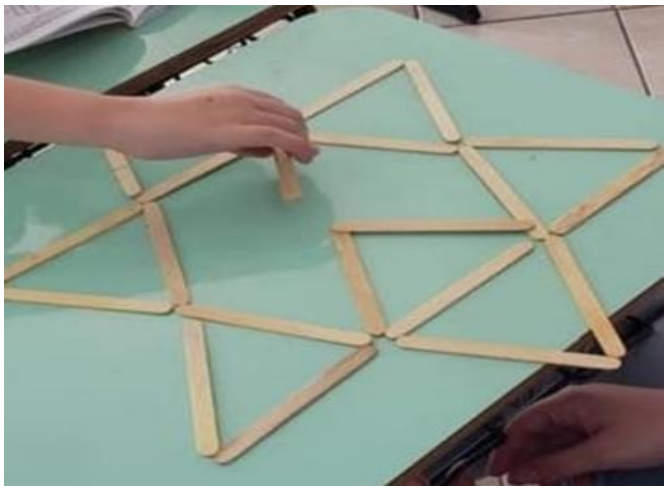


Figure 10. Use of toothpicks to solve the exercise.

Source: author.

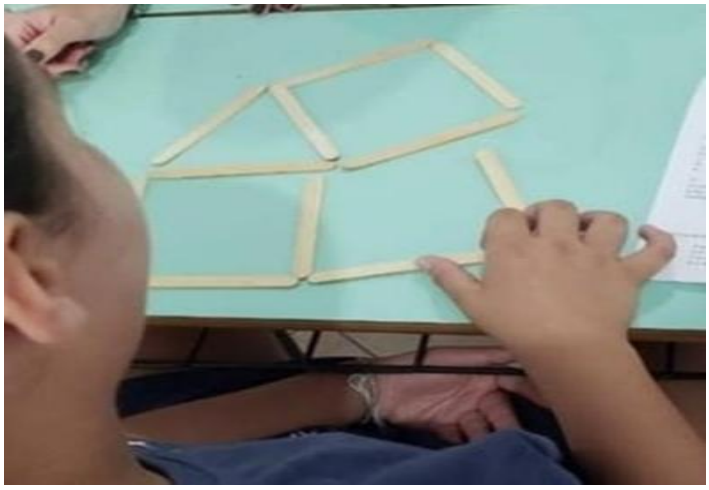


Figure 11. Using toothpicks to solve the exercise.

Source: author.

Figure 12. Using toothpicks to solve the exercise.

Source: author.

Discussion

Pontes et al. (2017) state that, Mathematical Logical Reasoning is a process of realigning thinking, following the rules of logic, which allows solving problems or exercises of an arithmetic, geometric or matrix nature , with the aim of developing the mental abilities and skills of those involved. They add that logical-mathematical reasoning should be stimulated from an early age so that children can process and retain the knowledge they acquire.

Similarly, Scolari, Bernardi and Cordenonsi (2007) argue that if logic is not taught from an early age, this can cause harm in adult life, such as not knowing how to explain, organize and support an idea, or interpret a text, or even solve a mathematical problem. It is essential that students understand and reason about what is being proposed and not just memorize and apply formulas. The cited authors also emphasize that one of the important factors in using a learning object is to make it a tool to support teaching practice, capable of helping the teacher retain the students' attention and at the same time making it a means of facilitating learning, visually stimulating students through animations, colors and movements, just as we use ice cream sticks associated with drawings and geometric shapes to solve strategy and logical reasoning problems.

From this perspective, the data analyzed here demonstrate the importance of working on logical reasoning activities in childhood, especially through games. And it is worth highlighting that it is possible to work with very simple and easily accessible materials that are present in children's daily lives. From the activities applied it was possible to observe in the act of 'thinking while playing' a process of manipulation, experimentation and exploration that are essential characteristics of creative learning. Furthermore, the use of games in the educational context proposes learning and working together considering that 'making mistakes' does not disqualify, but encourages the search for a new solution (FERREIRA GUARDA; DA SILVA PINTO, 2021, p. 33).

In the words of Riccetti (2001), play is a cultural phenomenon with multiple manifestations and meanings, which vary according to time, culture and context. What characterizes a playful situation is the child's initiative, intention and curiosity" (p. 19). Therefore, in relation to mathematics, the aforementioned author argues that games help children to build "qualitative or logical relationships, to learn to reason and question their mistakes and successes" (p. 21). It is up to the teacher to observe how each child participates and whether they are being mentally mobilized.

The results of the work showed that the students had greater difficulty in the class in which they worked on the competition exercises, which was already expected. As these are questions taken from real competitions that have been difficult for many adults and people who have already graduated, it would be no different with children. But even with difficulty, they managed to solve them in a pleasant way after all the training that took place in previous classes.

According to Riccetti (2001), to obtain a good result when working with games with children, we first need to be clear that we should never force the child to play, because what is imposed ends up becoming unpleasant and generates fear, insecurity and blocks. Likewise, it is necessary to intervene as little as possible, leaving children to walk alone. The only way to intervene that the author considers positive is to question the students at the right times about a problem situation, to generate constructive dialogues between participants. In this way, using the game as a teaching-learning tool will achieve the goal of contributing to the cognitive development of children at school level.

And even in the face of so much technology and innovation, the teaching of Mathematics in schools - at any level of education - remains traditional and still causes fear. However, it is considered a fundamental subject for cognitive development and solving everyday problems. Hence the need to develop work that involves students from their earliest years of school in activities that naturalize Mathematics and logical reasoning and that awaken curiosity and the desire to discover new ways of learning. Therefore, the use of play as a pedagogical tool in the process of teaching and learning Mathematics is a plausible alternative for reducing the gaps between this science and the student's daily life, as already well reported by DOS SANTOS SILVA et al. (2022).

> Furthermore:
>
> Mathematical games can be included in a multiplicity of purposes within the context of teaching and learning mathematics. These activities enable greater involvement and motivation between teacher and students, and consequently generate a strengthening of specific content in the area. The game that provides the learner with a strong feeling of curiosity and interest makes this practice significant in the search for new knowledge (DOS SANTOS SILVA et al., 2022, p. 249).

In the same way, Isidro and Almeida (2003) emphasize the idea that during a game, in addition to practicing techniques and strategies, students will also train social interaction and the different ways of dealing with social conflicts that may arise during this activity, and he add that it is in games with similar peers, whether in social or cognitive terms, that development its best.

Certainly, as we have seen, games are an excellent tool for working on logical reasoning in mathematical activities, but it is up to the teacher to reinvent strategies that provoke the student's desire to learn, recognizing fears, difficulties and valuing every step - right or wrong - that the student takes in this process. Therefore, mathematical games should be a school practice that brings students closer to their daily lives and develops a taste for the subject, as they "have an extremely essential pedagogical relevance for the construction of new knowledge" (DOS SANTOS SILVA et al., 2022, p. 252).

Conclusion

Analyzing the evolution of each student who participated in the process - introduction, resolution and progress of the logical reasoning exercises using popsicle sticks as a methodological tool - we can conclude that when worked on from childhood, they can obtain good personal and cognitive results. We observed improvements in

mathematical thinking, interpersonal relationships, determination to solve everyday problems and challenges, as well as stimulating creativity and enthusiasm for knowledge, bringing children in contact with rules and understanding that there are limits and possibilities.

Therefore, based on the ideas developed during the project, it can be stated that children show an evolution in their cognitive aspects and in problem solving through the use of games. According to Vygotsky (1991), play creates zones of development and these provide qualitative leaps in children's development and learning.

There learning process becomes very meaningful when we have fun while learning, when we are in direct contact with other people. These situations bring us a smile or a tear, which puts us in doubt, which awakens feelings and affections, which develops not only our cognitive, but also remains forever recorded in our affective memory. These moments can be seen and experienced when using games as a playful tool in teaching and learning.

Acknowledgements

At the end of this study, I would like to thank Danielle Gonçalves de Oliveira Prado and Isabelle Gonçalves de Oliveira Prado for guiding and assisting us in every step and decision of the project. I thank the parents of each student for their trust in our work and also the participating students.

Reference

Ataíde, Artur, 1981 - Palitos de fósforo: utilização da estratégia, da lógica e das formas geométricas - Raciocínio Lógico: Volume Alfa / Artur Ataíde. 6 .ed - Recife: Artus Editora, 2017 .116.

Dos Santos Silva, B. H. M. .; Silva, A. L. Da .; De Oliveira, E. G. .; Lira, L. L. E .; Pontes, E. A. S. Jogos Matemáticos como Ferramenta Educacional Lúdica no Processo de Ensino e Aprendizagem da Matemática na Educação Básica. Rebena - *Revista Brasileira de Ensino e Aprendizagem*, v. 4, p. 246–254, 2022. Disponível em: https://rebena.emnuvens.com.br/revista/article/view/59.

Ferreira Guarda, G.; Da Silva Pinto, S. C. C. O uso dos Jogos Digitais Educacionais no Processo de Ensino-aprendizagem com Ênfase nas Habilidades do Pensamento Computacional: experiências no ensino fundamental. Revista Brasileira de Pós-Graduação, v.17, n. 37, p. 1-35, 2021. DOI:10.21713/rbpg.v17i37.1750. Disponível em: https://rbpg.capes.gov.br/rbpg/article/view/1750.

Isidro, A.; Almeida, A. T. M. Projecto Educar para a convivência social: O jogo no currículo escolar. *Cadernos encontro*: O museu a escola e a comunidade. Centro de Estudos da Criança, Universidade do Minho, Braga, 2003.

Pontes, E. A. S.; Pontes, T. A.; Silva, L. M. Da; Miranda, J. R. De; Santos, J. F. Dos; Amorim, I. A. de. Raciocínio lógico matemático no desenvolvimento do intelecto de crianças através das operações adição e subtração. *Diversitas Journal*, *[S. l.]*, v. 2, n. 3, p. 469–476, 2017. DOI: 10.17648/diversitas-

journal-v2i3.552. Disponível em: https://www.diversitasjournal.com.br/diversitas_journal/article/view/552.

Riccetti, Vanessa Pugliese. Jogos em grupo para educação infantil. ***Educação Matemática em revista,*** v. 8, n. 11, p. 18-25, 2001.

Scolari, A. T.; Bernardi, G.; Cordenonsi, A. Z. O Desenvolvimento do Raciocínio Lógico através de Objetos de Aprendizagem. ***Revista Novas Tecnologias na Educação,*** Porto Alegre, v. 5, n. 2, 2007.

Silva, D.M.C.; Grillo, M. *A utilização dos Jogos Educativos como instrumento de Educação Ambiental: O caso Reserva Ecológica de Gurjau- PE***.** Contrapontos, v.8, n.2, p.229-238, 2008.

Vygotsky, L. S. *A formação social da mente*: o desenvolvimento dos processos psicológicos superiores. 4ª ed. São Paulo: Martins Fontes, 1991.

Infusing Virtual Reality into Middle School Science Curriculum

Dr. Temitope Olokunde, Dr. Brian Warren, Dr. Ratana Warren, Dr. Opeyemi Ojajuni, Nikhilrao Pendyal, Sri Mettu, Jahnavi Balaji, Jaden Martin, Raghavender Reddy Chukkapuram, Mussie Samuel, Devender Rapolu, Dr. Michael Stubblefield, Teacher Deidre Street, Dr. Luria Young, Dr. Christopher Guillory

Southern University and A & M College, United States

Abstract: Integrating innovative approaches to instructional practices is paramount to enhance teaching and learning in STEM education. This study adapts an innovative educational technology approach to enhancing middle school science education in the form of virtual reality. Science education is an aspect of STEM that is vital for the scientific development of learners, particularly those in their formative years such as middle school students to solve problems and interpret scientific information. The purpose of middle school science education is to instill knowledge and awareness in students about the basics of science, in a way that fosters scientific discovery and literacy. Virtual reality (VR) provides students with an immersive experience of a real-life context, which makes it very applicable to middle school science education, where students are developing their opinions about science subjects. Hence, this study focuses on VR-infused science curricula that meets National Science Standards for middle school (6^{th}-8^{th} grade) students. The study is a pilot program forming a K-12 workforce pipeline to engage middle school science teacher candidates and clinical educators in Louisiana, on the use of virtual reality tools and resources in science education. The virtual reality tools include head mounted displays called headsets, and a CAVE automatic virtual environment. The activities and efforts to infuse virtual reality in middle school science curriculum will be presented.

Keywords: Virtual reality, Science education, Middle School

Citation: Olokunde, T., Warren, B., Warren, R., Ojajuni, O., Pendyal, N., Mettu, S., Balaji, J., Martin, J., Samuel, M., Rapolu, D., Stubblefield, M., Street, D., Young, L. & Guillory , C. (2024). Infusing virtual reality into middle school science curriculum. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024-- International Conference on Life Sciences, Engineering and Technology* (pp. 26-32), San Francisco, CA, USA. ISTES.

Introduction

Virtual reality technologies have gradually gained adoption in several facets of life due to its simulative features that capture a real-world scenario in an immersive manner. The immersive experience that virtual reality (VR) provides engages users through headset-mounted screens and speakers, that simulate actual situations. For example, in healthcare, surgeons can use virtual reality to simulate procedures before carrying out the actual

operation. Interior designers can also use virtual reality to create models of spaces that let clients experience immersive visualization before committing to a design. Audiences can enjoy an entertaining show via VR headsets. Educational institutions are also not left out in this emerging technology and as such, are starting to insert virtual reality into their curriculums. It is quite understandable why virtual reality proves to be valuable in diverse settings because it is content driven and allows users to see a digital representation of any space, surrounding or environment. One of the primary applications of virtual reality in education has been targeted at student engagement. Research has shown that people are prone to absorb knowledge more quickly when virtual reality is utilized in the teaching and learning process (Chamkeh & Hammami, 2020). This shines a curious light on the possibility of using virtual reality to engage students in science education, particularly middle school students who are in their formative years of developing their opinion about science subjects.

A visioning report by the National Science Foundation clearly articulates that "To be prepared for STEM careers of the future, all learners must have equitable opportunity to acquire foundational STEM knowledge" (Honey et al., 2020). Hence it is vital to embrace innovative practices that can foster foundational STEM knowledge such as the use of modern technology. Our project SURADD which stands for "Southern University Reaching Across the Digital Divide" is one of many initiatives that is set out to cultivate a culture of innovation in scientific inquiry. SURADD is focused on transforming educational pedagogy in Science, Technology, Engineering, and Mathematics (STEM) with modern technology tools especially the use of virtual reality technology. One of the pilot project objectives of SURADD is to infuse virtual reality in middle school curriculum (6^{th}-8^{th} grade), that meets National Science Standards. Hence, the SURADD project got hands-on in providing immersive virtual learning environments and training programs that enhance middle school science teaching and learning. This led to the delivery of VR-infused science content to participants such as clinical educators, teacher candidates and students in demonstrations, trainings, and presentations/workshops.

Virtual reality creates an immersive space that can be considered as the next evolution of the digital environment that moves beyond flat web pages, images and videos to enable learning experiences that are more engaging, as well as conducive for shared collaboration and interaction. According to research studies, virtual reality trainees absorb knowledge more quickly than traditional classroom learners and are more prone to apply skills learned in the real world (Munim & Schramm, 2023). In K-12 science education, there have been reforms advocating for the promotion of excellence in science teaching and learning (National Research Council, 2012).

A study by Bugtai, Batilaran & Kilag (2024) highlights a multifaceted and contemporary approach to middle school science education that provides students with real world connections, leading to a positive impact in scientific exploration. Hence it becomes paramount for science educators and leaders to think of innovative ways that can enhance both teachers and students experience in the classroom. Research shows that virtual reality is yet to gain widespread inclusion in K-12 science education curricula (Tilhou, Taylor, Crompton, 2020). Consequently, the research question that guided this study is: "How is virtual reality infused in middle school science curriculum?". Our pilot study provides information on the steps our project took for infusing virtual reality in middle school curriculum, in a way that aligns with teaching standards and practices.

Project Steps/Methodology

The first phase of the SURADD project was focused on providing high-quality VR-infused instructional science content in VR simulations and CAVE automatic virtual environments. Integrating virtual reality provided real-life scenarios with science theory for instructional delivery. The research setting for this study was in Southeastern Louisiana. The steps involved in implementing the first phase of the project is illustrated in the Table below:

Table 1. Project Steps

Period	Event/Activity	Key Takeaway
Summer 2023	• Quarterly meeting discussions with funding agency 'US Dept of Commerce, NTIA (National Telecommunications & Information Administration) • VR Headset Assessment • Content Development • Team Training on use of CAVE automatic virtual environments • Hosted a VR Summer Experience for Middle school science students	• Team Introductions • Project Planning & Implementation • Matrix to assess features of different headsets • Aligning VR content with Open SciEd and National Science Standards • Student engagement and sparking science interest
Fall 2023	• Review of initial development of VR infused Open SciEd curriculum content • Selection and Purchase of VR Headsets for middle school science content • Recruitment of Graduate & Undergraduate students to foster engagement in virtual reality activities • Installation of VR Resources • Research Development in VR • Quarterly meeting discussions with	• VR Simulation of Unit 6.1 in Open SciEd (Light and Matter) • Immersive experience of VR Simulation using Oculus Quest 2 Headset • Supplemental use of pre-loaded science content (ClassVR) • Presentations • Project Progress

	funding agency	
Spring 2024	• Supplemental use of VR-Anatomage for Health Physics curriculum • VR-infused curriculum delivery to participants (clinical educators, teacher candidates, and students) • Research Development in VR • Quarterly meeting discussions with funding agency	• VR Tours and Demonstrations • Trainings/Workshops • Presentations • Conference Papers by Team members (students and faculty) on virtual reality activities.

More information on SURADD's implementation of virtual reality is provided in the sections that follow focusing on "student experience," "VR-infused curriculum" and "delivery to participants."

VR Implementation

VR Summer Experience for Middle School science students

In the Summer of 2023, a 3-D Virtual Reality (VR) immersive educational experience was provided to middle school science students (6^{th} –8^{th} grade). OpenSci Ed modules and 3D simulations relating to coastal erosion and climate change were utilized as educational tools. Also, the students experienced VR tours of other scientific learning environments, such as; the NASA (National Aeronautics and Space Administration) International Space Station, Health Physics comprising of nurses and surgeons attending to patients in a nursing station, and Basic science with a focus on molecules matter – solids, liquids, and gases. These VR Tours were explored using the CAVE Automatic virtual environment. Virtual reality headsets provided the students a personalized immersive experience of the "Exxon Operator Training module" provided by ExxonMobil as a channel for students to learn about "science, technology, engineering and mathematics (STEM)" careers in the energy industry. Overall, the VR Summer program was an excellent way to immerse and introduce climate change, coastal erosion, space station, health physics, basic science and STEM careers to the middle school students.

VR Infused Curriculum for Middle School science students

It was imperative to ensure the VR science contents are aligned with National Science Standards. To achieve this, we leveraged sources that provided such alignment that will harmonize with contents being taught in the traditional middle school science classrooms. OpenSciEd is one of the current curricula options approved for students to utilize in the state of Louisiana at the middle school level.

Through the simulation of select OpenSciEd activities, VR content was developed to provide students an immersive and experiential learning experience of science subjects that are being taught in the classroom. Also,

to supplement this, we utilized "ClassVR", a VR technology that provides tools and resources needed to introduce VR into the classroom, and deliver a rich, engaging experience. We worked with middle school science teachers to select content that meets the learning goals, objectives and national standards of middle school science curriculum.

Delivery of VR-infused curriculum to Participants

We delivered VR-infused curriculum to participants including clinical educators, teacher candidates, and students through different avenues such as: VR tours and demonstrations, presentations, trainings/workshops, and classroom activities. We showed participants a VR simulation of middle school science content relating to topics such as the experimentation of light and matter, human anatomy, natural environments, cells and diseases. Through the VR simulations of these science topics, participants were able to dive into a world of scientific concepts to visualize and explore fascinating views of experiments, processes and concepts in an immersive way. VR Training tools and resources were also provided to participants for continuous engagement.

Findings

This study used a qualitative field notes approach from observations at different events and sessions of the project. During the VR tours and demonstrations, it was observed that participants who experienced the VR simulations felt their basic understanding of science come alive in a way that fostered curiosity and deeper understanding. Students showed exciting interest to learn more as they explored scientific concepts in immersive spaces. Hence the VR simulation of real-world science concepts enabled participants connect STEM related theory to practice. Targeting middle school science revealed the need for digital inclusion, as such, a middle school science teacher affirmed that the VR simulation would be a useful resource in helping his students gain a better understanding of STEM concepts taught in the classroom. Overall, we discovered that the provision of high quality digital instructional content via VR simulations led to the gradual formation of a K-12 workforce pipeline that engages the science community in hands-on, inquiry-based teaching and learning.

Discussion and Conclusion

Living in an increasingly digital world causes us to think differently and creates a need for students to become lifelong learners if they are to thrive digitally. Virtual reality is a digital tool that evidently plays a role in shaping today's educational curriculum and learning environments. This study focused on the infusion of virtual reality in middle school science curriculum, as an approach to improve students understanding of STEM concepts. The accessibility of virtual reality in science education provides a greater opportunity for experiential learning. Using a VR headset to view science content transports students to a place of engaged learning that creates a dialogue-based classroom. This pilot research study highlights the steps taken to infuse VR simulations to enhance the teaching and learning of middle school science curriculum. Therefore, this study adds to the pool of STEM initiatives that digitally transforms and strengthens science curriculum/instructional practice.

Science education in a digital world is a dynamic journey of discovery and exploration that calls for creativity and innovation in teaching and learning. This paper explored the infusion of virtual reality into middle school science curriculum, that enhances students learning to explore wonders of the natural world alongside building digital skills that prepares them for success in a digital age. In conclusion, this paper highlighted the approach and steps taken to infuse virtual reality into middle school science curriculum. On a broader note, the steps taken in this research study helps to drive the cornerstone of STEM education, which is to foster critical thinking and problem-solving skills. STEM education encompasses a wide array of subject areas that ignite curiosity and spark creativity. This study was focused on incorporating virtual reality in subjects pertaining to middle school science to improve teachers' instructional practice and student engagement.

Recommendations

This research study affirms that innovation in this digital age is key to successful teaching and learning of science subjects, hence it is recommended that other studies can discuss other innovative strategies for fostering STEM education in a digital world. This study recommends educational technology teams in middle school science education to align science content with National Science Standards such as the Next Generation Science Standards, to improve science education through three-dimensional learning involving crosscutting concepts, science & engineering practices, and disciplinary core ideas.

Acknowledgements

This project "Southern University Reaching Across the Digital Divide (SURADD)" is funded and supported by the US Department of Commerce, NTIA (National Telecommunications & Information Administration).

References

Butgai, G., Batilaran, J., Kilag, O. K. (2024). Enhancing Science Education in Middle Schools: A Systematic Review. *International Multidisciplianry Journal of Research for Innovation, Sustainability, and Excellence (IMJRISE), 1*(2), 7-13.

Chamekh, Y., & Hammami, M.A. (2020). Impact of Virtual reality on Modern Education. *International Journal of Sciences: Basic and Applied Research*, 50(2), 1-8

Honey, M., Alberts, B., Bass, H., Castillo, C., Lee, O., Strutches, M. M., Vermillion, L, Rodriguez, F. (2020). STEM Education for the future: A visioning report. *National Science Foundation. Accessed January 15*, 2023.

Munim, Z.H., & Schramm, H.J. (2023). Training, Education and Learning Sciences, Vol 109, 2023, 94-101 AHFE. *Training, Education, and Learning Sciences,* 94.

National Research Council, Division of Behavioral, Board on Science Education, & Committee on a Conceptual

Framework for New K-12 Science Education Standards. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* National Academies Press. https://doi.org/10.17226/13165.

Tilhou, R., Taylor, V., & Crompton H. (2020). 3D virtual reality in K-12 education: A thematic systematic review. *Emerging technologies and pedagogies in the curriculum*, 169-184

Case Study: Incident Involving Non-compliance with Occupational Safety Standards Applied to a Construction Site with Irregularities, resulting in a Cave-in with Victims in the City of Marilândia do Sul - PR

Lucas Augusto Vieira
Military Fire Department of Paraná, Brazil, https://orcid.org/0000-0002-2945-524X

Danielle Gonçalves de Oliveira Prado
Federal University of Technology of Paraná, Brazil, https://orcid.org/0000-0003-2802-6037

Vinícius Mateus Silveira Martins
Evolution College, Brazil, https://orcid.org/0009-0003-9184-2165

Abstract: Based on the assumption of a case study, this paper discusses the implications of preventive measures in the event of a cave-in in the city of Marilândia do Sul - PR - Brazil, which ended up claiming the lives of four workers. It discusses preventive engineering measures, rescue operations and the victims, statistical data on the number of incidents in the state, as well as a legal approach to which the owner of the construction site where pipes were being installed to irrigate crops was subjected. The entire procedure was carried out by digging trenches more than 4metter deep, without any kind of preventative measure. By gathering data from sources that reported on the incident, together with the experience and conduct of the first author of the article, who was one of the rescuers and other military personnel involved in the case, it was possible to list the main mistakes made in the excavation process. All the research carried out is based on regulatory standard NR 18, which establishes administrative, organizational and planning guidelines, the aim of which is to implement control and preventive safety systems on construction sites.

Keywords: Burial, Work safety, Rescue, NR18.

Citation: Vieira, L. A., Prado, D. G. O., & Martins, V. M. S. (2024). Case Study: Incident Involving Non-compliance with Occupational Safety Standards Applied to a Construction Site with Irregularities, resulting in a Cave-in with Victims in the City of Marilândia do Sul - PR. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024 -- International Conference on Life Sciences, Engineering and Technology,* (pp. 33-47), San Francisco, CA, USA. ISTES.

Introduction

Currently in Brazil, the civil industry has one of the worst safety records in the workplace, caused by countless accidents, with an increasing percentage in this area over the years. Many of these incidents are due to a lack of

supervision and, above all, the eradication of the cost of essential materials by companies. This requires qualified professionals and specialized assistants in the various elements and services that make up a construction project, whether private or public, in which the engineer or architect is responsible for culpable or harmful acts that may occur (PELACANI, 2016). A tiny number of unskilled laborers are notorious in the production stages of construction sites. This lack of qualification is directly linked to their lack of training to work correctly (Rebello, 1978; Parente, 1993; Farah, 1992).

The recruitment system in this sector is archaic, due to the requirements of the terms of the contract signed between employer and employee, leading to irregular hiring processes, absolving the employer of responsibility, as well as a lack of social and human commitment to its employees (Melo,1991; Pinto,1996). These irregular contracts, which are often temporary, generate a high level of instability in the profession. The number of layoffs after the work is finished is the main problem in terms of labor laws, such as workers' rights and benefits (Castell,1993; Escorel,1999).

The impact of accidents at work is more visible in companies, due to the uneconomical consequences they cause, although their managers don't always realize this. It could even be said that managers are generally unaware of the losses they incur as a result of accidents, and sometimes don't even realize how much accidents cost their work or services. (ARAÚJO, 2002).

In the event of an accident at work, it is essential to find answers to what happened, and in the event of failure, the company is obliged to compensate the worker. This compensation is analyzed according to the situation after the accident, i.e. whether or not the worker died in the field. If there are no deaths, accident compensation is paid for material and moral damages to the victim, but if there are deaths, the amount of compensation for material damage follows the rule in article 948 of the Civil Code:

In the case of homicide, the compensation consists of, without excluding other reparations:

> I - payment of the victim's treatment, funeral and family bereavement expenses;
>
> II - in the provision of maintenance to the persons to whom the deceased owed it, taking into account the probable duration of the victim's life; [...].

This rule does not limit material damage to expenses after an accident at work, such as the victim's treatment, funeral and family bereavement, nor does it apply to maintenance payments to the employee's dependents. We have the result of compensation payments for other aspects, such as moral damage. These damages are demonstrated by documentary evidence of the company's costs to the employee, as well as food aid to the victim's family, taking into account their probable lifespan. Compensation should therefore be considered in the form of alimony, the probable duration of the victim's life and the dependents of the deceased (NETO, 2010).

Even though legislation in our country requires employers and employees to follow the rules in order to avoid future problems, there is still a high rate of informal workers carrying out this type of work.

The responsible for oversight is CREA (Regional Council of Engineering and Agronomy). The Regional Council of Engineering and Agronomy of Paraná (Crea-PR) was created on June 11, 1934 and its purpose is to

regulate and supervise companies and professionals in the field of engineering. This authority belongs to the Federal Council of Engineering and Agronomy (CONFEA), a body that aims to protect the sustainable development of the country and ensure the defense of society (FEDERAL COUNCIL OF ENGINEERING AND AGRONOMY, 2021).

Location of the incident

Marilândia do Sul, located in the northern region of Paraná, has a territorial extension of approximately 384.424 km², representing 0.1929 % of the state, 0.0682 % of the region and 0.0045 % of the entire Brazilian territory, with geographic coordinates of latitude 23°44'42"S, longitude 51°18'28"W, altitude of 758 meters above sea level. Its population is 8,814 (IBGE, 2020). The economy is basically agricultural, with soybeans, corn and wheat being the main crops grown on large properties and carrots, cabbage, tomatoes, peppers, chard and other crops being the main crops to meet regional demand. The study area is located in rural areas, characterized by the presence of rural properties dedicated to crop production.

Figure 1 . Study area – location of the incident

Shoring according to safety regulations

The excavation process is a process adopted to break the capacity of the soil, using tools, making its removal possible (REDAELLI & CERELLO, 1998). In Brazil, there are regulatory standards that regulate trench excavation processes. Regulatory Standard 18 establishes working conditions in the construction industry and lays down rules for excavation work or work in trenches with guaranteed stability, which is understood to be a characteristic relating to structures, slopes, trenches and shoring that do not pose a risk of collapse or collapse and for which legally qualified professionals are responsible (BRASIL, 1995).

Compliance with NR 18 does not exempt compliance with other legislation and Brazilian Technical Standards that determine safety conditions in the preparation of projects and execution of excavations for open-cast works, and NBR 12.266 (ABNT, 1992) standardizes projects and execution of trenches for laying water, sewage or drainage pipes, with their respective shoring sizing.

Shoring systems

Based on these regulations, a shoring system is essential for the excavation process, both for construction work and for rescue. For trenches with a depth of less than 1.25 m, shoring should be used whenever the side walls are made of soil and are liable to collapse, as well as if the excavation service finds instability near the service area. For manual excavation, shoring must be done together with the excavation. In the case of mechanical excavation, the maximum distance between the last shored point and the front of the excavation must be 2.00 m, so every meter excavated is every meter shored.

The NBR12266 standardizes the conditions necessary for the execution of trenches for sewage, water or urban drainage pipes and establishes procedures for the execution of excavations, which include information to be taken into account regarding the excavation itself, shoring, drainage, domain strip, easement strip, closure, bottom of the trench, roadbed, depth and backfill of the trench, lowering of the water table and covering of the pipe. It also provides for specifications in the hydraulic project, such as minimum depths or coverages, lists minimum and maximum values for the width of the bottom and the depth of the trench, which equipment may be used in the excavation and the most suitable type of shoring to be used in each section.

Safety shoring consists of the lateral containment of soil walls in pits, trenches and shafts by means of "planks", which can be metal, wood or geotextile fabric, positioned perpendicular to the ground and locked together with the use of stringers and pontoons, which can be metal or wood. The forces from the lateral compression exerted by the soil in the trenches along the excavation profile will be dispersed among the pontoons, stringers and shoring plates, which provides "relative safety" when working in the space between them.

The types of shoring used during operations in sloped areas will depend on local conditions and the materials available, and will also depend on the observation of determining local factors, such as the geomorphology of the terrain, the depth of the trench or pit, the proximity of buildings or traffic routes, climatic conditions (weather) and available materials.

Commonly used materials:
Metal plates

They are very usable because they have high mechanical resistance, among other factors, which make them excellent for this activity, but their use is not viable due to their high cost, and difficult handling, cutting and weight (see Figure 2).

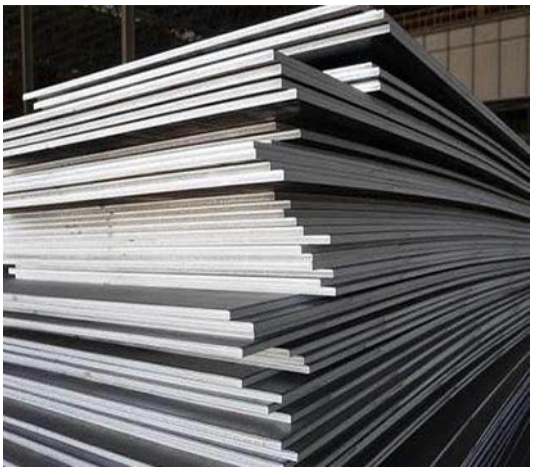


Figure 2. Metal plates

Plywood

It is a sheet widely used in construction, also known as plywood, sold in sheets of 110 cm x 220 cm with varying thicknesses, and its four types have different purposes:

- Resin: is the most widely used and least expensive, know as fence (see Figure 3).

Figure 3. Resin Plywood

- Phenolic: commonly used in building construction and industry for its greater resistance to humidity (see Figure 4).

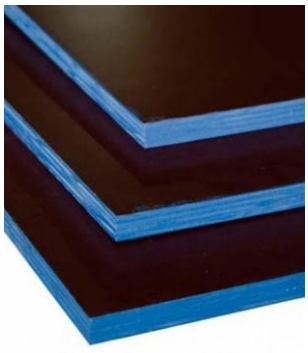


Figure 4. Phenolic Plywood

- Plasticized: usually used to make exposed concrete and work that requires water resistance (see Figure 5).

Figure 5. Plasticized Plywood

- Marine plywood: used in construction and the shipbuilding industry because it is immune to attack by insects such as termites and fungi. Pressed at a high temperature, it is highly resistant to humidity (see Figure 6)

Figure 6. Marine Plywood

Beams

These are supports to which the pontoons are fixed in order to stabilize the slabs and improve the dispersion of forces. They are usually made of various types of wood or metal (U-beams). One of the advantages of the U-beam is its versatility in fitting and greater mechanical resistance, and a disadvantage is its high cost (see Figure 7).

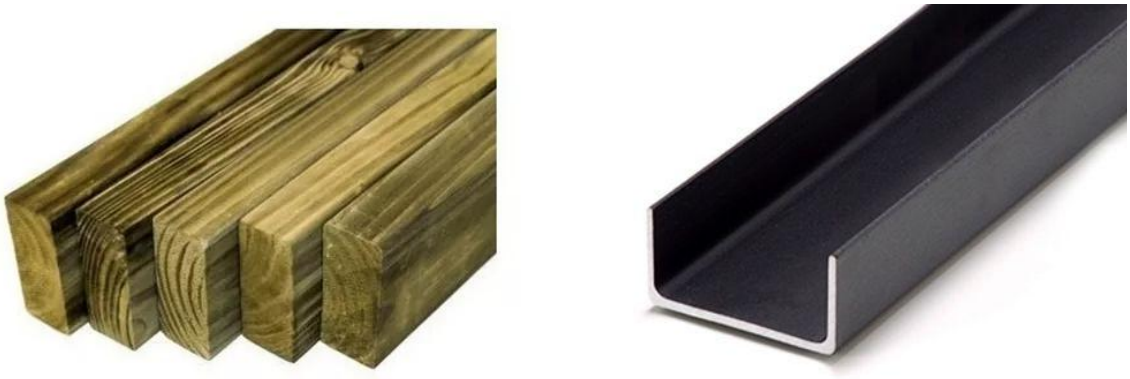


Figure 7. Types of stringers - left wooden stringer and right U beam

Scaffolding

Scaffolding or pontoons, are metal or wooden structures that support and give stability to the stringers and plates or geotextile, so that there is a necessary space for action, the space that will be created between the four pontoons placed on each plate will provide greater safety of action to the agent who is in the trench.

The basic difference between metal and wooden props is their fine adjustment and cost (see Figure 8).

Figure 8. Types of scaffolding or pontoons - left-hand metal and right-hand wood

Excavation processes:

Scaffolding or pontoons:

It uses 0.027m x 0.30m planks, spaced 1.35m apart, horizontally braced with 0.20m pontoons, spaced 1.00m apart vertically. Composed of crimped planks arranged vertically, spaced from axle to axle. Horizontal blocking, round timber or metal vertically spaced (see Figure 9).

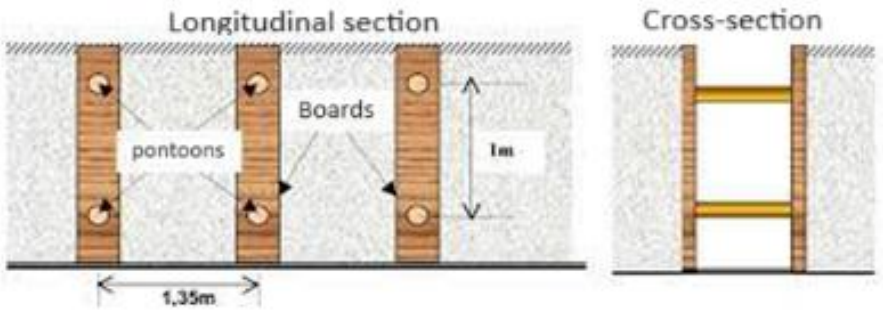


Figure 9. Scaffolding or pontoons

Discontinuous shoring:

Made up of 0.027 m x 0.30 m boards, spaced 0.30 m apart, horizontally braced by 0.06 m x 0.16 m stringers along the entire length, spaced 1.00 m apart vertically with 0.20 m posts spaced 1.35 m apart, the first post being placed 0.40 m from the end of the stringer (see Figure 10).

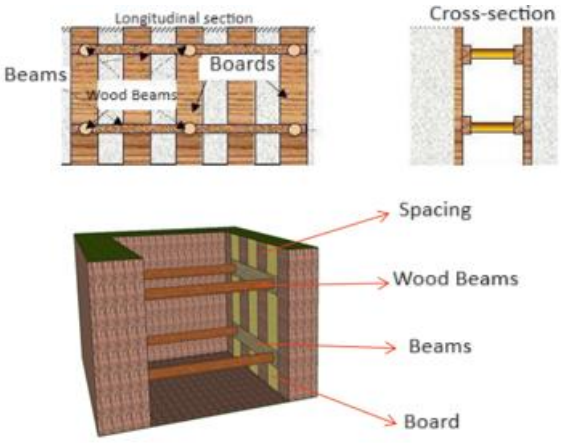


Figure 10 Discontinuous shoring

Continuous shoring:

Made up of 0.027 m x 0.30 m boards, covering the entire side surface of the trench, horizontally locked together by 0.06 m x 0.16 m stringers along its entire length, spaced 1.00 m apart vertically with 0.20 m posts (see Figure 11).

Figure 11 Continuous shoring

An important point to note when shoring up a building is that you should use hard, moisture-resistant wood

(peroba, maçaranduba, angelim, canafístula, etc.). The struts can be made of eucalyptus.

Table 1 Scaffolding

SOIL TYPE	SHORING RECOMMENDED
Consistent clay soil	Discontinuous shoring or pontoons
Mix of sand and clay	Continuous shoring or discontinuous, depending on the level of soil saturation (high or low).
Organic soil	Continuous shoring
Fine or coarse sand	Continuous shoring

IMPORTANT AND PRELIMINARY OBSERVATIONS

1.Shoring is a risky activity and should ONLY be carried out when there is no other possible technical alternative;

2.Shoring must be progressive, i.e. as the dismantling activities progress, so must the shoring;

3.Shoring should be carried out from a depth of 1 meter;

4.Shored dismantling operations must be fast.

Method

The methodology is based on a case study of an incident involving workers digging trenches for an irrigation system in the city of Marilândia do Sul - PR. Unfortunately, it turned out that the construction site was not equipped with a safety system and ended up claiming the lives of four employees who were drilling the trenches by suddenly being buried. The incident took place on August 30, 2019. On site, there was a lack of shoring systems, and all the work was carried out in an archaic way on the construction site, without any preventive system, failing to follow the norms of the regulatory standards.

Through a survey of reliable sources that reported on the disaster, this paper seeks to list the main mistakes made in the trench excavation process, looking for the related regulations that penalize and outline the incident. In addition, the types of punitive sanctions that the owner was subjected to will be presented, following the criteria of the labor laws, CREA and other bodies that, when faced with the fact, sought to take measures in accordance with the regulations, as well as a statistical survey of the number of incidents of burial in the state of Paraná.

Results and Discussion

The state of Paraná was divided into 6 major regions, where 92 burials were reported in 54 different cities between 01/01/2013 and 31/05/2023. The graph below shows a concern for the north of Paraná, since the

Londrina and Maringá regions together account for 45% of the cases (see Figure 12).

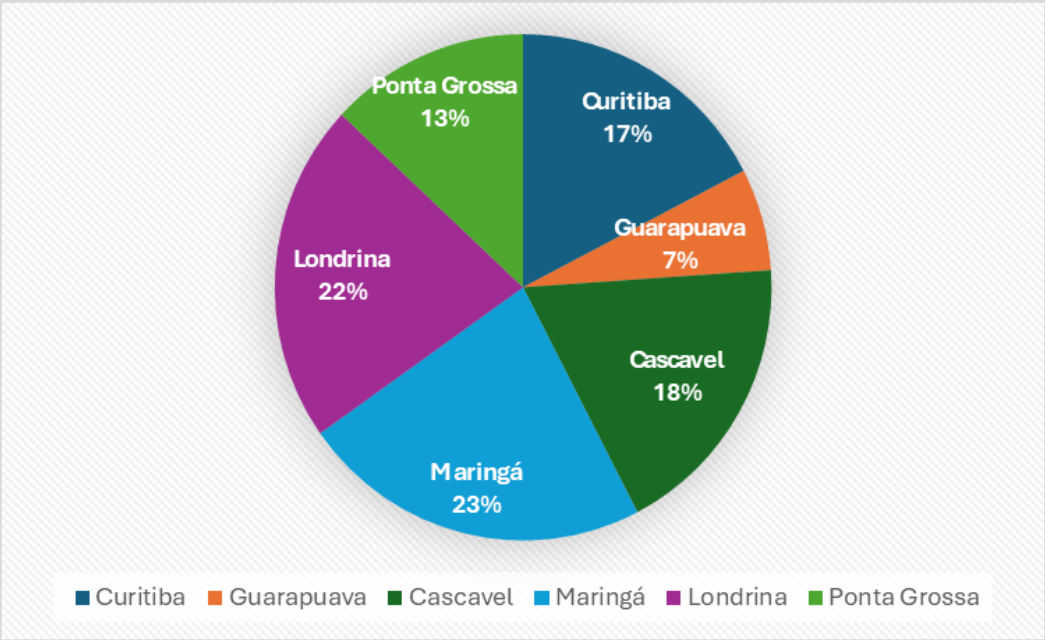


Figure 12. Regions in Paraná where a total of 92 burials were reported between Jan.13 and May.23

In the Maringá region, 10 cities were cited and Maringá and Paranavaí led the way, followed by Umuarana, Nova Esperança, Ubiratã and Cianorte. The other cities have only one occurrence each (see Figure 13).

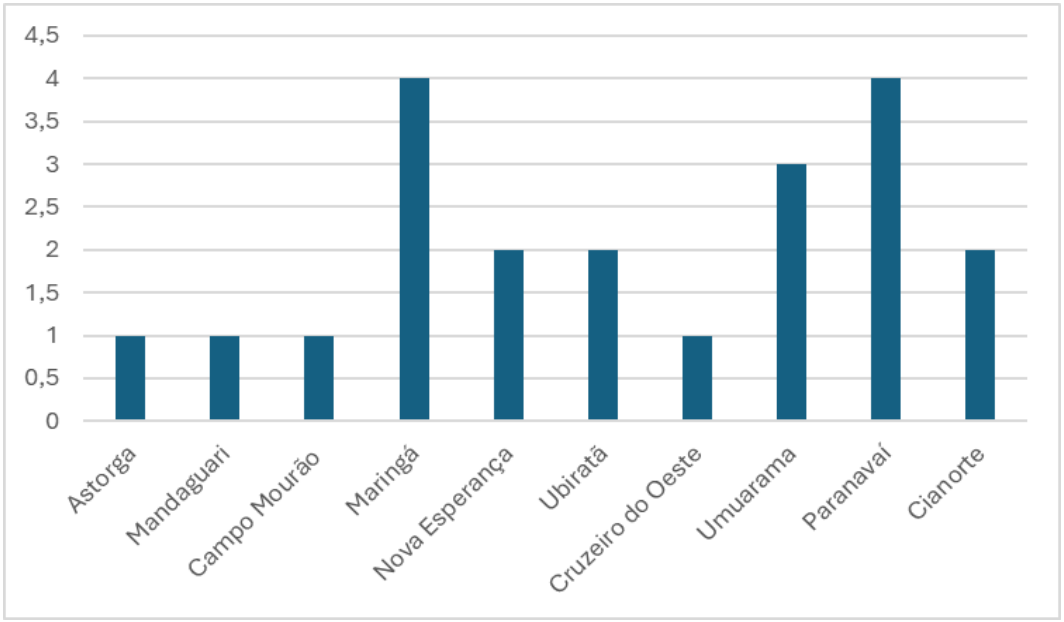


Figure 13. Cities in the Maringá region that were reported with some occurrence of burials in the period Jan.13 to May.23

The Londrina region, on the other hand, which follows the Maringá region as the leader in burial cases, has a

very large discrepancy in terms of cases, given that the city of Londrina has accumulated 8 burial incidents. This situation could raise alarm bells, as this is the highest number of cases in any one city in Paraná. The second city in terms of the number of cave-ins is the capital Curitiba, which has recorded 5 cases of cave-ins in the same period (see Figure 14).

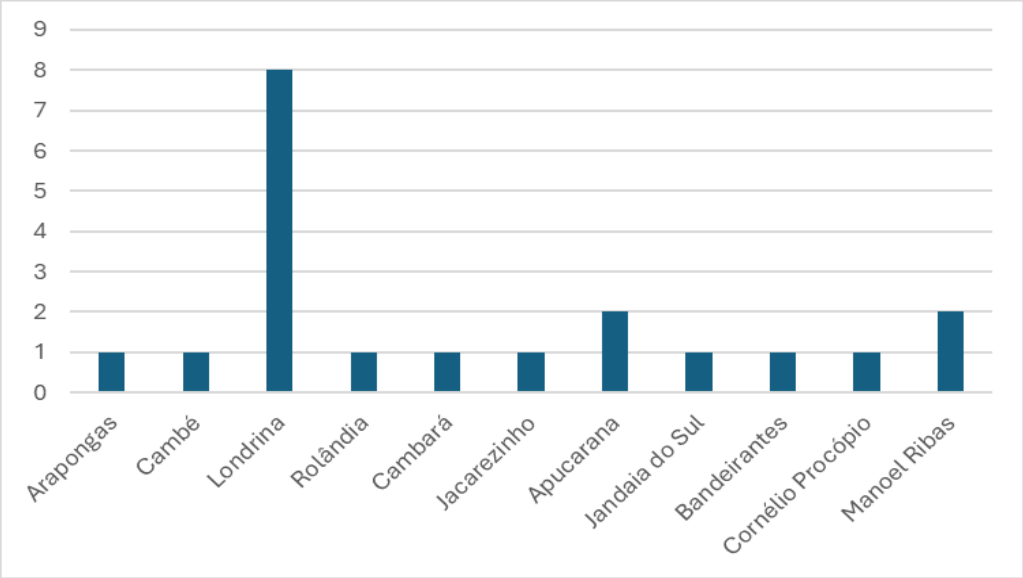


Figure 14. Cities in the Londrina region that were reported with some occurrence of burials in the period Jan.13 to May.23

The data above was taken from the Occurrence and Statistics Registration System of the Paraná Military Fire Brigade.

Therefore, in the respective case study, a number of irregularities were listed with regard to Occupational Safety regulations:

- Absence of PPE and collective use;
- No safety standards adopted in the excavation process;
- No shoring or ramps for rapid evacuation;
- Absence of engineering project and responsible engineer;
- Irregular deposit of earth.

Inspectors from the Regional Council of Engineering and Agronomy of Paraná were also at the site and identified the absence of a person responsible for the construction of the ditch, as well as a lack of respect for occupational safety guidelines, and found through an expert report that the owner had not taken due care of the shoring regulations prior to the construction of the irrigation pipeline. He also failed to comply with the regulations issued by the Ministry of Labor.

The Paraná Institute of Criminalistics found that the excavation did not have any kind of shoring. There were no

ladders or ramps for quick evacuation and the earth was deposited irregularly, so no technical standards were respected. The agency also concluded that if the work had been properly shored up, the workers would not have been killed. It also states in its report that any type of excavation with a depth of more than 1.25m with unstable slopes or more than 1.75m with any type of slope must be shored up. The depth of the work under study was 3.90m.

Also according to the investigations, the judge indicted the owner for manslaughter, when there is no intention to commit a crime, as typified in article 121 of the Brazilian Penal Code, and culpable bodily injury, with a maximum sentence of 3 years, increased by a fraction by the judge, due to the number of deaths at the scene of the accident.

Rescue operation

It took approximately eight hours to remove the victims, with the support of various agencies. When the intervention team arrived, one victim was still alive, and it was necessary to urgently remove the earth from his thorax in order to improve his breathing conditions and expand his respiratory movements. Once the first victim who was still alive had been removed and given basic life support, the excavation process began to remove the other victims, who had already died, using machinery from dealerships that had moved to the scene of the accident, which was of the utmost importance for speeding up the activities.

The material used for the shoring was planks and ropes that supported part of the earth and from there a ramp was created with the help of the machinery, to prevent future landslides, providing safety for the rescue team. The type of shoring used was discontinuous shoring (see Figure 15), with the aid of ropes, due to the absence of a counter-wall for the installation of the pontoons.

Figure 15. Rescue operation and removal of victims

Conclusion

With regard to the research, which works on regulations for incidents involving cave-ins, we can see that in the construction industry there are many such incidents related to falls from height, crushing and cave-ins. In order to reduce this rate, which is considered to be one of the worst in our country, it is necessary to work together and raise awareness of all the risks that exist on a construction site, in order to intervene through plans to identify the risks that can occur in this type of activity. It is also essential to adopt effective occupational safety measures to prevent incidents and train workers.

Recommendations

Recommendations for future studies, improving regulations and inspections on this subject, as well as encouraging government bodies to improve construction sites.

References

Brazilian Association of Technical Standards. *NBR 12266/92: design and execution of trenches for laying water, sewage or urban drainage pipes*. Rio de Janeiro, 1992. Available at: . Accessed on August 15, 2019.

Araújo, N. M. C. D., 2002. *Custos da Implantação do PCMAT na Ponta do Lápis*. 1. ed. São Paulo: FUNDACENTRO.

Brazil (1995). *NR 18: working conditions and environment in the construction industry*.

Castel, R. (1993). *From indigence to exclusion, disaffiliation: precarious work and relational vulnerability*. In Saúdeloucura, 4 (pp. 21-48).

of Engineering, C. F. (2021). Agronomy (Confea).(2021). The system.

Escorel, S. (1999). *Vidas ao léu: trajetórias de exclusão social*. SciELO-Editora FIOCRUZ.

IBGE - Brazilian Institute of Geography and Statistics. *Municipal boundaries*. Rio de Janeiro: IBGE, 2020. Available at:https://www.ibge.gov.br/cidades-e-estados/pr/marilandia-do-sul.html?. Accessed: 18/04/2021.

Melo, M. C. G., 1991. *Contribution to the Study of Accidents at Work in Civil Construction*. Master's dissertation, Rio de Janeiro. Institute of Social Medicine State University of Rio de Janeiro.

Neto, J. D. (2010).*Compensation for accident damage in the labor courts*.Rev TRT-9a R, 35, 1-24.

Pelacani, V. L. *Responsibility in civil construction.Curitiba: Cadernos do CREA-PR*, 142 p., 2010.

Pinto, A. A. (1996). *Navegando o Espaço das Contradições: A (Re) Construção do Vínculo Trabalho Saúde por Trabalhadores da Construção Civil* (Doctoral dissertation, Dissertação Mestrado, São Paulo. Pontifícia Universidade Católica de São Paulo).

Redaelli, L. L., & Cerello, L. (1998). *Excavations.Engineering Geology. São Paulo: Brazilian Association of Engineering and Environmental Geology*. ABGE. Chap, 19, 311-330.

Rebello, M. T. B. (1978). *Education and occupational mobility: the case of civil construction workers in the state of Rio de Janeiro* (Doctoral dissertation).

Categorizing Assignments in Online Repositories

Ruth Lamprecht
Mount St. Mary's University, United States, https://orcid.org/0000-0002-1843-7679

Ed Novak
Franklin and Marshall College, United States, https://orcid.org/0000-0002-2204-1546

Emily Kisner
Mount St. Mary's University, United States, https://orcid.org/0009-0005-4138-0518

Abstract: Although there is a wealth of exemplary programming assignments, locating an assignment in an online repository that fits course learning outcomes is onerous and often requires reading multiple project descriptions and navigating between many different projects. This work seeks to address how learning outcomes and conceptual domains can be related to online repositories for introductory computer science courses. This isn't intended to be a complete resource; the focus is on introductory programming courses and a limited selection of online repositories. The authors developed a set of learning outcomes relevant to these early CS courses and examined several popular repositories for recent assignments that relate to these learning outcomes. Presented here are the five learning outcomes and a collection of assignments for each. Other learning outcomes are discussed but not included in the assignment collection due to either the nature of the outcome (such as being broad enough to apply to most assignments) or because the outcome is not always core to the introductory courses. The repositories were chosen based on related prior research, with an emphasis on ones more suitable to college-level courses (sites that focus on CS for lower levels of K-12 were excluded).

Keywords: CS1/CS2, Undergraduate Instruction, Programming, Curriculum Issues

Citation: Lamprecht, R., Novak, E., & Kisner, E. (2024). Categorizing Assignments in Online Repositories. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024-- International Conference on Life Sciences, Engineering and Technology* (pp. 48-70), San Francisco, CA, USA. ISTES.

Introduction

As educators, we want to keep our coursework engaging for our students, while remaining relevant to the current state of computer science. The danger of trying a new project in class is that it does not always work as expected. Having an assignment that others have already used and presented allows an instructor to bring new materials into their classroom without that danger. To aid this, the creation of the Nifty Assignment track at the ACM SIGCSE Technical Symposium began in 1999 and eventually the online forum was set up (Parlante & Zelenski, 1999). Exploring the assignments on the Nifty Assignment forum is a great way to find new ideas and

inspiration. However, the natural ordering of the assignments on the site is by the year of publication, with name, author, description, and course level. This is useful information, but without reading more of each assignment, much is unclear. What learning outcome(s) does the assignment focus on? Does the assignment fit near the beginning, middle, or end of the respective course? What is the expected knowledge base that a student should have to be successful in completing the project?

This work is motivated by the authors' searches for new materials to use in early programming classes, both to refresh the course for the professor as well as to find new ways to engage students in the challenge of learning to write code. The research question we seek to explore in this work is (RQ1): "What learning outcomes (LOs) pertain to existing online assignments for introductory, undergraduate computer science courses that teach programming?" Additionally, we define conceptual domains and capture the flexibility of the complexity for the assignments. These extra categorizations provide further guidance in deciding whether an assignment will work for an instructor for a particular class with a unique set of students.

Previous work by Leake and Lewis (2017) presents recommendations for setting up an online repository of programming assignments. They concluded the need to consider what is required by new teachers separately from experienced teachers. This is part of the decision for this paper to focus mainly on the introductory courses as an initial exploration of connecting learning outcomes to online repositories. Other research shows that the that these gateway courses have high failure and dropout rates (Ambròsio, et al., 2011; Robins, 2010; Suarez, et al., 2023) which further emphasizes the need to have engaging assignments in these courses. The work by de Deus and Barbosa (2022) presents a method to classify open educational resources (OER) but found that there is still a lack of methodologies to organize OERs.

In the following sections we present our learning outcomes and the process we used to define them. We then discuss the online repositories included in this study as well as some that were excluded. We also present the conceptual domains considered and we emphasize the need to consider a project's flexibility. Later sections list the assignments and their alignment to the categorizations; organized by LOs. We conclude with our discussion of how our process can be followed to make finding assignments an easier process in future work to include more assignments and repositories in this categorization process.

Learning Outcomes

For this research, we focused on a two-sequence introduction to programming (CS1 and CS2), where the expected start is that students have little or no formal training in writing code and the expected finish is that students can use and create classes to create OOP solutions to relatively complex problems, but without extended knowledge of data structures, beyond standard arrays or lists. CS1 and CS2 courses can differ between sections at one institution, and often differ substantially between different institutions. The set of learning outcomes we define in this work cover many standard aspects of these courses. It is our hope that defining them

broadly in this way should assist other educators in aligning this work with what they are doing in their classroom(s).

The work presented by Lister (2001) provides one set of objectives for CS1, and a process by which other instructors could define objectives. Salguero (2023) presents the beginning of a literature review on connections between the student experience in CS1 and their success or failure in the course. This prior research sets the need to frame a course by its learning outcomes.

We started with the learning outcomes used in our courses, then created an anonymous survey that was shared with the CS education community (via the SIGCSE eMail list) and refined. We received 21 responses from a variety of institutions: five schools with undergraduate student populations above 15,000, five schools with 5000 to 15,000 students, and rest were smaller institutions. About half of the responses were from schools that are primarily urban, and the rest were split between primarily rural and primarily suburban. On a scale of 1 to 5, the five learning outcomes included here were given an average value of importance of at least 4.0.

CS1 Learning Outcomes

The following are the learning outcomes (LOs) that generally fit into a first introduction to programming course. This is a course where the expectation is that most of the students have never written code. While it is likely that some students might have programming experience, it may not always be in the language of the course. Such an introductory course is the beginning of a Computer Science undergraduate program.

1. Apply algorithmic techniques to problem solving. (LO1)
2. Write short programs in a programming language demonstrating understanding of fundamental concepts including writing and using control structures, loops, and functions. (LO2)
3. Demonstrate proficiency with a programming language using arrays, lists, complex I/O, and recursion. (LO3).

We define these three learning outcomes for a CS1 course where a student first learns how to program. The first LO is focused on the task of composing e a set of instructions to solve problems but not necessarily by writing a program. The second LO covers the basic structures needed to write a simple program. And the third LO starts to explore the concepts needed for more interesting and realistic programs. We have purposefully removed any specific programming language from our LOs to be able to more broadly apply them to various projects.

The numbering of learning outcomes will continue from this. In this way, the authors hope to allow other instructors the ability to shift the learning outcomes between their own courses in the case where they follow a different ordering of topics through a sequence of programming courses.

CS2 Learning Outcomes

The following are the learning outcomes that generally fit into a continuation programming course. This is a course where the expectation is that all students have programming experience from at least one semester prior to this course. Such a continuation course may begin with coverage of prior learning before moving into more complex programming.

4. Develop a moderately complex project with use of some object-oriented design. (LO4)
5. Understand and use the principles of object-oriented programming through objects, classes, abstract classes, inheritance, and polymorphism. (LO5)

For a second course in computer programming, we defined two LOs. With the use of OOP, a student should be prepared for data structures and other higher-level programming, as well as further study in computer science. Given that OOP is a complex topic, we split it into two LOs with the first focused more on using OOP and the second more on developing classes and exploring the concepts of abstraction, inheritance, and polymorphism.

At this point, there begins a broader list of options for learning outcomes to be included in the early programming courses. Some schools want students to get to algorithms and advanced data structures in the first two courses. Some additional learning outcomes are broad enough to fit into most assignments. And we are now seeing more outcomes related to the higher level of correctness and access to AI-generated code. These are discussed briefly in the next section, but not included in this study.

Other Learning Outcomes

Depending on the level an instructor or institution wants to go to with an introductory programming course, there are many other learning outcomes that could be considered. We excluded ones that don't have many findable projects in online repositories. There are also some general LOs that could be applied broadly because they don't cover specific programming concepts.

- Students will generate an approximate model of computer memory and describe how a program affects its contents.
- Students will gain an awareness of social, legal, and ethical issues raised by computing and consideration of computing for the greater good.
- Students will communicate a complex problem and its solution to an audience of peers.
- Students will construct programs utilizing Graphical User Interfaces with event-driven programming.

The survey also included an open-ended question for respondents to share other learning outcomes from their courses. While there are many good ones relating to tracing code, analyzing efficiency, and general understanding of given code, we did not include these in this current work because most of the projects that we have found online have a focus of students developing a program to solve a problem rather than these other

skills, which are important for students to learn but can generally be included in any projects. There was also some feedback about the need to consider aspects of AI, but this is a new enough topic that there are not many projects that use AI for completion, and writing programs to be AI are beyond the scope of a CS1/CS2 sequence. All of these are of interest and could lead to more categorizations in the future. Additional outcomes related to linked lists, solution efficiency, can be included later in a CS2 course or in a Data Structures (CS3) course.

Repositories

There is a wealth of exemplary computer science materials available online. Unfortunately, most of that content is not well curated or accessible. Often, the work is not properly attributed to the author(s). The largest obstacle is inconvenient accessibility due to content buried in PDFs, content locked behind paywalls, and content locked behind (free) authentication walls. Meta-data, such as expected prior knowledge, intended audience, learning objectives, associated course lecture content, etc. is often obscured or not provided. And the discovery process is largely manual beyond basic search-engine queries. This work started as a summer project focused on the ACM SIGCSE Nifty Assignments since that has free and open access, with an initial goal of identifying projects that could be included in our courses. Since then, we have expanded to additional repositories for this categorization. To determine what other repositories to explore, we included in our survey a set of questions listing some repositories we had encountered that seemed of interest to college-level CS1 and CS2 (see Table 1). Respondents were asked about their use of these repositories. Did they make use of entire assignments wholesale? Did they reference assignments for augmenting their own existing materials? Or did they use these repositories casually; browsing only for broad inspiration?. The survey ended with an open question for any other sites used in a substantial way, which gave us several other repositories to investigate.

Table 1. Repositories Considered for Exploration

Name	URL
Alice Community	https://www.alice.org/community/
Code.org	https://code.org/
College Board AP CS Resources	https://apcentral.collegeboard.org/courses/ap-computer-science-a/classroom-resources
CS-POGIL	https://cspogil.org/Home
CSTA Resources Library	https://csteachers.org/resources-library/
EngageCSEdu.org	https://engage-csedu.org/search/materials
Peer Instruction for CS	https://peerinstruction4cs.com/
SIGCSE Nifty Assignments	http://nifty.stanford.edu/

The CS-POGIL (Process Oriented Guided Inquiry Learning in Computer Science) site has a wealth of exemplary in-class materials (which means approximately 20-minute activities) designed in the POGIL

methodology (Kussmaul, et al.). Amongst the options online, it is one of the best curated and accessible repositories of teaching materials. They are categorized roughly by course and topic (e.g., Programming Languages, CS1, CS2, Operating Systems, etc.). In the CS1 category there are 6 courses comprising roughly 100 activities (Hu). Note, POGIL materials are in-class activities designed for small groups of students, unlike homework assignments like those found in the SIGCSE NIFTY repository. Individually, very few of the materials we found there matched our learning objectives since the lessons are on a very small scale. An area of future work might be to explore how smaller scale, daily learning objectives culminate into larger weekly objectives, then into entire course learning outcomes.

While we excluded most of the POGIL resources from this research (leaving that to future work), we did analyze and categorize the materials from Helen Hu's CS1 in Java (Hu) as a sample. Surprisingly, Hu's course covers all five learning objectives nicely despite it being a CS1 course only. For each of Hu's roughly 20 activities some learning objectives are usually stated. But they differ dramatically from activity to activity and there is no explicit mapping of how the individual learning objectives culminate (or should culminate) across the entire course.

On the code.org site, there don't seem to be stand-alone assignments. Most of what is available is presented as a rigid "curriculum" composed of lecture slides and videos and syllabi. The main purpose is to provide educators and learners a "click here, do this" style tutorial that takes place in the code editor itself. This is similar to quick start tutorials found in modern apps and video games when they're first launched, and do not necessarily align with the learning outcomes and course goals this work is centered on. Ultimately the students do "assignments", but the guidance is very heavy-handed compared to what normally occurs in a college setting. Additionally, the resources available are geared mostly at younger children in elementary school, which is also outside the intended scope of our work. Although they explicitly include high school age students in the target age ranges, assignments are not presented in a way that will engage most college students. A last concern that cemented our exclusion of this site is that the lessons are typically in a block-based programing language rather than a formal text-based language that is presented in typical CS1 and CS2 classes.

For the College Board Computer Science A AP exam site, it was challenging to find any actual assignments for students. Much of what is posted is behind authorization walls that requires proof that it is an educator (from a verifiable institution and part of a course that the College Board could audit) wanting the materials and not a student trying to cheat on the AP exam, an AI bot, or something else that is not for a learning experience. Generally, it is a repository that is hard to navigate and includes a lot of technical terminology specific to the CS A AP exam. Overall, this is not a place that many educators of a college-level CS1 or CS2 course will go to for projects, even though there are useful items that might make the effort getting access to be worthwhile.

In a similar vein, the CSTA Resources library is heavily tailored towards K-12 education, requires a paid login to access many of the resources, and includes only a few activities that could be used as a project in an introductory programming course. The Alice Community site is specific to the Alice programming tool. This is

a highly used tool that incorporates a drag and drop interface for creating programs (worlds) that engage students in programming and is highly successful in teaching students how to write good code. Alice 3 is a Java-based tool that allows an easy transition to traditional Java programming. However, we excluded this site because unless a course is teaching in Alice, the materials posted are not easily transferred to another language and programming environment.

Additional Categorizations

Domains

In addition to categorizing assignments by their learning outcomes, we also add a statement on how each project fits into one or more of the following five conceptual domains. Logic domain covers projects that focus on problem solving skills that may or may not include programming. Projects in the game domain focus on an implementation of a game and generally have a fun or competition aspect. Social impact projects focus on exploring social aspects, based on real-world data and applications. Computational projects focus on data analysis or mathematical processes and frequently are part of other domains as the application of the computations. Graphics projects focus on a graphical output that is something more than just having a GUI instead of a text console output. Most projects do fall into multiple domains so there are not exclusive categorizations.

Flexibility

An additional aspect we tried to capture for each assignment is its flexibility either in terms of making the project easier or harder to adjust for varied levels of student ability, or in some sort of customization that individual students could apply to make a project more their own. This consideration is a key aspect that is not always explicitly stated in an assignment description, but most groups of students include a wide range of abilities. Providing students with an option to challenge themselves beyond the basic requirements is something which has been shown to help with student engagement (Hirsch, 2013; Buck et al., 2008; Vojinović, et al., 2020).

Project Assignments

The following sections present the authors' collection of suggested projects for the five learning outcomes included in this study.

Algorithmic Techniques (LO1)

"By the end of this course, students will be able to apply algorithmic techniques to problem solving."

The goal of this learning outcome is to start students on the path of using critical thinking to solve problems presented in any situation, but with the goal of writing programs. Projects included here may or may not involve students writing a runnable program since the focus is to get students to transition from a problem explanation to an algorithmic solution that could potentially be used in a program.

Fatal Police Shootings (2023 SIGCSE Nifty)

Students are asked to complete data analysis to investigate the percentages related to black victims of fatal police shootings in the United States as compared to the US population that is not black in the project by Lynn (2023). Students are asked to complete mostly logic and syntax-based problems. There is not a lot of programming complexity involved although the use of dictionaries is included so it may not fit at the very beginning of CS1. This project is in the social impact domain.

- Flexible Complexity. Project complexity can be driven by the depth of data analysis as chosen by a student and is not a specific requirement of the project.
- Specific Skills. This project focuses the student learning on dictionaries and data analysis techniques.

Musical Dice Game (2023 SIGCSE Nifty)

Students 'compose' a waltz by concatenating a mix of random musical fragments, based on the result of a dice throw in the project by Wayne (2023). This project is based on logic, not on building a complete program. This is in the logical domain.

- Flexible Complexity. Project complexity is fixed, assuming there is no variability in the code provided to students.
- Specific Skills. This project focuses the student learning on randomization, data handling, and concatenation.

Decision Makers (2020 SIGCSE Nifty)

Students implement a program that asks the user a series of questions and determines their housing priority based on the answers in the project by Peck (Parlante et al., 2020). This project does not require background on many topics and is well suited to beginner programming students. This is in the logical and social impact domain.

- Flexible Complexity. Project complexity is fixed due to its simplicity.
- Specific Skills. This project focuses the student learning on conditionals and basic data types.

Post-It Pandemonium (2019 SIGCSE Nifty)

Students complete an "unplugged" activity to explore the use of data structures and algorithms in image

representation and compression in the project by Popyack (Parlante et al., 2019). This project does not involve any programming although it does teach some higher-level concepts, which makes it a nice way to introduce students to computer science concepts without needing to discuss code. This is in the logical domain.

- Flexible Complexity. Project complexity is fixed due to its simplicity.
- Specific Skills. This project focuses the student learning on image representation and compression.

Picobot (Engage-CSEdu.org)

Students define the rules a robot should follow to traverse an environment (Alvarado, et al.). This project does not involve writing a programming but guides the students to think algorithmically. This is in the logic and game domain.

- Flexible Complexity: Project complexity is fixed due to its simplicity.
- Specific Skills: This project focuses student learning on s decomposing problems.

1_DNA: Playing with (strings of) DNA (Engage-CSEdu.org)

Students begin a series of five projects related to analyzing DNA (LeBlanc). This project guides the students through the analysis of a "snip" of DNA while presenting proper code setup. This is in the logic and social impact domain.

- Flexible Complexity: Project complexity is fixed due to its simplicity but can be expanded into tangential topics for additional learning and engagement.
- Specific Skills: This project focuses student learning on string indexing, substrings, slicing strings, and other string manipulation.

POGIL Activities for CS1 (CS-POGIL)

As stated earlier, most of the CS-POGIL resources are smaller than a single LO, but we include some here for reference and as a starting place for educators who want to use the POGIL instructional approach.

Hu's CS1 materials (Hu) have several relevant classroom activities that pertain to LO1. Interestingly, nearly all of this collection of POGIL activities include critical thinking and likely implicitly teach students general problem solving. However, only some of the activities seem to ask students to write or evaluate algorithms that consist of more than one step. Specifically, activities 5 (Tracing Turtles), 8 (Intro to Loops), 9 (Loop Design), 10 (Arrays and For-Loops), 11 (Class Design), 16 (Advanced Arrays), and 19 (File I/O) are most exemplary. These are in the logical domain.

- Flexible Complexity. Project complexity is fixed due to their small scale and detailed steps to follow but many do include aspects that allow for student customization.
- Specific Skills. Each project focuses the student learning on stated skill.

Control Structures, Loops, Functions (LO2)

"By the end of this course, students will be able to write short programs in a programming language demonstrating understanding of fundamental concepts including writing and using control structures, loops, and functions."

The goal of this learning outcome is for students to master the basic building blocks of programming. Projects included here involve compiling programs that are generally simple programmatically, although they may be more complex if additional components are provided for students to interact with.

Nifty Illusions (2023 SIGCSE Nifty)

This project asks students to choose an optical illusion to replicate through different coding methods in the project by Liu (2023). The focus of the assignment is using loop logic to replicate images, and therefore has a simple but engaging use of graphics. This is in the graphics domain.

- Flexible Complexity. Project complexity is driven by the student through choosing their own optical illusion to recreate.
- Specific Skills. This project focuses the student learning on for loops, nested loops, variables, and graphics primitives.

Sankey Diagrams (2021 SIGCSE Nifty)

Students implement a program that visualizes data flow by drawing a variation of a Sankey Diagram (a flow diagram with proportional arrow widths based on the flow amount) in the project by Stephenson (Parlante, et al., 2021). This project requires several different computational skills in both logic and syntax. This is in the graphics and computational domains.

- Flexible Complexity. Project complexity can be altered by the instructor through the expectations that they have for the Sankey diagrams. The Nifty Assignment write-up gives the example that a professor could increase the expectation of the assignment to a multi-level Sankey diagram for a higher difficulty level.
- Specific Skills. This project focuses the student learning on file I/O, dictionaries, lists, strings, and functions.

Bar Chart Racer (2020 SIGCSE Nifty)

Students implement a program to create an animated bar chart in the project by Wayne (Parlante, et al., 2020). This assignment is less complex than most Nifty Assignments and is labeled as being from a course for mostly

scientists and engineers, not computer scientists, but it is programming heavy and so is categorized in LO2. A background in data would be beneficial to students, which makes this project a good fit for either an early CS class or an early Data Science course. This is in the computational domain.

- Flexible Complexity. Project complexity can be changed by the instructors in a few different ways. For example, an instructor could ask students to create their own data file via web scraping. Students would then have to clean the data before using it. Instructors could also alter the expectation for the visualization or ask students to use more sophisticated computational skills to sort and visualize the data.
- Specific Skills. This project focuses the student learning on data visualization/graphics, sorting arrays/lists, and file I/O.

Hawaiian Phonetic Generator (2019 SIGCSE Nifty)

Students input Hawaiian words and write a program that re-writes the word phonetically based on a set of pre-written rules in the project by Bingham (Parlante et al., 2019). This needs a base understanding of several different introductory skills to fully complete the program and is well placed in the middle of a CS1 course. This is in the computational domain.

- Flexible Complexity. Project complexity could be adjusted by the students or instructors by changing what language is being processed.
- Specific Skills. This project focuses the student learning on string manipulation, iterations, and functions.

Motion Parallax (2019 SIGCSE Nifty)

Students create a visual scene that can emulate the effects of motion parallax (when in a moving vehicle, close objects seem to move past quickly while distance objects move past slowly) in the project by Dicken (Parlante et al., 2019). The Nifty Assignment description places this project in the middle of a CS1 course, but it does rely heavily on graphics and mathematical understanding, which could affect where in the CS1/CS2 sequence students would have the most success completing. This is in the graphics and computational domains.

- Flexible Complexity. Project complexity can be controlled by what scene is modeled and whether students are allowed to be creative in what they produce.
- Specific Skills. This project focuses the student learning on graphics, loops, functions, and mathematical calculations.

Gerrymandering (2019 SIGCSE Nifty)

Students visualize voting districts and write a program that determines if the districts are gerrymandered based on a mathematical definition in the project by Obourn (Parlante et al., 2019). Students need a background in a

few different introductory topics to proficiently complete the data analysis and displaying of the project. This is in the social impact domain.

- Flexible Complexity. Project complexity can be controlled by what visualizations are required for the output.
- Specific Skills. This project focuses the student learning on file reading, string manipulation, and basic graphics.

Passwords and Python: Introducing Security Concepts in Lower-Division Programming (Engage-CSEdu.org)

Students create a program to check and store passwords (Fiesler, et al., 2023), while considering security and ethics concerns. Students need prior knowledge of loops and conditionals. This is in the graphics and game domains.

- Flexible Complexity: Project complexity can be controlled by how much pre-built code is provided to students or modifications of the assignment objectives.
- Specific Skills: This project focuses on practicing loops and string manipulation while reinforcing basic programming skills.

Lottery and the Wealth Gap (Engage-CSEdu.org)

Students create a program to simulate a lottery based on a real state game (Lin, et al., 2023), while considering the impact of lotteries on the wealth gap. Students need prior knowledge of lists, loops, and conditionals. This is in the logic and social impact domains.

- Flexible Complexity: Project complexity can be controlled by how much starter code, helper functions, and guiding comments are provided to students.
- Specific Skills: This project focuses on thinking through branching logic to gain better understanding of prior skills.

POGIL Activities for CS1 (CS-POGIL)

In Hu's CS1 materials (Hu) the most relevant activities to LO2 are 6 (Booleans), 8 (Intro to Loops), 9 (Loop Design), 10 (Arrays and For-Loops), 11 (Class Design), 12 (Constructors), and 13 (Scope). A somewhat surprising result is activities 14 (Inheritance), 15 (Polymorphism), 17 (Recursion), and 18 (Exceptions), which also teach "control structures" even if not in the colloquial sense. Although these topics (e.g., polymorphism) aren't traditionally associated with program "control" the same way that if statements and function calls are, the activities involve questions such as, "which function is called?" when overloading and inheritance are at play.

Arrays, Lists, Recursion (LO3)

"By the end of this course, students will be able to demonstrate proficiency with a programming language using arrays, lists, complex I/O, and recursion."

The goal of this learning outcome is for students to master the next building blocks of programming to include arrays, lists, and recursion, as well as more complex input/output (such as formatting styles or the use of a graphical user interface). Projects included here involve programs that are still generally simple programmatically, but now include more sophisticated programming skills.

Enigma Machine (2023 SIGCSE Nifty)

Students are asked to implement a simulator that models Enigma Encryption in the project by Roberts and Rembold (2023). There are 6 milestones, with 10-15 lines of code for each. This starts with basic logic in a few milestones, ending with more complexity in later milestones, most of which belong to LO3, but some are LO4. This is in the computational domain.

- Flexible Complexity. Project complexity is controlled by the instructor through the splitting of the project into milestones; using more or less than the standard 6 would modify each part.
- Specific Skills. This project focuses the student learning on dictionaries, lists, and classes.

Hex Game (2023 SIGCSE Nifty)

Students build a board game where users try to get the highest number of pieces, or 'islands', on the board in the project by Godbout (2023). The student is asked to complete the back-end logic of the project. The front-end part of the game is provided through supplemental code given to the students. This is in the game domain.

- Flexible Complexity. Project complexity for this project is determined by how much supplemental code the professor uses in their starter code project file.
- Specific Skills. This project focuses the student learning on complex if statements, aligning new code to existing code, validation of user moves, and handling of a data structure.

Spelling Bee + Wordle (2022 SIGCSE Nifty)

Students replicate the popular New York Times word games (Spelling Bee and Wordle) in a project that is split into milestones in the project by Roberts and Rembold (Parlante et al., 2022). The Nifty Assignment provides starter code in both Python and Java, which adds flexibility without changing the project complexity. Students are creating a usable program that replicates a real, existing game using the starter code to allow early programmers to be successful. This is in the game domain.

- Flexible Complexity. Project complexity is controlled through disbursement of starter files or through the splitting of project milestones. This project could be aligned with LO2 depending on the use of the starter code.

- Specific Skills. This project focuses the student learning on string, list manipulation, and reading files.

Food Web Zombies (2022 SIGCSE Nifty)

Students analyze data relating to the food web to understand contact between infected individuals. The full scope of the project allows students to work with data storage, analysis, and display in the project by Stephenson and Hudson (Parlante, et al., 2022). This is in the social impact and computational domains.

- Flexible Complexity. Project complexity can be controlled by both the student and the instructor. Outside of the first milestone, students can complete the different pieces of the project in whatever order they choose, giving the student flexibility to complete the project in a way that is easiest to them. The instructor can control the difficulty of the project through adding pieces to the project such as exceptions/input validation. There is also a listed option stating that students could be given the opportunity to choose the structure in which to store their food web data, which could place this project more into a CS2 course rather than the end of a CS1 course.
- Specific Skills. This project focuses the student learning on lists, dictionaries, file I/O, exceptions, strings, and functions.

Bias Bars (2022 SIGCSE Nifty)

Students parse and store a dataset relating to college professor reviews and then build a graphical tool to display word data visualizations in the project by Bowman, Creel, and Woodrow (Parlante et al., 2022). The assignment is meant for a student at the end of their first computer science term. This is in the computational and graphics domains.

- Flexible Complexity. Project complexity is fixed for the project, as it is written for the Nifty Assignment.
- Specific Skills. This project focuses the student learning on data processing, parsing, dictionaries, nested data structures, data visualization, graphics, and ethics.

Reddit Bot (2022 SIGCSE Nifty)

Students create a reddit bot that can post on reddit and reply to other messages in the project by Izbicki (Parlante et al., 2022). This project is complex, especially with the use of external Python libraries, but it is feasible for students at the end of a first programming class. Reddit comments are structured as simple trees, so this topic would need to be partially introduced for students to be successful. This is in the logical domain.

- Flexible Complexity. Project complexity is fixed into pre-defined labs, and homework assignments. These milestones could be altered by the instructor to increase or decrease the amount of time the students spend working on the assignment, and therefore, slightly modifying the difficulty of the assignment.

- Specific Skills. This project focuses the student learning on Python libraries, object-oriented programming, trees, randomness, and devops.

Rocket Landing Simulation (2021 SIGCSE Nifty)

Students create a game where players can control and land a rocket on a moving boat in the project by de Freitas and Weingart (Parlante et al., 2021). This project includes a lot of background logic in addition to graphics displays and front-end code. This is presented in the Nifty Assignment write-up as a capstone of a first programming class so we have placed it with LO3, but the complexity could also fit with LO4. This is in the game and graphics domains.

- Flexible Complexity. Project complexity is driven by the instructor. The project is designed to have 4 milestones covering 1-1.5 weeks. This time could be shortened or lengthened by the professor to vary the difficulty of the project. In addition to this, the write-up states that instructors can rescope the project to being either 'manual simulator only' or 'artificial intelligence only'.
- Specific Skills. This project focuses the student learning on graphics, modules, data structures, control structures, and AI.

Typing Test (2020 SIGCSE Nifty)

Students implement a game where users take a typing test and match their scores with other users in the project by DeNero et al. (Parlante et al., 2020). This project is mildly complex but is very rigid in its directions. This means that students must complete the project following the model, rather than creating new structures based on their own logic. There is a focus on creating a user-interactive environment with a GUI. This is in the game domain.

- Flexible Complexity. Project complexity could be modified by asking students to improve their autocorrect suggestions through a few different computational methods.
- Specific Skills. This project focuses the student learning on lists, strings, dictionaries, list comprehensions, higher-order functions, iterations, and tree recursion.

Color My World (2020 SIGCSE Nifty)

Students take random data and see if visualizing it helps them to understand what the data is explaining in the project by Albing (Parlante et al., 2020). This project requires a strong background in programming as well as some knowledge of visualizing data. While it fits at the end of CS1 or the beginning of CS2, it would also work in an upper-level elective that blends CS and Data Science curricula together. This is in the computational domain.

- Flexible Complexity. Project complexity could be altered in several different ways, including simplifying the project by eliminating the command line or adding a challenge by requiring more

statistical analysis of the data.

- Specific Skills. This project focuses the student learning on visualization, big data, image processing, and color maps.

DNA (2020 SIGCSE Nifty)

Students write a program that is given DNA data as input and identifies who the sample belongs to in the project by Yu and Malan (Parlante et al., 2020). This project focuses on interpretation of data through logic and syntax. This is in the computational domain.

- Flexible Complexity. Project complexity could be modified by the student with the challenge of finding more efficient algorithms to process the DNA input.
- Specific Skills. This project focuses the student learning on algorithms, computational biology, file I/O, loops, and string manipulation.

Recursion to the Rescue (2020 SIGCSE Nifty)

Students write three recursive algorithms that explore hospital scheduling, US elections, and disaster preparations in the project by Schwarz (Parlante, et al., 2020). The use of maps and sets with recursive backtracking places this project later in the programming sequence than other projects using recursion. This is in the social impact domain.

- Flexible Complexity. Project complexity could be adjusted by the students adding or changing the given algorithms to gain additional understanding of the topics.
- Specific Skills. This project focuses the student learning on recursive backtracking, maps, sets, and lists.

Code Crusher (2019 SIGCSE Nifty)

Students implement a game similar to Candy Crush, using images of code block words in the project by Stephenson (Parlante et al., 2019). This project is advanced for CS1 students to do on their own, but it is a great introduction to working with and adding onto existing supplemental code.

- Flexible Complexity. Project complexity could be changed through the amount of code given to the students. In addition to this, students could also be given the chance to add or remove rules to the game to make it more/less difficult.
- Specific Skills. This project focuses the student learning on functions, 2D lists, loops, and conditionals.

Matching Game (Engage-CSEdu.org)

Students create a program to play a matching game, managing the board and game play (Gondree). Students

need prior knowledge of loops, conditionals, and graphical libraries. This is in the graphics and game domains.

- Flexible Complexity: Project complexity is fixed but is split into checkpoints and allows for students to customize the game ascetics.
- Specific Skills: This project focuses student learning on 2-D arrays, loops, functions, control structures, and graphical interactions.

A CS1 Open Data Analysis Project with Embedded Ethics (Engage-CSEdu.org)

Students create a final project for a CS1 class that incorporates the knowledge gained in beginning programming, combined with analysis of a real-world data set (Wein, et al., 2023). This is in the computational and social impact domains.

- Flexible Complexity: Project complexity is fixed but is dependent on the open data set that individual students (or teams of students) select to work with.
- Specific Skills: This project focuses student learning on using files, conditionals, loops, strings, dictionaries, and lists while considering issues of ethics related to data responsibility.

POGIL Activities for CS1 (CS-POGIL)

In Hu's CS1 materials (Hu), the most relevant activities to LO3 are 4 (Strings), 10 (Arrays and For-Loops), 16 (Advanced Arrays), 17 (Recursion), and 20 (ArrayLists). Because these materials are in-class group work, it is questionable whether they effectively assess if students achieve LO3. It's possible that students are only working towards proficiency in a programming language during these activities. It is also possible that some students in the group make substantial progress, while others contribute and engage less.

Object-Oriented Design (LO4)

"By the end of this course, students will be able to develop a moderately complex project with use of some object-oriented design."

The goal of this learning outcome is for students to comprehend the basics of object-oriented programming. Projects included here involve using or writing classes as well as instantiation of objects.

Rising Tides (2023 SIGCSE Nifty)

Students create a flood fill algorithm showing the effects of rising tides in different geographical locations in the project by Schwarz (2023). This project, while complex, could be categorized with LO3 and used near the end of a CS1 course or the beginning of a CS2 course, along with supplemental code being given to the students. The focus of the project is for students to become more comfortable with critically thinking about data storage

and using arrays to store, move, and analyze data. This project is in the social impact and computational domains.

- Flexible Complexity. Project complexity is controlled by the instructor by restricting certain supplemental materials. As an example, the write-up states there are easier versions of the project that include giving students the pseudocode for BFS.
- Specific Skills. This project focuses the student learning on arrays and search algorithms.

Ray Marching (2022 SIGCSE Nifty)

Students use iteration to measure the distance between a point and other different objects in a plane in the project by Crotts and Matzureff (Parlante et al., 2022). This project is complex mathematically, visually, and logically with requirements of trigonometry, so its use is dependent on the mathematical abilities of the students. This is in the computational domain.

- Flexible Complexity. Project complexity is fixed but an instructor could give more time to work on the project to adjust the difficulty level.
- Specific Skills. This project focuses the student learning on ray marching, computer graphics, collision detection, and sphere tracing.

Competitive Pig Game (Engage-CSEdu.org)

Students build a program to play the game “Pig” (Smith). Students need prior knowledge of using classes. This is in the logic and game domain.

- Flexible Complexity: Project complexity is fixed but allows for students to make some design decisions.
- Specific Skills: This project focuses student learning on working with the provided simple classes while refreshing skills learned in CS1.

Console Game Application (Engage-CSEdu.org)

Students create a program to play a hidden object search game (Jones). Students need prior knowledge of all introductory programming concepts as well as using classes. This is in the game domain.

- Flexible Complexity: Project complexity is fixed but allows for students to customize the game theme and ascetics.
- Specific Skills: This project focuses student learning on working with the creation of simple classes and enforces skills learned previously.

POGIL Activities for CS1 (CS-POGIL)

In Hu's CS1 materials (Hu), the most relevant activity to LO4 is activity 3 (Turtles), which involves using objects but not defining them. We consider the "use of some object-oriented design" to be a two-stage process. First students explore pre-existing objects, such as the python "turtle." They build their skills and familiarity with OOP by writing complex programs that make use of objects. Then, in a second stage, students explore creating and developing their own custom objects to be used in such programs. There are several such activities from Hu's materials, that match this second stage, which we detail the end of the next section.

Object-Oriented Programming (LO5)

"By the end of this course, students will be able to understand and use the principles of object-oriented programming through objects, classes, abstract classes, inheritance, and polymorphism."

The goal of this learning outcome is for students to be thoroughly immersed in object-oriented programming. Projects included here involve complex classes that incorporate abstraction, inheritance, and polymorphism.

Handwriting Recognizer (2022 SIGCSE Nifty)

Students use template-matching methods to write a program that recognizes handwriting in the project by Valentine (Parlante et al., 2022). There is a heavier focus on creating objects and completion of a robust program. This is in the game and logic domains.

- Flexible Complexity. Project complexity is high, requiring basic knowledge in code-reading, API usage, file I/O, modularity, object-oriented programming, and unit testing; however, the 'template-matching' part of the project allows for students to focus more on logic, rather than writing their syntax. The amount of work that is done through this template matching influences the difficulty of the project. The instructor would control this flexibility.
- Specific Skills. This project focuses the student learning on sorting with comparators, computer graphics, and touches on strings, arrays, loops, functions, objects, file I/O, and unit testing.

COVID Simulator (2021 SIGCSE Nifty)

Students simulate a visualization showing how following social distancing recommendations impacts the spread of COVID-19 in the project by Bitner (Parlante et al., 2021). This project is a well-rounded project that involves some complex topics beyond that of a basic algorithmic or syntactical solution and best fits at the end of a CS2 course. This is in the social impact domain.

- Flexible Complexity. Project complexity is fixed, outside of the possibility that instructors add more controls to the assignment to increase the difficulty. The project is at its base level of difficulty as it is presented.
- Specific Skills. This project focuses the student learning on random numbers, time-based display

updates, graphical UI, and interfaces.

Linked List Labyrinth (2021 SIGCSE Nifty)

Students explore and escape from linked list mazes using the debugger in the project by Schwarz (Parlante, et al., 2021). This assignment is more practice-based and is focused heavily on learning to use the debugger, rather than building a complex program, but due to the use of linked lists, this project needs to be in a course that includes this data structure. This is in the game domain.

- Flexible Complexity. Project complexity can be controlled by the instructor in several ways as described in the Nifty Assignment narrative. The size of a maze can be increased or decreased, items in the maze can be added or removed, or the students could be asked to validate a path through the maze rather than find a path.
- Specific Skills. This project focuses the student learning on linked lists and debugging.

Blocky (2019 SIGCSE Nifty)

Students create a game focusing on using recursive structures to work toward a visual goal in the project by Horton and Liu (Parlante et al., 2019). The use of inheritance implies the utilization of a multi-class structure to complete this assignment, which would work well as a capstone to the CS1/CS2 sequence, however the use of trees places this in a course that teaches data structures. This is in the game domain.

- Flexible Complexity. Project complexity has many options for variability. The first way is for the instructor to take away the stated goal of building a connected blob of one color. Another way to vary the complexity is that students could be allowed to use their own types of moves or goals in the game.
- Specific Skills. This project focuses the student learning on recursion, trees, and inheritance.

Credit Card Validation (Engage-CSEdu.org)

Students build upon two prior projects to create a program calculating credit transactions with varied card types, interest rates, and rebate plans. Students need prior knowledge of the use of classes and objects (Yu & Lancor). This project is in the computational domain.

- Flexible Complexity: Project complexity is fixed and relies heavily on completion of prior projects.
- Specific Skills: This project requires the use of classes and objects, inheritance and polymorphism, text files, and string manipulation.

POGIL Activities for CS1 (CS-POGIL)

In Hu's CS1 materials (Hu), the most relevant activities to LO5 are 11 (Class Design), 12 (Constructors), 13 (Scope, specifically static, private, public instance variables), 14 (Inheritance), and 15 (Polymorphism). Because

Hu's course and POGIL materials use the Java programming language the OOP principles are robustly explored. Advanced topics like the use of the "static" keyword, function overloading, and inheritance are all covered in a rich and comprehensive way, making this an excellent set of resources for LO5. However, as previously stated, POGIL materials are in-class, small group activities as opposed to traditional homework assignments.

Discussion and Future Work

One observation from this work is that the largest category of many online assignments is for LO3, meaning the assignments fit at the end of CS1 or the beginning of CS2. It is interesting that that level is where instructors are more likely to create assignments that are worth sharing. And there are significantly fewer assignments that are designed for the very beginning programmers, or for advanced programmers without getting into complex data structures.

A possible continuation of this work is to include more of the assignments from the identified repositories. Much of the current limits were used to stay with more recent projects or ones that were more readily available, but many older projects and those that require more work to access are still of interest. Having another way to find resources to enliven student engagement and retention.

We also consider another research question to measure the use of these assignments. It would be interesting to see if those assignments that have higher usage are correlated to higher student engagement and retention.

References

Alvarado, C., Kuenning, G., Libeskind-Hadas, R. & Dodds, Z. (n.d.) *Picobot.* EngageCSEDU. https://engage-csedu.org/find-resources/picobot

Ambròsio, A. P., Costa, F. M., Almeida, L. S., Franco, A., & Macedo, J. (2011). Identifying cognitive abilities to improve CS1 outcome. *2011 Frontiers in Education Conference (FIE)*. https://doi.org/10.1109/fie.2011.6142824

Buck, B., Carr, S. R., & Robertson, J. (2008). Positive psychology and student engagement. *Journal of Cross-Disciplinary Perspectives in Education*, *1*(1), 28–35. http://mxtsch.people.wm.edu/Teaching/JCPE/Volume1/JCPE_2008-01-05.pdf

De Deus, W. S., & Barbosa, E. F. (2022). A systematic mapping of the classification of Open Educational Resources for Computer Science Education in Digital Sources. *IEEE Transactions on Education*, *65*(3), 450–460. https://doi.org/10.1109/te.2021.3128019

Fiesler, C., Dalal, S., & Paup, J. (2023). *Passwords and python: introducing security concepts in lower-division programming.* EngageCSEdu. https://engage-csedu.org/find-resources/passwords-and-python-introducing-security-concepts-lower-division-programming

Godbout, A. (2023). Islands of Hex. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education*, *2*, 1275. https://doi.org/10.1145/3545947.3573223

Gondree, M. (n.d.). *Matching game, a CS1 project.* EngageCSEdu. https://engage-csedu.org/find-resources/matching-game-cs1-project

Hirsch, K. A. (2013). *The impact of differentiated instructional techniques on non-traditional, adult student engagement in a baccalaureate nursing completion program for registered nurses (RN-BSN) course*. (Publication No. ED553443) [Ed.D. Dissertation, Ball State University]. ERIC.

Hu, H. (n.d.). *CS-POGIL | Helen Hu - Computer Science 1*. CS-POGIL. https://cspogil.org/Helen+Hu+-+Computer+Science+1

Jones, S. H. (n.d.). *Console game application.* EngageCSEdu. https://engage-csedu.org/find-resources/console-game-application

Kussmaul, C., Hu, H., Mayfield, C., Yadav, A., Lang, M., & Pirmann, T. (n.d.) CS-POGIL. Retrieved March 15, 2024 from http://cspogil.org/

Leake, M., & Lewis, C. M. (2017). Recommendations for Designing CS Resource Sharing Sites for All Teachers. *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*, 357–362. https://doi.org/10.1145/3017680.3017780

LeBlanc, M. (n.d.). *1_DNA: Playing with (strings of) DNA.* EngageCSEdu. https://engage-csedu.org/find-resources/1dna-playing-strings-dna

Lin, S., Zeichick, K., & Lewis, C. M. (2023). *Lottery and the wealth gap*. EngageCSEdu. https://doi.org/10.1145/3488379

Lister, R. (2001). Objectives and Objective Assessment in CS1. *Proceedings of the Thirty-second SIGCSE Technical Symposium on Computer Science Education,* 292–296. https://doi.org/10.1145/364447.364605

Liu, F. T. 2023. Nifty Assignments: Optical Illusions Using Loops and Nested Loops. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education, 2,* 1276. https://doi.org/10.1145/3545947.3573224

Lynn, M. (2023). Project: Fatal Police Shootings. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education, 2*, 1276. https://doi.org/10.1145/3545947.3573221

Parlante, N. & Zelenski, J. (1999). Nifty Assignments Archive. Retrieved June 15, 2023 from http://nifty.stanford.edu/.

Parlante, N., Zelenski, J., Dicken, B., Stephenson, B., Popyack, J. L., Mongan, W. M., Bingham, K., Horton, D., Liu, D., & Obourn, A. (2019). Nifty Assignments. *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, 1230-1231. https://doi.org/10.1145/3287324.3293871

Parlante, N., Zelenski, J., DeNero, J., Allsman, C., Perumpail, T., Arya, R., Gupta, K., Cang, C., Bitutsky, P., Moughan, D., Malan, D. J., Yu, B., Peck, E. M., Albing, C., Wayne, K., & Schwarz, K. (2020). Nifty Assignments. *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, 1270-1271. https://doi.org/10.1145/3328778.3372574

Parlante, N., Zelenski, J., de Freitas, A. A., Weingart, T. B., Schwarz, K., Stephenson, B., & Bitner, S. (2021). Nifty Assignments. *Proceedings of the 52nd ACM Technical Symposium on Computer Science*

Education V. 2, 1270-1271. https://doi.org/10.1145/3408877.3439501

Parlante, N., Zelenski, J., Roberts, Rembold, J., Stephenson, B., Hudson, J., Valentine, S., Woodrow, J., Creel, K., Bowman, N., Crotts, L., Matzureff, A., & Izbicki, M. (2022). Nifty Assignments. *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education*, 1270-1271. https://doi.org/10.1145/3478432.3499268

Roberts, E., & Rembold, J. J. (2023). Nifty Assignments: Enigma Machine Simulator. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education, 2*, 1276. https://doi.org/10.1145/3545947.3573220

Robins, A. (2010) Learning edge momentum: a new account of outcomes in CS1. *Computer Science Education*, *20*(1), 37-71. https://doi.org/10.1080/08993401003612167

Salguero, A. (2023). Establishing an Empirical Foundation for a Theory of Student Learning and Success in CS1. *Proceedings of the 2023 ACM Conference on International Computing Education Research, 2*, 52–54. https://doi.org/10.1145/3568812.3603444

Schwarz, K. (2023). Rising Tides: A Literal Flood-Fill. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education, 2*, 1277. https://doi.org/10.1145/3545947.3573222

Smith, A. A. (n.d.) *Competitive pig game*. EngageCSEDU. https://engage-csedu.org/find-resources/competitive-pig-game

Suarez, C. G. H., Bucheli, V., & Ordóñez, H. (2023). Rubric based on learning competencies in a CS1 course to evaluate CSCL programming activities. *Scientific Magazine*, *46*(1), 134–146. https://doi.org/10.14483/23448350.20095

Vojinović, O., Šimić, V., Milentijević, I., & Ćirić, V. (2020). Tiered assignments in lab programming sessions: Exploring objective effects on students' motivation and performance. IEEE Transactions on Education, 63(3), 164–172. https://doi.org/10.1109/te.2019.2961647

Wayne, K. (2023). Mozart Musical Dice Game. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education, 2*, 1275. https://doi.org/10.1145/3545947.3573219

Wein, S., Patterson, A., Brick, S., & Luken, S. (2023). *A CS1 open data analysis project with embedded ethics*. EngageCSEdu. https://engage-csedu.org/find-resources/cs1-open-data-analysis-project-embedded-ethics

Yu, W., & Lancor, L. (n.d.). *Credit card validation project*. EngageCSEdu. https://engage-csedu.org/find-resources/credit-card-validation-project

The Effect of Web 2.0 Based Environmental Education on Students' Academic Achievement, Motivation and Attitude in Social Studies Course

Özkan Akman
Süleyman Demirel University, Isparta, https://orcid.org/ 0000-0002-8264-3178

Fatma Nur Şahan
Süleyman Demirel University, Isparta, https://orcid.org/ 0009-0001-3146-5877

Abstract: The aim of this study is to determine "The Effect of Web 2.0 Supported Environmental Education in Social Studies Course on Students' Academic Achievement, Motivation and Attitude". In the study, pretest-posttest paired control group design, one of the quasi-experimental designs, which is one of the quantitative research methods, was used. The study group of the research consists of 40 students studying at the 5th grade level of a secondary school in the central district of Isparta province in the 2023-2024 academic year. There were 22 students in the experimental group and 18 students in the control group. "Environmental Problems Academic Achievement Test", "Environmental Attitude Scale for Secondary School Students" and "Secondary School Environmental Motivation Scale" prepared by the researcher were used as data collection tools in the study. The application took place during 18 lesson hours. While the experimental group was given Web 2.0 supported environmental education, the control group was given environmental education with constructivist approach. The data obtained were analyzed by SPSS program. It was seen that there was no significant difference between the pretest achievement scores, pretest motivation scale scores and pretest attitude scale scores of the experimental and control groups. After the application, it was determined that there was a significant difference between the post-test achievement scores, post-test motivation scale and post-test attitude scale scores of the experimental and control groups. According to the data obtained, it was concluded that web 2.0 supported environmental education in social studies course contributed positively to students' academic achievement, attitude and motivation.

Keywords: Social studies course, Web 2.0 tools, Environmental education.

Citation: Akman, Ö. & Şahan, F. N. (2024). The Effect of Web 2.0 Based Environmental Education on Students' Academic Achievement, Motivation and Attitude in Social Studies Course. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024-- International Conference on Life Sciences, Engineering and Technology* (pp. 71-82), San Francisco, CA, USA. ISTES.

Introduction

The environment is the external environment in which all living things are affected, influenced and maintain

their relationships throughout their lives. It covers all ecological, geographical and social concepts that are in direct or indirect relationship with individuals over time, shape their lifestyles and ensure their development (Sevinç, 2009). The environment does not have a defined border line (Yıldız, Sipahioğlu, Yılmaz, 2011).

The survival of living things is realized through certain balances. Human interaction with the environment creates a natural balance. The breaks between the bonds that make up the natural balance affect all of the bonds and lead to the deterioration of the natural balance and cause environmental problems (Kiziroğlu, İnanç, Turan, 2001). Human beings have tried to change the environment they live in according to their own wishes and interests. With the rapid population growth, the development of the industrial sector and the ease of transportation, individuals have ignored the environment, which has paved the way for the formation of environmental problems (Gürpınar, 1992). The increase in environmental problems has also led to the formation of environmental pollution. Increases in environmental pollution have negatively affected human health and led to the emergence of some diseases (Güney, 2004).

The main objectives of the social studies course are to enable individuals to recognize the characteristics of the environment they live in, to comprehend the relationship and interaction between the environment and human beings, and to adopt the understanding of protecting the natural environment (MEB, 2018). In this context, the social studies course is of great importance in instilling environmental awareness and environmental education in students.

Environmental education is the name given to all of the activities carried out in order for living beings to understand, recognize and protect the environment they live in and to show their best efforts in this direction. Environmental education aims to ensure that living beings live a healthy life without any difficulties (Turkish Environment Foundation, 1993). Education lies at the heart of raising societies' awareness about the environment and making use of the natural environment without destroying it. In order to develop and maintain environmental awareness, environmental education should be implemented regularly and continuously (Ada, Baysal, Şahenk-Erkan, 2017). Children have a great interest in the environment and are very open to gaining permanent habits (Turkish Environment Foundation, 1993). It is very important to provide students with permanent environmental behaviors. In this context, developing and changing technology can be utilized to create environmental awareness. Environmental education can be provided with the support of web 2.0 tools in education.

Web 2.0 tools are applications that enable easy content design, collaboration and contribution to pre-designed content on the internet (Atıcı, Yıldırım, 2010; Cakir, Ozturk, Unal, 2019; Ozturk, 2023). As time passed, the areas of use of Web 2.0 tools increased and expanded and enabled the use of Web 2.0 tools in education (Deperlioğlu, Köse, 2010). With the development of technology and the increasing importance of the internet, it has led to the internet reaching classroom environments. Web 2.0 tools diversify education and training materials and aim to attract students' interest in the course and ensure their active participation (Kırkkılıç, Ulaş, Sevim, Epçaçan, 2022).

Purpose of the Research

The aim of this study is to determine the effect of Web 2.0 supported environmental education on students' academic achievement, attitude and motivation in social studies course. In order to achieve the aim of the research, answers to some questions were sought. The questions are as follows.

1. Is there a significant difference between the environmental problems achievement test pre-test scores and environmental problems achievement test post-test scores of the experimental and control group students of Web 2.0 supported environmental education in social studies course?
2. Is there a significant difference between the pre-test and post-test scores of Web 2.0 supported environmental education in social studies course and the environmental attitude scale for middle school students of experimental and control group students?
3. Is there a significant difference between the pre-test and post-test scores of Web 2.0 supported environmental education in social studies course and middle school environmental motivation scale of experimental and control group students?

Method

Research Model

The research was prepared according to a quasi-experimental design with a paired pretest-posttest control group from quantitative research methods. The aim of experimental research is to test the effect of the differences prepared by the researcher on the dependent variable and the cause-effect relationship between groups of variables. In the paired control group design, two of the already formed groups are matched on predetermined variables. Random assignment is made between the paired groups (Büyüköztürk et al., 2020).

Sample Group

The sample group of the study was conducted in a secondary school in the central district of Isparta Province in the fall semester of the 2023-2024 academic year. The sample group consisted of 40 students studying at the 5th grade level. Of the students, 22 were in the experimental group and 18 were in the control group. While determining the sample group of the study, two equal groups were formed based on academic achievement scores (Büyüköztürk, 2016), and random assignment was made while determining the experimental and control groups.

Application Process

In this study, all data were obtained in the 2023-2024 academic year. A pilot study was conducted with 96 students to test the validity and reliability of the achievement test. The final version of the questions has been reached. In order to determine the experimental and control groups, achievement test was applied to 5 5th grade

classes in the implementation school and two equivalent classes were determined (Büyüköztürk, 2016). The application lasted a total of 18 hours in a 5-week period. Table 1 shows the weekly and daily lesson hours of the applications prepared in accordance with the social studies curriculum for the experimental and control groups.

Table 1. Shows the weekly and daily lesson hours of the practices prepared in accordance with the social studies curriculum.

Group	**Week**	**Lesson Hours**	**Application Process**
Experimental Group	Week 1	2	The pre-test environmental problems achievement test and the pre-test "Middle School environmental motivation scale" were applied to the students (Çiçek-Şentürk, 2020).
Control Group	Week 1	2	Pre-test environmental problems achievement test and pre-test "Middle School environmental motivation scale" were applied to the students (Çiçek-Şentürk, 2020).
Experimental Group	Week 2	1	The pre-test "Environmental Attitude Scale for Secondary School Students" was applied (Özata-Yücel, Özkan, 2014).
Control Group	Week 2	1	The pre-test "Environmental Attitude Scale for Secondary School Students" was applied (Özata-Yücel, Özkan, 2014).
Experimental Group	Week 3	2	Students have started to be taught about environmental issues. The posters prepared from Canva were used in the lesson and the animation prepared by the researcher in Plotagon Studio application was shown to the students.
Control Group	Week 3	2	Environmental education course was given with a constructivist approach in accordance with the social studies curriculum.
Experimental Group	Week 4	2	Activities prepared in Canva were done and educational games prepared in Wordwall application were played.
Experimental Group	Week 5	1	Post-test "Environmental problems academic achievement test" was applied.
		1	The post-test "Middle school environmental motivation scale" was applied (Çiçek-Şentürk, 2020).
		1	The post-test "Environmental Attitude Scale for Secondary School Students" was applied (Özata-Yücel, Özkan, 2014).
Control Group	Week 5	1	The post-test "Environmental problems academic achievement test" was applied.
		1	The post-test "Middle school environmental motivation scale" was applied (Çiçek-Şentürk, 2020).
		1	The post-test "Environmental Attitude Scale for Secondary School Students" was applied (Özata-Yücel, Özkan, 2014).

Data Collection Tools

"Environmental problems academic achievement test", "Middle school environmental motivation scale" (Çiçek-Şentürk, 2020) and "Environmental attitude scale for middle school students" (Özata-Yücel, Özkan, 2014) prepared by the researcher were used to collect the data of this study.

Environmental problems academic achievement test was developed by the researcher. According to the students' responses to the achievement test, item difficulty levels and item discrimination indices were calculated, and after the item analysis, the test was finalized by taking the opinions of one Prof. Dr., one Research Assistant and two social studies teachers who are experts in their fields. Prof. Dr., a Research Assistant Professor and two social studies teachers, who are experts in the field, the test was finalized and 4 questions with item discrimination indices less than 0.20 were removed from the achievement test.

All values with an item discrimination index of 0.19 and below should be removed from the test and the test should not be used (Başol, 2019). The achievement test consists of 24 questions with 4 options. The Kr Alpha value of the environmental problems academic achievement test is 0,763. The Cronbach Alpha value obtained from the data analysis measures the reliability level of the total scores (Sipahi, Yurtkoru, Çinko, 2010). It is indicated by Alpha (a). If this value is between 0.60 and 0.80, the scale is reliable (Özdamar, 1997).

The "Environmental Attitude Scale for Secondary School Students" has two subscales in total. While the first subscale measures the behavior of the students, the second subscale measures the relationship between feelings, thoughts and actions (Özata-Yücel, Özkan, 2014). For this study, only the first subscale measuring students' behavior was used. (Özata-Yücel, Özkan, 2014) The first subscale has 14 items and is formed with 5-point Likert type. The Kr Alpha value is 0.815.

"Middle school environmental motivation scale" was developed to measure the motivation of students. The scale was prepared with 3-point Likert type and consists of 16 items. Kr Alpha value was 0.78 (Çiçek-Şentürk, 2020).

Data Analysis

The TAP (Test Analysis Program) program was used in the item analysis of the academic achievement test on environmental issues. The research data were analyzed using the SPSS program. Two tests were applied on the data obtained from the experimental and control groups, and Independent Sample t-Test was conducted to determine whether there was a statistically significant difference between the values obtained as a result of the application (Can, 2013).

Kolmogorov-Smirnov (K-S) and Shapiro-Wilks (W statistic) tests can be used to evaluate the univariate normality assumption (Kalaycı, 2006). Shapiro-Wilks test was used in this study (Can, 2013). Shapiro-Wilk test

should be applied when the number of observed students is below 30.

Results

Table 2. Findings related to the normality distribution of the results obtained by the experimental and control group students from the Environmental Problems Academic Achievement Test are given.

Group	Test	N	Mean	Ss	C.S.	K. C.	Shapiro-Wilk
Experimental	Pre Test	22	12.68	4.17	-.068	-.919	.405
Group	Post Test	22	16.68	2.95	.037	-1.000	.138
Control	Pre Test	18	12.72	3.73	-.226	-.522	.346
Group	Post Test	18	14.11	4.43	-.120	-.1.270	.072

Within the first sub-problem of the research, the answer to the question "Is there a significant difference between the pre-test and post-test scores of the environmental problems academic achievement test of the experimental and control group students?" was sought. In this context, Independent-Samples T Test (independent groups t test) was conducted to determine whether there was a significant difference between the pre-test and post-test scores of the experimental and control group students from the environmental problems academic achievement test, and the results obtained from the data are presented in Table 3 and Table 4, respectively:

Table 3. Independent groups t test results of the pre-test scores of the academic achievement test on environmental issues.

Group	N	Mean	SD	DF	t	p
Experimental Group	22	12.68	4.17	38	.032	.975
Control Group	18	12.72	3.73			

When the result data in Table 3 are examined, the mean pre-test score of the environmental problems academic achievement test of the experimental group students was (X=12.68) and its standard deviation was (Ss=4.17), and the mean score of the environmental problems academic achievement test of the control group students was (X=12.72) and its standard deviation was (Ss=3.73). According to the results of the independent samples t test ($t_{(38)}$=.032; p>.05), there is no statistically significant difference. In other words, there is no significant difference between the pre-test scores of the environmental education academic achievement test.

Table 4. Independent groups t test results of the post-test scores of the academic achievement test on environmental issues.

Group	N	Mean	SD	DF	t	p
Experimental Group	22	19.68	2.950	28.53	4.569	.000
Control Group	18	14.11	4.431			

When the result data in Table 4 are analyzed, it is seen that the mean post-test score of environmental problems academic achievement test of the experimental group students was (X=19.68) and its standard deviation was (Ss=2.950), and the mean post-test score of environmental education academic achievement test of the control group students was (X=14.11) and its standard deviation was (Ss=4.431). According to the results of the independent samples t-test analysis ($t_{(28.53)}$=4.569; p<.05), there is a statistically significant difference. In other words, there is a significant difference between the post-test scores of the environmental problems academic achievement test.

Table 5. findings of the experimental and control group students regarding the normality distribution of the results obtained from the environmental attitude scale for middle school students

Group	Test	N	Mean	SD	Ç.K	B.K	Shapiro-Wilk
Experimental	Pre Test	22	51.50	8.486	-.930	.232	.046
Group	Post Test	22	59.95	3.429	.362	-.381	.795
Control	Pre Test	18	51.05	8.390	-.622	-.461	.246
Group	Post Test	18	53.94	5.682	.706	.1.012	.014

Within the second sub-problem of the research, the answer to the question "Is there a significant difference between the pretest and posttest scores of the environmental attitude scale for middle school students of the experimental and control group students?" was sought. In this context, Independent-Samples T Test (Independent-Samples T Test) was conducted to determine whether there was a significant difference between the pre-test and post-test scores of the experimental and control group students from the environmental attitude scale for middle school students, and the results obtained from the data are presented in Table 6 and Table 7, respectively:

Table 6. Independent samples t test results of the pre-test scores of the environmental attitude scale for secondary school students

Group	N	Mean	SD	DF	t	p
Experimental Group	22	49.13	8.48	38	-.715	.479
Control Group	18	51.05	8.39			

When the result data in Table 6 are examined, the mean pretest score (X=49.13) and standard deviation (Ss=8.48) of the environmental attitude scale for middle school students of the experimental group students were shown, while the mean pretest score (X=51.05) and standard deviation (Ss=8.39) of the environmental attitude scale for middle school students of the control group students were determined as. According to the results of the independent samples t test ($t_{(38)}$=-.715); p>.05), there is no statistically significant difference.. In other words, there is no significant difference between the pre-test scores of the environmental attitude scale for middle school students.

Table 7. Independent samples t test results for the post-test scores of the environmental attitude scale for secondary school students

Group	N	Mean	SD	DF	t	p
Experimental Group	22	59.95	5.42	26.72	3.93	.001
Control Group	18	53.94	5.68			

When the result data in Table 7 are examined, the posttest mean score (X=59.95) and standard deviation (Ss=5.42) of the experimental group students on the environmental attitude scale for middle school students and the posttest mean score (X=53.94) and posttest standard deviation (Ss=5.68) of the control group students on the environmental attitude scale for middle school students were determined. According to the independent samples t-test results ($t_{(26,72)}$=3.93; p<.05), there is a statistically significant difference. In other words, there is a significant difference between the post-test scores of the environmental attitude scale for middle school students.

Table 8. Findings related to the normality distribution of the results obtained from the middle school environmental motivation scale of the experimental and control group students

Group	Test	N	X	SD	Ç.K	B.K	Shapiro-Wilk
Experimental	Pre Test	22	36.40	3.947	-.320	-.1,276	.046
Group	Post Test	22	42.09	3.160	.147	-.586	.343
Control	Pre Test	18	33.22	5.547	-.992	.1,114	.174
Group	Post Test	18	35.88	4.496	-.608	.775	.392

Within the third sub-problem of the research, "Is there a significant difference between the pre-test and post-test scores of the middle school environmental motivation scale of the experimental and control group students? The answer to the question was sought. In this context, Independent-Saples T Test (independent groups t test) was performed to see whether there was a significant difference between the pretest and posttest scores of the experimental and control group students from the middle school motivation scale, and the results obtained from the data are presented in table 9 and table 10, respectively.

Table 9. Independent groups t test results for the pre-test scores of the middle school environmental motivation scale

Group	N	Mean	SD	DF	t	p
Experimental Group	22	36.40	3.947	38	.371	.713
Control Group	18	35.83	5.833			

When the result data in Table 9 are examined, the mean pretest score of the experimental group students in the middle school environmental motivation scale was (X=36.40) and the mean pretest standard deviation was (Ss=3.947), and the mean pretest score of the control group students in the middle school environmental motivation scale was (X=35.83) and the mean pretest standard deviation was (Ss=5.833). The results of the

independent samples t-test ($t_{(38)}$=.371; p>.05) show that there is no statistically significant difference. In other words, there is no significant difference between the pre-test scores of the middle school environmental motivation scale.

Table 10. Independent sample t test results for the post-test scores of the middle school environmental motivation scale

Group	N	Mean	SD	DF	t	p
Experimental Group	22	42.09	3.160	38	5.113	.000
Control Group	18	35.88	4.496			

When the result data in Table 10 are analyzed, it is seen that the mean score of the experimental group students in the post-test of the middle school environmental motivation scale was (X=42.09) and the standard deviation of the post-test was (Ss=3.160), and the mean score of the control group students in the middle school environmental motivation scale was (X=35.88) and the standard deviation of the post-test was (Ss=4.496). According to the independent samples t-test results ($t_{(38)}$=5.113; p<.000), there is a statistically significant difference. In other words, there is a significant difference between the post-test scores of the middle school environmental motivation scale.

Discussion & Conclusion

Environmental problems cause great harm to living things and the environment in which they live. Industrialization, rapid population growth and unconscious behaviors of people cause environmental problems to increase. Social studies course has a great impact on raising environmental awareness. Students can be given an environmental education course within the scope of social studies. By utilizing the developing technology while providing environmental education, the permanence of learning can be increased and students can actively participate in the lesson.

As a result of this research, which investigated the effect of Web 2.0 supported environmental education on students' academic achievement, motivation and attitude in social studies course, it was revealed that there was no significant difference in the pre-test scores of the environmental problems achievement test of the experimental group and control group students, while there was a significant difference between the post-test scores of the environmental problems achievement test in favor of the experimental group. Accordingly, it can be said that environmental education provided by utilizing web 2.0 technologies in the social studies course contributes positively to students' academic achievement.

Almalı and Yeşiltaş (2020), in their study titled "The Effect of Teaching Geography Subjects in Social Studies Education Using Web 2.0 Technologies on Students' Academic Achievement and Attitudes", concluded that the use of web 2.0 technologies in geography subjects in social studies course positively affected students' academic

achievement. Can and Usta (2021), in the study titled "The Effect of Web 2.0 Supported Conceptual Cartoon on Achievement and Attitude", stated that the achievement test post-test scores of the experimental group students were high and that it was important in increasing academic achievement.

It was seen that there was no significant difference between the pre-test scores of the experimental and control group students regarding the environmental attitude scale for secondary school students (Özata-Yücel, Özkan, 2014), but there was a significant difference between the post-test scores in favor of the experimental group. Accordingly, it can be said that environmental education provided by utilizing web 2.0 technologies in the social studies course positively affects students' attitudes. When the literature is examined, Akbaba and Ertaş-Kılıç (2022) concluded that the science course given using Web 2.0 technologies positively affected students' attitudes.

It was observed that there was no significant difference between the pre-test scores of the experimental and control group students regarding the Middle School environmental motivation scale (Çiçek-Şentürk, 2020), while there was a significant difference in favor of the experimental group when the post-test scores were examined. According to this, it can be said that environmental education given by using web 2.0 technologies in social studies course positively affects students' motivation. In the study prepared by Maraşlı and Değirmencioğlu (2023), it was stated that web 2.0 technologies used in music lessons increased students' motivation towards the lesson. Mete and Batıbey (2019) concluded in their study that students' motivation increased positively by using Kahoot application in web 2.0 supported Turkish education.

Recommendations

Applications can be selected within the scope of Web 2.0 tools and studies can be prepared only for these applications. Similar studies can be conducted for courses in different branches.Teachers can be informed about the use of web 2.0 tools, printed books can be published, and practical guidance can be provided.

In this study, pretest-posttest control group design was used as one of the experimental designs. For another study, the Solomon four-group model can be used.Within the scope of the social studies curriculum, studies can be conducted for different learning areas and grade levels.

References

Ada, S., Baysal, Z. N., & Şahenk-Erkan, S. S. (2017). Environmental education in various dimensions (1st edition). Nobel Academic Publishing.

Akbaba, K., & Ertaş-Kılıç, H. (2022). The effect of Web 2.0 applications on students' science and technology use. Erzincan University Journal of Faculty of Education, 24(1), 130-139. https://doi.org/10.17556/erziefd.880542

Akçay, A. and Yaşar, H. (2022). Web 2.0. In H. A. Kırkkılıç, A. H. Ulaş, O. Sevim, & C. Epçaçan (Eds.), Web 2.0 tools and Turkish teaching (1st ed.), (pp. 1-12). Anı Publishing.

Almalı, H. and Yeşiltaş, E. (2020). The effect of teaching geography subjects in social studies education using Web 2.0 technologies on students' academic achievement and attitudes. Journal of Scientific Research in Turkey, 5(2), 165-182.

Başol, G. (2019). Measurement and evaluation in education (6th edition). Pegem Akademi.

Atıcı, B., & Yıldırım, S. (2010, February 10-12). The effect of Web 2.0 applications on e-learning. (Full text paper). Proceedings of XII. Academic Informatics Conference, Muğla University, Muğla, Turkey.

Büyüköztürk, Ş., Kılıç-Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2020). Scientific research methods (29th edition). Pegem Academy.

Büyüköztürk, Ş. (2016). Experimental designs pretest-posttest control group design and data analysis (5th edition). Pegem Academy.

Cakir, E., Ozturk, M.S., Unal, M. (2019). Interpainting as a Creating Method in Digital Illustration: Reinterpretations from Movie Scenes. Science, Education, Art and Technology Journal (SEAT Journal), 3(2), 78-88.

Can, A. (2013). Quantitative data analysis in scientific research process with SPSS (1st Edition). Pegem Academy

Can, B. & Usta, E. (2021). The effect of Web 2.0 supported conceptual cartoon on achievement and attitude. Turkish Academic Publications Journal (TAY Journal), 5(1), 51-69.Cerrah-Özsevgeç, L. (2009).

Introduction to environmental science. In V. Sevinç (Ed.), General Environmental Science for Education Faculties (1st edition), (pp. 11-20). Maya Academy Publication.

Çiçek-Şentürk, Ö. (2020). Argumentation-supported educational comics' effect on students' interest, motivation and academic achievement towards the environment and students' experiences [Unpublished doctoral dissertation]. Gazi University, Ankara.

Deperlioğlu, Ö. & Köse, U. (2010, February 10-12). The effects of Web 2.0 technologies on education and a sample learning experience. (Full text paper). Proceedings of XII. Academic Informatics Conference, Muğla University, Muğla, Turkey.

Dikmen, S. (1993). Education for the environment in primary schools. Turkey Environment Foundation (Ed.), Environmental education. (s. 21-34). Turkey Environment Foundation Publication.

Eroğlu, A. (2010). Assumptions of multivariate statistical techniques. In Ş. Kalaycı (Ed.), SPSS applied multivariate statistical techniques (5th edition), (pp. 207-230). Asil Yayın .

Güney, E. (2004). Geography of environmental problems (edition). Gündüz Education and Publishing.

Gürpınar, E. (1992). Environmental problems (2nd edition). Der Publications.

Inanc, N. and Kurgun, E. (2000). Environmental education and public awareness raising. In İ. Kiziroğlu, N. İnanç and L. Turan (Ed.), V. International symposium on ecology and environmental problems (1st edition), (pp. 51-57).

Maraşlı, S. and Değirmencioğlu, L. (2023). The Use of Web 2.0 Tools in Music Education: Effects on Student Motivation. Journal of Korkut Ata Turkiyat Research, 13, 1484-1501. https://doi.org/10.51531/korkutataturkiyat.1394462

MEB, (2018). Social studies course curriculum. T.C. Ministry of National Education.

Mete, F., & Batıbay, E., F. (2019). The effect of Web 2.0 applications on motivation in Turkish education: Kahoot example. Journal of Mother Tongue Education, 7(4), 1029-1047. https://doi.org/10.16916/aded.616756

Özata-Yücel, E., & Özkan, M. (2014). Developing an Environmental Attitude Scale for middle school students. Journal of Uludağ University Faculty of Education, 27(1), 27-48.

Özdamar, K. (1997). Package Programs and statistical data analysis I (1st Edition). T.C. Anadolu University Publications.

Ozturk, O.T. (2023). Examination of 21st Century Skills and Technological Competences of Students of Fine Arts Faculty. International Journal of Education in Mathematics, Science, and Technology (IJEMST), 11(1), 115-132. https://doi.org/10.46328/ijemst.2931

Sipahi, B., Yurtkoru, E. S., & Çinko, M. (2010). Data analysis with SPSS in social sciences (3rd Edition). Beta Basım Yayım Dağıtım.

Yıldız, K., Sipahioğlu, Ş., & Yılmaz, M. (2011). Environmental science and education. (2nd edition). Gündüz Education and Publishing.

"Cursinho Popular": The Importance of Extension Experience in the Academic Complement of Engineers

Danielle Gonçalves de Oliveira Prado
Universidade Tecnológica Federal do Paraná – campus Apucarana, Brazil
https://orcid.org/0000-0003-2802-6037

Julia Gonçalves Batista
Universidade Tecnológica Federal do Paraná – campus Apucarana, Brazil
https://orcid.org/0009-0006-6020-674X

Isabelle Gonçalves de Oliveira Prado
Universidade Federal de Viçosa, Brazil
https://orcid.org/0000-0003-4456-8303

Vinícius Mateus Silveira Martins
Colégio Evolução, Brazil
https://orcid.org/0009-0003-9184-2165

Abstract: In Brazil, there are countless studies that point to the devaluation of teaching, which is one of the main factors that makes many university students give up on choosing to work in this area. Through an extension project, engineering students had the opportunity to act as teachers and experience the classroom from a different angle. Cursinho Popular is an online project, with a wide reach at a national level and which offers some classes to solve questions that appear most frequently in the ENEM, the best-known exam in the country and the most used for admission to public universities. By facing the challenges of planning and taking on the role of classroom teacher, engineering students had the opportunity to overcome obstacles and develop confidence in their abilities. Furthermore, by interacting with students, they developed empathy, patience and improved communication, essential elements for their personal well-being. Living this experience made many students see teaching as a possible path to follow after training, thus contributing to the competitiveness and demand for this forgotten and victimized profession.

Keywords: teacher, extension project, engineer

Citation: Prado, D., Batista, J., Prado, I. & Martins, V. (2024). "Cursinho popular": the importance of extension experience in the academic complement of engineers. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024-- International Conference on Life Sciences, Engineering and Technology* (pp. 83-87), San Francisco, CA, USA. ISTES.

Introduction

In Brazil, there are countless studies that point to the devaluation of teaching, which is one of the main factors why many university students give up on choosing to work in this area. Dias and Nascimento (2020) discuss how teaching is socially valued and devalued, and how much these poles mix or move away from the evaluation of being and doing teaching, in the teacher's view, and conclude that this issue deserves psychological investigation. According to Oliveira, in Época (2014), what hinders academic appreciation is the classification of teachers as workers, giving the impression of a victimized, tired class, instead of being treated as professionals. This is not the only issue that keeps students away from pursuing this promising career. The salary and also the attraction of opportunities for easier and faster advancement in other businesses, such as engineering, are used as justification for choosing another profession. Gatti (2010) also states that the amount of cultural baggage carried by students and also the level of education of their parents can influence the choice of profession. Furthermore, with the sudden changes that the world has been experiencing, young people have increasingly sought different and unusual achievements. Teaching, in this case, becomes something predictable, a choice already known and experienced, however, from the other side of the situation: as a student, which does not always bring the best and most motivating memories.

For Alvarenga et. al (2012), there is an even bigger problem when it comes to the training of students from the public education network. This structure is permeated by some difficulties peculiar to the type of knowledge received, treating as one of the main factors the lack of motivation of teachers at work, due to low salaries. For Dias and Nascimento (2020), low remuneration, terrible working conditions and the unquestionable importance of continuing teacher training are added, as long as this also involves the problems of education and teaching work: making the teacher see himself as a real agent of change.

Bruns, in Época (2014), reports that there are three points for encouraging an academic career: The first is attraction, that is, attracting more talented and qualified students for the teaching profession to pedagogy faculties. The second is quality, that is, improving working conditions. And the third is incentive, that is, more motivated teachers. According to him, good supervision by directors, who cover responsibilities, makes professionals feel more valued and seek new tools to use in the classroom.

With the aim of encouraging UTFPR undergraduate students to become future teachers, this project presents an opportunity for them to experience a moment in front of a classroom, as a conductor of activities and also offers situations that bring them closer of a teacher's routine.

Method

The methodology for implementing Cursinho Popular was divided into two moments. The first consists of the production of teaching material to be used in the activities developed. And the second moment deals with the

application of the content.

To structure the first stage of the extension project, an in-depth analysis of the essential bases of the entrance exams was carried out, focusing on the National High School Exam (ENEM). Common areas of knowledge were observed, such as history, geography, Portuguese, mathematics, physics, biology and chemistry, as well as the specific bases of each area. Each subject was divided into topics and subtopics to facilitate student understanding. The first step was to identify the most frequent topics in previous tests, and then formulate detailed teaching plans on each subject, complemented by support material, lists of varied exercises, ranging from basic questions to more advanced ones. This provided students with comprehensive practice that was adaptable to their needs.

The second stage was planned with the aim of expanding the reach of the number of students, therefore, recorded classes were implemented, allowing free access to everyone, allowing students to review the content, helping to consolidate knowledge. Furthermore, the recordings also served as a resource for those who were unable to attend classes in real time, ensuring flexible access to the material. The project was designed to provide students with comprehensive preparation for university entrance exams, balancing depth of content with effective study strategies.

Several communication platforms, including Instagram, through the @digaaluno page, WhatsApp, Google Meet and email, were used. The main objective was to collaborate in the studies of those who were willing to learn through the educational resources offered, since, on our part, the teachers were ready to offer support completely free of charge. This was especially important for those who were facing financial hardship and were affected during the pandemic. This initiative aimed to make access to education easier for everyone by eliminating the financial barriers that prevented many from continuing their studies. By offering this support in an accessible way, it was possible to contribute to inclusive and accessible education for everyone interested in learning.

Classes were organized at night, allowing the majority of students and teachers in the project to participate. The Google Meet platform was chosen for the activities, offering an interactive and collaborative experience. Additionally, other learning tools were implemented using the Kahoot gaming platform, which allowed students to test their knowledge interactively after each content. During the sessions, monitors kept their microphones and cameras activated, encouraging students to do the same. This created a more welcoming environment and encouraged direct interaction between them. In addition to slide presentations, relevant videos were shared to enrich classes and provide more dynamic learning. Practical exercises, previously prepared, were discussed in detail, ensuring an in-depth understanding of the material presented.

All teaching materials and class recordings were centralized on the Google Classroom platform, ensuring that students could access the content at any time, facilitating their learning and review process. These strategies were adopted to create a practical and accessible educational environment.

Results

The majority of students who attended high school in a public school participated in the project, as can be seen in the image below. This points to the fact that the main objective of the project was respected, as it was possible to reach a population with low purchasing power and they had the opportunity to participate in activities free of charge and with quality education.

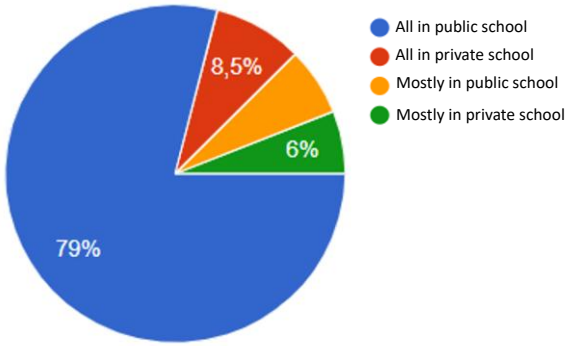


Figure 1. Percentage of students from public and private schools who participated in course activities

The progress and execution of this project has not only allowed university students to be practically involved in the design and delivery of lessons, taking responsibility for creating teaching materials to benefit students, but has also played a key role in the personal development of students. participants. The experience provided students with significant opportunities for individual growth, helping them improve their leadership, teamwork and problem-solving skills.

By facing challenges in planning and delivering classes, students had the chance to overcome obstacles and build confidence in their abilities. Furthermore, by interacting with students, they developed empathy, patience and interpersonal skills, all essential for personal development.

Conclusion

The project not only contributed to the well-being of the students receiving the education, but also enriched the lives of the participants, providing them with a deeper understanding of themselves as well as valuable skills that will be beneficial in their personal and professional lives.

Participating as a volunteer in this project was fundamental, allowing the contribution to the community, developing personal skills, and provided a feeling of purpose and fulfillment in making a difference in the lives of students.

Recommendations

In the coming years, it is possible to innovate and expand the impact of this project, taking into account its methodology. In addition to continuing to offer support for entrance exams. Activities can be diversified, including continuing education programs, professional courses and guidance for different careers. A personalized approach to learning using innovative educational technologies can create more engaging experiences for students.

Establishing academic partnerships and offering professional mentoring are also effective ways to enrich educational content. Furthermore, it is very important to continue with continuous evaluation systems by collecting feedback from students, contributing to adapting the project to real needs, ensuring that it continues to offer relevant educational support.

Acknowledgements

We thank the Federal Technological University of Paraná for all the support offered in the development of the project and also the “ Fundação Araucária” , which financed the idea through a scholarship for one of the project monitors.

References

Abreu Dias, M., & de Oliveira Nascimento, R. (2020). Autoestima do professor, satisfação/insatisfação profissional e valorização/desvalorização docente. *Perspectivas Em Diálogo: Revista De Educação E Sociedade*, *7*(15), 74-93. Recuperado de https://periodicos.ufms.br/index.php/persdia/article/view/9830

Amorim, Cloves; Kinoshita, Fernando. Reseña de" O ensino Universitário: seu cenário e seus protagonistas" de ZABALZA, Miguel A. Revista Diálogo Educacional, v. 4, n. 11, p. 1-5, 2004

Leite, Carlinda; Ramos, Kátia. Formação para a docência universitária: uma reflexão sobre o desafio de humanizar a cultura científica. Revista Portuguesa de Educação, v. 25, n. 1, p. 07-27, 2012.

Oliveira, Adriana Silva et al.. Descobrindo a docência através de uma experiência no cursinho popular 2019 – utfpr campus apucarana. Anais VII CONEDU - Edição Online... Campina Grande: Realize Editora, 2020. Disponível em: https://editorarealize.com.br/index.php/artigo/visualizar/68307. Acesso em: 15 ago. 2022

Pires, Marla Moniely de Sousa. Trabalho docente e desvalorização do profissional da educação no brasil. 2021.

An Empirical Evaluation of Content Specific Keyboard Layout Design for Smart TV Applications

Yavuz Keceli
College of Business, Alfred University, USA, https://orcid.org/0000-0002-8981-8217

Alexandra L. Evans
College of Business, Alfred University, USA, https://orcid.org/0009-0007-5385-1385

Abstract: This research aims to evaluate a proposed optimum keyboard layout for video streaming applications designed for smart TVs where users need to use the arrow buttons on their remote controls to type the title of the movie or the TV show they are searching for. In a previous research, the proposed layout was developed by analyzing the frequency of letter sequences in 9 million movie and TV show titles from the Internet Movie Database (IMDB) website and used genetic algorithms to determine the optimum keyboard layout that would minimize the total number of clicks required to type the title using arrow buttons on a remote control. Although the proposed layout is proven to require fewer number of clicks, it did not ensure to require less time to type as the users were not familiar with the new layout. Therefore, this research aims the test the new keyboard layout in an experiment in which volunteer participants were asked to type randomly given movie titles using multiple layouts with mockup keyboards, and actual number of clicks and time elapsed were recorded. The results indicate that although the proposed keyboard layout required fewer number of clicks, the time elapsed was not significantly increased. On the other hand, when users were asked to type three different movie titles, the time required to type those movie titles was reduced as the users get accustomed to the new layout.

Keywords: smart TVs, keyboard design, empirical testing

Citation: Keceli, Y. & Evans, A. L. (2024). An Empirical Evaluation of Content Specific Keyboard Layout Design for Smart TV Applications. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024--International Conference on Life Sciences, Engineering and Technology* (pp. 88-98), San Francisco, CA, USA. ISTES.

Introduction

In the last decade, there has been an addition of hundreds of new streaming services and other places to watch your favorite TV shows, movies, or content creators. These services include the big names used in most households, such as Netflix, Disney+, YouTube and YouTube TV, Amazon Prime Video, Hulu, or HBO Max, as well as smaller streaming services, such as FuboTV, Peacock, and FloSports. Among these are also those

used by content creators, such as Twitch TV. What these services have in common is that you can watch most of your favorite programs with ads for free, or for a small monthly fee, which most users go for. These services have brought about more people using solely streaming services, and abandoning cable TV (Tefertiller , 2018). The switch from cable to streaming has changed the way people search for their programs, they used to just scroll through the guide, or type in a channel number, now the search whole movie and TV show titles. The content available from these platforms is accessible across a range of gadgets, including computers, smartphones, tablets, and smart TVs. While devices like computers, smartphones, and tablets offer convenient physical or touchpad keyboards, smart TV users typically rely on their remote control's arrow buttons for typing, which makes it more difficult for smart TV users to search and browse content, which was already a difficult task due to the sheer amount of digital content offered on these platforms (Jan, et al., 2022).

For this reason, Keceli and Wilson (2024) study proposed an optimized keyboard layout for smart TV users to minimize the number of clicks when a movie or TV show title is to be typed using the arrow buttons on a typical smart TV remote control. The research analyzed the letter sequences in movie and TV show titles listed in IMDb (www.imdb.com), and used genetic algorithms to propose a keyboard layout to minimize the number of clicks. The paper also tested the proposed layout with several keyboard layouts used in popular video streaming apps using an algorithm, and found out that theoretically the proposed layout requires less clicks to type the movies in IMDb Top 100 List, but did not test it on actual users to determine whether it requires less time to type since the actual users will not be familiar with the new layout.

Based on Keceli and Wilson (2024) study, this research aims to test the proposed keyboard layout on actual users by using a controlled experiment. We created an application with three mockup keyboards and asked volunteer participants to type randomly selected movie titles from IMDb Top 100 List, using only the arrow keys as if they were typing on a TV remote control. The application automatically recorded the time elapsed and actual number of clicks during the experiment. The results are evaluated using paired sample t-test for each participant to test for statistical significance.

Theoretical Background

Literature Survey for Keyboard Layout Design

Several researchers studied the concept of keyboard layout design from different perspectives. For example, in Agpak (2016) study, a layout for a two-finger keyboard in the Turkish language for virtual devices was created. The main purpose of the study was to minimize the total finger movement. With the use of a generic algorithm, and a distance matrix, which finds the frequency of letters and the distance between keys.

In a similar study, Hosny, et al. (2014) aimed to optimize the layout of a single finger Arabic Keyboard, with the goal of improving accuracy, comfort, and speed. To minimize the difference between frequently occurring sets of letters a simulated annealing algorithm was used. Using Fitts law, the new layout was evaluated for

effectiveness based on the speed of typing. Arabic language has more letters than the American alphabet, so in this layout some letters share a key and there is no shift key. Similarly, Kazem and Naghsh (2011) used evolutionary strategy to optimize a Persian keyboard by coding chromosomes to find potential solution, as well as using a fitness function that shows the typing time between different sets of letters for each layout. The optimal keyboard created had the top ten commonly used letters in the center and the least used letters towards the edges.

Onsorodi and Korhan (2020) tried to optimize an English language keyboard layout, aiming to minimize the total distance one's finger needs to travel between keys. Using three thousand most commonly used word in the English dictionary, and analyst found the most frequent and commonly paired letters. This results in the most commonly used letters centered in the keyboard with frequently paired letters next to one another. Similarly, in the study by Pardeepmon et al. (2018) a better layout for single finger keyboard that will promote swift typing was created. The first part of the experiment was developing algorithms as well as frequencies of the English alphabet were computed to discover the layout that requires the least finger movement. Then, two keyboard layouts were created and tested with already exciting keyboards like QWERTY, on young kids who were unfamiliar with any keyboard to avoid a bias.

Janthanasub and Meesad (2015) attempted to create a new arrangement of Thai characters to optimize single finger typing. With their optimal keyboard it was discovered that on average it could produce 41 words per minute. What makes this research unique is that the Thai language is very complex with multiple vowels, tone markers, and punctuation required.

In a 2011 research by Perrinet, aims to find the most efficient keyboard design for text in Spanish. Analyzing the four following keyboards: QWERTY, alphabetical, genetic, and mobile phone keyboards, to find the minimum number of keystrokes used. It was found that the genetic keyboard used the smallest number of keystrokes, while the QWERTY keyboard took the most strokes.

The goal of Samanta, et al. (2013) study is to optimize key arrangements for minimum eye movement and mouse movement for Indian languages which has a large character set, more complex characters, and inflexions, in comparison to the English language. This study created a new keyboard called iLiPi where frequently used letters were placed in the center. The keyboard follows a rectangular layout to accommodate inflection characters and uses a covering window approach. This study followed both user evaluation and a model-based evaluation which included read and type, listen and type, and type freely experiments.

Li, et al. (2006) aim to create a keyboard design for single pointer applicants to minimize movement time according to Fitts law using character transition frequency, meaning keys with high frequent transitions from each other were put close together on the keyboard.

Finally, the study of Najjar, et al. (2021) tries to optimize Arabic keyboard for mobile devices using simulated

annealing algorithm based on movement time and character transition frequency. Characters with a high frequency transition were positioned close to each other. The proposed layout was tested using 12 participants and it outperformed the currently used layouts.

Although all of these studies cited above have different purposes, contexts, and methods, they all follow a similar approach to keyboard layout design, i.e. analyzing letter frequencies and placing most frequently used letters closer to each other.

The Proposed Layout by Keceli and Wilson (2024)

Keceli and Wilson (2024) developed an optimal keyboard for streaming applications for smart TVs where the users need to type movie or TV show titles using the arrow keys on a remote control. In this study, all the movie and TV show titles listed in the IMDb database were accessed, all spaces, numbers, punctuation marks, special characters, non-English characters were removed, and all the TV show episodes titled only with the episode number were eliminated. The remaining titles were used to create a frequency matrix for letter pairings. This frequency matrix shows how many times a letter is followed by another letter in a movie or TV show title. Then, a calculation function was defined to find the number of clicks necessary to reach from any letter to any letter by only using the arrow buttons on a remote control in a 6 by 5 keyboard layout. This would be the rectilinear distance between the letters in any given layout. The final step being to create a generate alternative keyboard layout to minimize the number of clicks used. Using a 6 by 5 layout ensures that the number of rows and columns are equal from the start (upper left corner). Finally, the evaluation function computes the sum of products obtained by multiplying distance values between letters with their corresponding frequency values. The study used genetic algorithms to generate different random permutations of letters in the alphabet and arrange them in a 6 by 5 layout, and to find which permutation would yield the minimum sum of products calculated by the evaluation function. Figure 1 shows the final layout proposed by the study.

J	B	M	D	Y
F	O	A	R	L
K	N	I	E	P
U	C	T	S	V
Z	G	H	W	X
Q				

Figure 1. The Optimum Keyboard Layout Proposed by Keceli and Wilson (2024)

The proposed keyboard layout was compared against other frequently used layouts in smart TV streaming applications. Five keyboard layouts were compared using the IMDb Top 100 list, tallying the clicks needed to spell each movie title from the top left corner. Only arrow button clicks on the remote were tallied, while clicks

on the "OK" button was disregarded, as they remained constant across all layouts. The proposed keyboard layout proved superior in minimizing clicks for spelling out movie titles in 87 out of 100 tests, with 4 times. In the 13 instances where a different keyboard outperformed the proposed keyboard, the average difference in performance was only 3.54 clicks.

The research aims to create a keyboard layout tailored for smart TV streaming apps, reducing the clicks needed to spell out movie or TV show titles. Additionally, while the layout is initially designed using the IMDb database, it can be adapted to specific streaming service content and updated dynamically as the available shows change. The primary limitation of this research is its focus solely on the number of clicks required by the proposed keyboard layout without confirming if it translates to reduced typing time. While existing literature discusses aspects like learning new layouts and user preference for familiar ones, these factors were not tested in the smart TV environment. Further research is warranted to assess if the proposed layout enhances typing speed and reduces both clicks and time, necessitating user testing for validation.

The Difference Between Keceli and Wilson (2024) Study and the Current Study

Although this research relies heavily on the findings of Keceli and Wilson (2024) study, it has two major differences.

1. Keceli and Wilson (2024) study was purely theoretical. All the analysis, design, and testing tasks were conducted using computer algorithms. This study aims to test the proposed keyboard's performance on actual human users.
2. Keceli and Wilson (2024) study used "theoretical number of clicks" required to type a movie title using the arrow buttons on a remote control to evaluate the performance of the proposed layout, ignoring any imperfections of the users. Since the users are not familiar with the new layout, there may be some unnecessary clicks when the users are searching for a letter. This research counts the "actual number of clicks" of the users during the typing process.
3. Keceli and Wilson (2024) study solely focused on the number of clicks while ignoring the time required to type a movie or TV show title. Since the users are not familiar with the new layout, requiring fewer clicks may not mean requiring less time to type. This research records the total duration of typing as well as the actual number of clicks.

Experiment Design

We created a user-friendly application using Visual Basic for Applications (VBA) for MS Excel to run the experiments. The MS Excel file contains a list of IMDb Top 100 movies, and records the experiment data for each participant. This experiment was open to college aged students, where it was supervised by a mediator. To ensure the data was clean if the participant became distracted the monitor would restart the experiment.
The experiment consists of two parts. In the first one, the application randomly chooses a movie title from the

list and the participants were asked to type the same movie title with three different keyboard layouts, using only the arrow keys of the keyboard and the space key for confirmation, as shown in Figure 2. In this experiment, Keyboard 1 refers to a 6 by 5 keyboard layout in alphabetical order, Keyboard 2 refers to standard QWERTY layout, and Keyboard 3 refers to the keyboard layout proposed by Keceli and Wilson (2024) study.

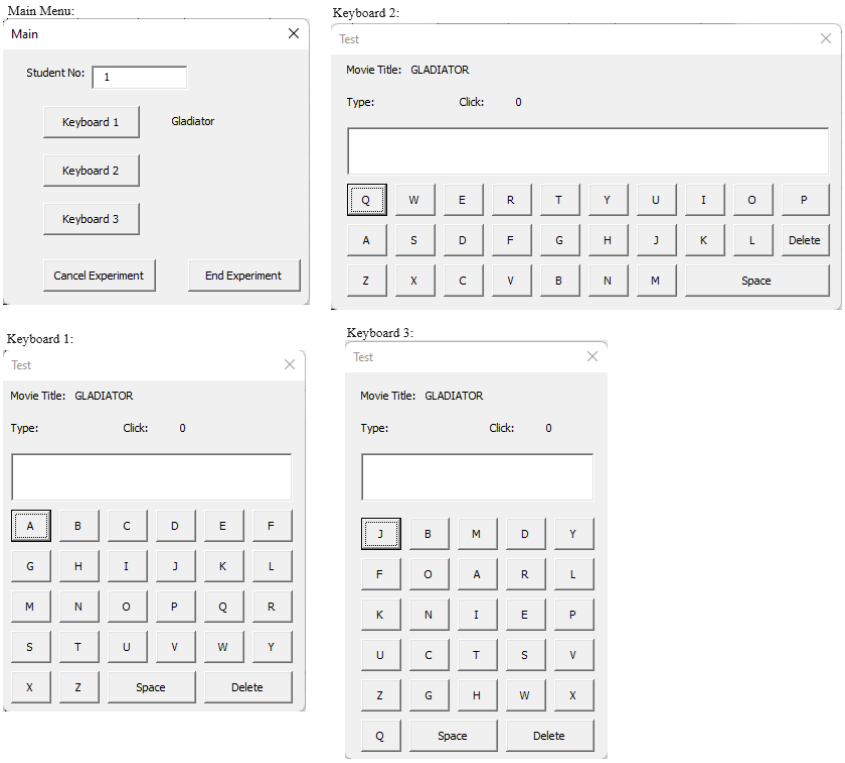


Figure 2. User Interfaces for the First Experiment

In the second part, the application randomly selects three movie titles, and the participants were asked to type them with only the proposed keyboard layout, i.e. Keyboard 3. Figure 3 shows the user interfaces for the second experiment. All the data is automatically recorded and save in the same MS Excel file simultaneously with the experiment.

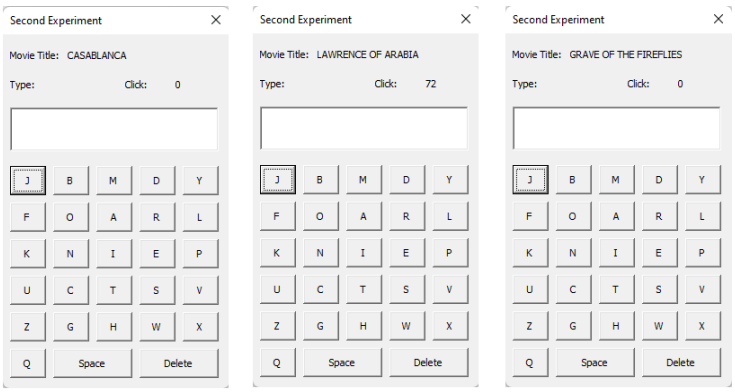


Figure 3. User Interfaces for the Second Experiment

Experiment Results

Table 1 shows the results of the first experiment, in which the participants were asked to type the same movie title using different keyboard layouts.

Table 1. Results of Experiment 1: Same Title, Different Keyboard Layouts

	Keyboard 1		Keyboard 2		Keyboard 3	
Participant	Duration (sec)	Number of Clicks	Duration (sec)	Number of Clicks	Duration (sec)	Number of Clicks
1	33	79	32	86	27	69
2	38	85	30	81	36	62
3	26	66	25	76	25	67
4	31	36	21	48	24	26
5	7	18	9	32	7	14
6	26	86	22	86	17	56
7	50	108	28	97	25	82
8	40	103	68	211	38	72
9	24	30	16	37	16	27
10	47	91	41	104	42	70
11	49	110	29	84	41	99
12	30	70	27	73	27	65
13	42	66	20	71	34	73
14	37	121	31	120	31	102
15	32	72	49	125	43	92
16	53	87	40	87	40	77
17	45	84	36	87	46	79
18	33	67	29	72	29	60
19	16	35	16	40	20	40
20	15	29	22	54	16	26
21	34	73	26	66	60	86
22	40	60	33	88	35	57
23	21	33	16	34	26	39
24	39	69	35	93	31	63
25	10	30	7	20	13	20
26	18	42	15	57	15	50
27	23	61	22	62	18	40
28	34	59	24	53	24	56
29	37	66	21	48	60	60
30	21	45	17	52	17	42

We conducted paired sample t-test to check if the differences in duration and the number of clicks between Keyboard 3 and other two keyboards are statistically significant. Table 2 summarizes the results of the paired sample t-tests.

The results indicate that the proposed optimum keyboard layout significantly reduces actual number of clicks required to type a movie title, however the time required to type is not significantly increased, compared to other two keyboard layouts the participants are familiar with.

Table 2. Paired Sample t-test Results of Experiment 1: Same Title, Different Keyboard Layouts

	Duration (sec)				Number of clicks			
Keyboard	Keyboard 1	Keyboard 3	Keyboard 2	Keyboard 3	Keyboard 1	Keyboard 3	Keyboard 2	Keyboard 3
Mean	31.700	29.433	26.900	29.433	66.033	59.033	74.800	59.033
Variance	142.493	168.875	148.645	168.875	719.551	534.309	1318.097	534.309
Observations	30	30	30	30	30	30	30	30
Pearson Correlation	0.702		0.546		0.891		0.659	
Hypothesized Mean Difference	0		0		0		0	
Degrees of Freedom	29		29		29		29	
t Statistic	1.284		-1.154		3.136		3.160	
P(T<=t) one-tail	***0.105***		***0.129***		***0.002***		***0.002***	
t Critical one-tail	1.699		1.699		1.699		1.699	
P(T<=t) two-tail	0.209		0.258		0.004		0.004	
t Critical two-tail	2.045		2.045		2.045		2.045	

The second experiment was conducted to check if the participants get familiar with the new keyboard layout after several exposures. In this experiment, we asked the users to type different random movie titles three times using Keyboard 3 only. Since the length of the title was different in each attempt, we evaluated the typing duration by seconds per character. Table 3 summarized the experiment results.

Table 3. Results of Experiment 2: Different Titles, Same Keyboard Layout

	Typing duration (seconds per character)		
Participant	First title	Second title	Third title
1	2.35	1.43	1.69
2	2.07	1.83	1.62
3	3.83	2.30	2.64
4	3.13	3.00	2.42
5	2.43	2.04	1.72
6	1.89	1.56	1.60
7	3.29	1.83	1.33
8	3.37	3.12	4.50
9	2.18	2.17	1.83
10	2.20	2.64	2.60
11	2.29	2.64	1.67
12	2.50	2.00	2.29
13	1.83	2.05	1.40
14	1.67	1.39	1.62
15	2.76	2.70	1.78
16	3.58	3.00	1.80
17	2.83	2.72	3.00
18	1.69	2.00	2.00

Participant	Typing duration (seconds per character) First title	Second title	Third title
19	2.78	1.96	1.63
20	2.78	3.00	2.00
21	3.00	3.10	3.90
22	3.17	2.96	2.08
23	2.69	2.29	2.90
24	2.65	2.33	2.11
25	1.12	1.29	1.62
26	1.50	1.29	1.70
27	1.88	1.69	2.04
28	2.44	2.89	2.27
29	5.81	3.13	3.75
30	1.38	1.59	1.39

To check the statistical significance of the results, we conducted paired sample t-tests for each trial, and the results are summarized in Table 4.

The results indicate that the typing becomes significantly faster from the first trial to the second trial as participants get familiar with the new layout as they use. But the typing speed does not change significantly from the second trial to the third one, which indicates that the users reach a limit and cannot type faster as they get more experience with the new keyboard. However, the difference between the first trial and the third trial remains significant. Based on these results, we can conclude that the users can get familiar with a new keyboard layout within a few trials.

Table 4. Paired Sample t-test Results of Experiment 2: Different Titles, Same Keyboard Layout

Trial	First trial	Second Trial	Second Trial	Third Trial	First Trial	Third Trial
Mean	2.570	2.264	2.264	2.163	2.570	2.163
Variance	0.820	0.370	0.370	0.602	0.820	0.602
Observations	30	30	30	30	30	30
Pearson Correlation	0.684		0.639		0.587	
Hypothesized Mean Difference	0		0		0	
Degrees of Freedom	29		29		29	
t Statistic	2.539		0.905		2.881	
P(T<=t) one-tail	***0.008***		***0.187***		***0.004***	
t Critical one-tail	1.699		1.699		1.699	
P(T<=t) two-tail	0.017		0.373		0.007	
t Critical two-tail	2.045		2.045		2.045	

Conclusion

This study aims to prove the usability of the optimum keyboard layout for smart TV applications proposed in

Keceli and Wilson (2024) paper through a series of experiments. We created a application program using Visual Basic for Applications (VBA) for MS Excel, which randomly selects movie titles from IMBD Top 100 list, and automatically records durations and number of clicks when volunteer participants were typing there movie titles on mockup keyboards only using the arrow keys and the space key on their keyboards, as if they were typing with a remote control of a smart TV. The experiments were conducted in a supervised and controlled environment to ensure that the participants were not distracted, or the rules of the experiment were not violated. The experiment results indicate that the keyboard layout proposed in Keceli and Wilson (2024) study is assumed to be acceptable by users as it not only reduces the theoretical number of clicks but also actual number of clicks without increasing the typing time significantly. Besides, the typing speed tends to increase significantly as the user get used to the new layout. This contradicts with the study of Lee, et al. (2020) that claims that users rarely invest time in learning new layouts, and the study of Bi, Smith, & Zhai (2010) arguing that the users need to invest a few hours to get used to any keyboard layout other than standard QWERTY keyboard. On the other hand, these papers refer to keyboards where each key can be accessed directly. On the other hand, our research indicates that when it comes to using a keyboard layout only though arrow keys of a remote control, the users get used to the new layout quickly, and their speed of typing starts to increase even in the second try.

The main limitation of this research is that it was tested only on college students. Therefore, the potential differences in the acceptance of the new layout according to the subject's age could not be determined, as indicated in Chiobanu (2014). Therefore, we believe more extensive research is necessary to test the proposed layout across various demographics.

Notes

This research is supported by Alfred University's Bernstein Funds for Student and Faculty Development, and Shaner College of Business Support Fund, therefore, the authors would like to thank the Bernstein Family and Lance T. Shaner for their generous contributions.

References

Agpak, K., Karateke, H. & Mete, S., 2016. Two-Finger Keyboard Layout Problem: An Application On Turkish Language. *arXiv*.

Bi, X., Smith, B. A., & Zhai, S. (2010). Quasi-Qwerty Soft Keyboard Optimization. *Proceedings of the 28th International Conference on Human Factors in Computing Systems, CHI 2010*, (pp. 283-286). Atlanta, Georgia, USA. doi:https://doi.org/10.1145/1753326.1753367

Hosny, M. I., Alswaidan, N. & Najjar, A. B., 2014. *An optimized single-finger Arabic keyboard layout.* London, UK, IEEE, pp. 321-328.

Jan, M., Khusro, S., Alam, I., Khan, I. & Niazi, B. (2022) Interest-Based Content Clustering for Enhancing Searching and Recommendations on Smart TV. Wireless Communications and Mobile Computing,

2022, Article ID: 3896840.

Janthanasub, V. & Meesad, P., 2015. Improving the Evolutionary Computation for General Keyboard Arrangement Problem. In: *Applied Mechanics and Materials.* s.l.:Trans Tech Publications, Ltd., p. 337– 340.

Kazem, A. A. P. & Naghsh, K. N., 2011. *Attaining a suitable Persian keyboard layout using an Evolutionary Strategy.* Hong Kong, s.n., pp. 451-454.

Keceli, Y. & Wilson, A. (2024) Content specific keyboard layout design for smart TV applications. *International Journal on Engineering, Science, and Technology (IJonEST)*, 6(1), 40-54. https://doi.org/10.46328/ijonest.191

Lee, L. H., Braud, T., Lam, K. Y., Yau, Y. P., & Hui, P. (2020). From seen to unseen: Designing keyboard-less interfaces for text entry on the constrained screen real estate of Augmented Reality headsets. *Pervasive and Mobile Computing, 64*, 101148. doi:https://doi.org/10.1016/j.pmcj.2020.101148.

Onsorodi , A. H. H. & Korhan, O., 2020. Application of a genetic algorithm to the keyboard layout problem. *PLosONE*, p. e0226611.

Pradeepmon, T. G., Panicker, V. V. & Sridharan , R., 2018. Hybrid estimation of distribution algorithms for solving a keyboard layout problem. *Journal of Industrial and Production Engineering*, 35(6), pp. 352-367.

Perrinet, J. et al., 2011. Evaluation of Virtual Keyboards for Interactive Digital Television Applications. *International Journal of Human–Computer Interaction*, 27(8), pp. 703-728.

Samanta, D., Sarcar, S. & Ghosh, S., 2013. An Approach to Design Virtual Keyboards for Text Composition in Indian Languages. *International Journal of Human–Computer Interaction*, 29(8), pp. 516-540.

Tefertiller , A., 2018. Media Substitution in Cable Cord-Cutting: The Adoption of Web-Streaming Television. *Journal of Broadcasting & Electronic Media*, 62(3), pp. 390-407.

Implementing Virtual Reality for Immersive Learning about Heavy Machinery Operation

Jahnavi Balaji, Sri Divya Reddy Mettu, Dr. Temitope Olokunde, Prof. Dr. Brian Warren, Prof. Dr. Ratana Warren,Devender Rapolu, Dr. Opeyemi Ojajuni, Jaden Martin, Amaka Ojieh, Mussie Samuel, Sirisha Nallaguntahalli Byrareddy, Nikhilrao Pendyal, Dr. Michael Stubblefield, Deidre Street, Dr. Luria Young, Dr. Christopher Guillory

Southern University and A&M College, USA

Abstract: Virtual reality (VR) provides an immersive and interactive learning environment, allowing individuals to engage with content in a three-dimensional space. This immersive quality facilitates a deeper comprehension of intricate concepts by allowing learners to visualize abstract ideas and scenarios. ExxonMobil has initiated a training program in collaboration with local IT firms and Louisiana Economic Development. A virtual reality module has been created to train crane operators before transitioning to practical, on-site operations. Similarly, development for training crane operators can be extended to various other machinery. The research question is focused on how virtual reality facilitates academic/workforce training in diverse machinery while mitigating on-site risk factors. Implementing virtual reality modules that replicate the operation of different types of machinery, providing students with a realistic and interactive learning experience. This approach allows learners to familiarize themselves with the intricacies of operating diverse equipment in a controlled virtual environment before engaging with the physical counterparts. Implementing such immersive learning strategies enhances the practical skills of students across various disciplines, ensuring they are well-prepared for real-world applications and contributing to a more comprehensive and effective educational experience. This will ensure the preparation of a workforce capable of navigating today's virtual infrastructure. This research study discusses the process, guidelines and resources for implementing innovative workforce training and development using virtual reality.

Keywords: immersive learning, virtual reality, diverse machinery

Citation: Balaji, J., Mettu, S., Olokunde, T., Warren, B., Warren. R., Rapolu, D., Ojajuni, O., Martin, J., Ojieh, A., Samuel, M., Byrareddy, S., Pendyal, N., Stubblefield, M., Street, D., Young, L., Guillory, C. (2024). Implementing Virtual Reality for Immersive Learning about Heavy Machinery Operation. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024-- International Conference on Life Sciences, Engineering and Technology* (pp. 99-106), San Francisco, CA, USA. ISTES.

Introduction

In recent times, virtual reality (VR) has emerged as a powerful tool in education and professional training,

offering immersive learning environments that go beyond traditional methods. This technological advancement has the potential to transform how people learn and apply knowledge, particularly in fields where hands-on experience with complex machinery is crucial. ExxonMobil, in partnership with local IT companies and Louisiana Economic Development, has launched an innovative training program utilizing VR to prepare crane operators for their tasks on-site. This initiative represents a significant departure from conventional training approaches, as VR enables trainees to engage in realistic simulations of crane operation without actual risk.

This research study investigates the effectiveness of VR in educational and workforce training settings, specifically focusing on its application in various machinery operations. VR modules replicate the functions of diverse machinery within a controlled virtual environment, providing learners with the opportunity to become acquainted with equipment intricacies before undertaking physical tasks. Through interactive simulations, trainees can develop practical skills and deepen their understanding of machinery operations, ultimately leading to safer work practices and environments.

Furthermore, the study explores the broader implications of incorporating VR-based training across different fields, highlighting its potential to cultivate a highly skilled and adaptable workforce capable of navigating today's digital landscape. By immersing students in realistic learning experiences, educational institutions can bridge the gap between theoretical knowledge and practical application, resulting in a more comprehensive learning journey. By examining the process, guidelines, and resources necessary for implementing VR-based workforce training, this research aims to contribute to the advancement of innovative educational practices. Through the utilization of VR technology, educators and employers can unlock new avenues for experiential learning, empowering individuals to succeed in an increasingly dynamic and digitized world.

Method

Formation of Collaborative Partnerships:

Begin by forging partnerships among educational institutions, industry players like ExxonMobil, local IT firms, and economic development agencies such as Louisiana Economic Development. These collaborations facilitate the exchange of knowledge, resources, and insights crucial for implementing VR-based training programs successfully.

Needs Assessment and Curriculum Design:

Conduct a thorough needs assessment to identify specific training requirements and objectives for various machinery operations. This involves gathering input from industry experts, educators, and potential trainees to ensure alignment with real-world needs. Based on the assessment, develop a customized curriculum outlining learning objectives, content structure, and assessment criteria for VR training modules.

Development of VR Content:

Engage VR content developers and instructional designers to craft immersive and interactive training modules tailored to identified machinery operations. This process utilizes advanced simulation technologies, 3D modeling, and animation to replicate authentic equipment environments and scenarios. Implement feedback loops to continually refine the content for optimal learning outcomes.

Integration of Hardware and Software:

Procure and integrate necessary hardware and software components to deliver VR-based training experiences. This includes VR headsets, motion controllers, tracking systems, and computing infrastructure capable of supporting high-quality simulations. Ensure compatibility and usability across different VR platforms to maximize accessibility and scalability.

Pilot Testing and Evaluation:

Conduct pilot testing of VR training modules with a diverse group of trainees, ranging from novices to experienced operators, to evaluate usability, effectiveness, and engagement levels. Gather qualitative and quantitative feedback through surveys, interviews, and performance assessments to identify strengths, weaknesses, and areas for improvement. Use evaluation results to iteratively enhance content and instructional design.

Implementation and Deployment:

Roll out the VR training program across educational institutions, vocational training centers, and industry sites in collaboration with relevant stakeholders. Provide comprehensive training and support for instructors, facilitators, and technical personnel responsible for administering VR modules. Monitor usage metrics, learner progress, and performance outcomes to gauge the program's impact and effectiveness.

Continuous Improvement and Sustainability:

Establish mechanisms for ongoing evaluation, iteration, and continuous improvement of the VR training program. Foster a culture of innovation and collaboration among partners to adapt to changing technology trends, industry standards, and learner needs. Develop sustainable funding models and partnerships to ensure the long-term viability and scalability of VR-based workforce training initiatives.

CAVE and a Headset:

CAVE (Cave Automatic Virtual Environment):

A CAVE is a physical room-like space where virtual environments are projected onto multiple walls or screens surrounding the user. Users typically wear lightweight glasses or use tracked handheld devices to interact with the virtual environment. CAVE systems offer a shared immersive experience, allowing multiple users to interact within the same virtual environment simultaneously. CAVEs provide a large-scale immersive experience with a high degree of realism, making them suitable for applications such as scientific visualization, architectural design, and collaborative training simulations. Requires dedicated physical space and specialized projection equipment.

Headset (such as VR headsets like Oculus Rift, HTC Vive):

A headset is a wearable device that users wear over their eyes to enter virtual or augmented reality environments. Headsets typically include built-in displays, motion sensors, and audio systems to deliver immersive experiences. Headsets offer individual immersive experiences, allowing users to interact with virtual environments privately. Headsets come in various forms, including tethered (connected to a computer or console), standalone (self-contained), and mobile (paired with smartphones). Headsets are widely used for gaming, education, training, simulation, virtual tours, and other applications requiring immersive experiences. Offers flexibility in terms of mobility and accessibility, allowing users to experience virtual environments in different locations and settings.

CAVE(Cave Automatic Virtual Environment) and Challenges:
Presence and Immersion:

While immersion can enhance learning experiences, it can also be overwhelming for some learners, leading to distraction or disorientation.

Simulation Fidelity:

Ensuring that the virtual environment accurately represents the real world can be challenging. Inaccuracies or inconsistencies might hinder learning or even lead to misconceptions.

Hardware and Software Complexity:

CAVE environments often require specialized hardware and software, which can be costly to acquire, set up, and maintain. Technical issues such as system crashes or software glitches can disrupt learning sessions.

Navigation and Interaction:

Navigating and interacting within a virtual environment might not come naturally to all learners. Some may struggle with using the controls or understanding how to manipulate objects effectively.

Collaboration:

Collaborative learning in a virtual environment can be challenging, especially if learners are physically separated. Coordinating actions, communicating effectively, and maintaining engagement across different users can be difficult.

Motion Sickness:

Some individuals may experience motion sickness or discomfort when using VR technology for an extended period, which can detract from the learning experience.

Content Design:

Designing effective educational content for a virtual environment requires careful consideration of factors such as spatial layout, interaction design, and instructional strategies. Content must be engaging, informative, and conducive to learning within the virtual environment.

Accessibility:

Ensuring that the virtual environment is accessible to all learners, including those with disabilities, can be challenging. Designing for accessibility requires careful attention to factors such as user interface design, alternative modes of interaction, and compatibility with assistive technologies.

Learning Transfer:

Ensuring that knowledge and skills acquired in the virtual environment transfer effectively to real-world contexts can be challenging. Learners may struggle to apply what they've learned in the virtual environment to real-world situations without appropriate scaffolding and support.

Evaluation and Assessment:

Assessing learning outcomes in a virtual environment can be challenging. Traditional assessment methods may need to be adapted or supplemented to account for the unique features of the virtual environment and the types of learning experiences it enables.

Results

The presence of demonstrations featuring operational working models exemplifies the notable progress achieved

in risk mitigation through VR technology. These demonstrations vividly showcase how VR simulations furnish trainees with authentic and immersive environments, enabling them to participate in crane operations devoid of exposure to potential hazards. By providing hands-on experience within a meticulously controlled virtual environment, trainees can securely navigate intricate scenarios and refine their skills without endangering personnel or equipment. This concrete evidence underscores the efficacy of VR in augmenting safety protocols and reducing on-site risks inherent in conventional training approaches.

Authentic Simulations:

VR technology delivers highly realistic simulations of heavy machinery operation, accurately replicating the appearance, feel, and behavior of real equipment. This authenticity allows learners to interact with machinery in a virtual environment closely resembling real-world scenarios, facilitating deeper understanding and knowledge retention.

Hands-On Practice:

VR enables learners to gain practical experience with heavy machinery operation within a safe and controlled virtual environment. Through interaction with virtual equipment using motion controllers or similar devices, learners can practice operating machinery without the risk of injury or damage to physical equipment.

Engaging Interactivity:

VR environments are inherently interactive, encouraging active engagement with content rather than passive consumption. This interactive nature fosters greater motivation and engagement, leading to improved learning outcomes and better retention of information.

Multi-Sensory Learning:

VR engages multiple senses, including sight, sound, and sometimes touch, to create a multi-sensory learning experience. By appealing to different senses simultaneously, VR enhances engagement and comprehension, making it easier for learners to grasp complex concepts.

Customization and Adaptability:

VR simulations can be tailored to meet the specific learning needs and preferences of individual learners. This flexibility allows educators to customize learning experiences to suit different skill levels, learning styles, and training objectives, ensuring that each learner receives personalized instruction.

Immediate Feedback:

VR simulations provide instant feedback to learners, allowing them to assess their performance in real-time. This feedback loop enables learners to identify areas for improvement and adjust their approach accordingly, facilitating more effective skill development and mastery of machinery operation techniques.

Risk-Free Learning:

Importantly, VR offers a risk-free learning environment for heavy machinery operation. Learners can make mistakes and learn from them without fear of causing harm to themselves, others, or expensive equipment. This safety net encourages experimentation and exploration, nurturing a culture of continuous learning and improvement.

Conclusion

The integration of Virtual Reality (VR) technology into workforce training and education, particularly in heavy machinery operation, marks a significant advancement in learning methodologies. Through immersive simulations, realistic scenarios, and hands-on experiences, VR offers a transformative approach to skill development that enhances safety, engagement, and comprehension. By leveraging VR for immersive learning, individuals can acquire practical skills in heavy machinery operation within a controlled and risk-free environment. The ability to interact with virtual equipment, receive immediate feedback, and customize learning experiences ensures that learners are well-prepared for real-world applications. Moreover, VR facilitates collaboration between industry stakeholders, educational institutions, and technology providers, fostering innovation and knowledge sharing. This collaborative approach not only addresses workforce development needs but also drives advancements in training methodologies and technology adoption. As we look towards the future, the widespread adoption of VR-based training programs holds promise for cultivating a highly skilled and adaptable workforce capable of navigating today's virtual infrastructure. By embracing innovation and harnessing the power of VR, we can empower individuals with the practical skills and competencies needed to thrive in an ever-evolving technological landscape. Together, we can shape a future where immersive learning experiences drive continuous improvement, safety, and success across diverse industries and disciplines..

Recommendations

To maximize the effectiveness of VR-based training for heavy machinery operation, it's essential to invest in cutting-edge technology, establish collaborative partnerships, and emphasize continuous enhancement. Integrating VR modules into current curricula ensures a smooth skill-building process, while ensuring accessibility guarantees that training is accessible to all individuals. Supporting research efforts and raising awareness promotes ongoing innovation and acceptance. Through the implementation of these approaches,

organizations can develop a workforce that is not only safer but also more proficient in handling the complexities of modern heavy machinery.

Acknowledgements

We express our sincere appreciation to Southern University and A&M College for their indispensable assistance and provision of resources throughout the research phase of virtual reality content utilizing Reality Capture technology. Their expertise and guidance have played a pivotal role in navigating the intricacies of Reality Capture technology, enabling us to bring our vision of immersive content creation to fruition. Additionally, we extend our gratitude to all team members involved in the research for their unwavering dedication and valuable contributions. Together, we have reached noteworthy milestones in pushing the boundaries and exploring new applications of Reality Capture technology within the realm of virtual reality content development. This research under "Southern University Reaching Across the Digital Divide (SURADD)" is funded and supported by the US Department of Commerce, NTIA (National Telecommunications & Information Administration).

References

Cutini, M., Bisaglia, C., Brambilla, M., Bragaglio, A., Pallottino, F., Assirelli, A., ... & Menesatti, P. (2023). A Co-Simulation Virtual Reality Machinery Simulator for Advanced Precision Agriculture Applications. *Agriculture*, *13*(8), 1603.

Dado, M., Kotek, L., Hnilica, R., & Tůma, Z. (2018). The application of virtual reality for hazard identification training in the context of machinery safety: a preliminary study. *Manufacturing Technology*, *18*(5), 732-736.

Dickey, J. P., Eger, T. R., Frayne, R. J., Delgado, G. P., & Ji, X. (2013). Research using virtual reality: mobile machinery safety in the 21st century. *Minerals*, *3*(2), 145-164.

Ojajuni, O., Ismail, Y., Mellieon-Williams, F., & Lawson, A. (2023). Factors contributing to student experience in the Cave Automatic Virtual Environment (CAVE) for Computational Thinking (CT) development. In *Society for Information Technology & Teacher Education International Conference* (pp. 65-74). Association for the Advancement of Computing in Education (AACE).

Ojajuni, O., Ismail, Y., Mellieon-Williams, F., & Lawson, A. (2023). Investigating student and faculty attitudes and perceptions towards using Virtual Reality (VR) to improve Computational Thinking (CT) levels in Cybersecurity-Additive Manufacturing (CAM) training. In *Society for Information Technology & Teacher Education International Conference* (pp. 75-84). Association for the Advancement of Computing in Education (AACE).

Wu, Y. F., Zhang, Y., Shen, J. W., & Peng, T. (2013). The virtual reality applied in construction machinery industry. In *Virtual, Augmented and Mixed Reality. Systems and Applications: 5th International Conference, VAMR 2013, Held as Part of HCI International 2013, Las Vegas, NV, USA, July 21-26, 2013, Proceedings, Part II 5* (pp. 340-349). Springer Berlin Heidelberg.

Cave Automatic Virtual Environment (CAVE) and Unity Software

Ratana Prinyawiwatkul, Dr. Brian Warren, Dr. Temitope Olokunde, Dr. Devender Rapolu, Dr. Michael Stubblefield, Res. Asst. Deidre Street, Prof. Dr. Mathieu Kourouma

Southern University and A&M College, United States

Abstract: Virtual reality (VR) is a form of immersive technology that is gaining worldwide recognition as a practical way to enhance education and training. VR provides a simulated environment that allows users to explore and interact with the applications. Cave Automatic Virtual Environment (CAVE) is a virtual environment where the images are projected onto the walls and viewed by using transparent 3D glasses. CAVE facilitates collaborative learning through immersive experiences and helps students learn better than the traditional way or non-immersive 2D computers. There are some software being used to develop the applications for the CAVE. Unity is a game development software that can be used to create applications for 2D/3D interactive environments. Unity has grown to be an open-source gaming engine; however, developers can choose to buy and use the professional version as well. It is a full-featured cross-platform game software. Many assets created by other developers are available to be reused and many plugins like getReal3D are embedded inside the Unity project. At Southern University and A&M College, CAVE has been used to demonstrate VR models to middle school students, undergraduate students, faculty, and administrators as well. The development of unity models for use in the CAVE is in progress to support and improve student learning.

Keywords: CAVE, Unity, VR,

Citation: Prinyawiwatkul, R., Warren, B., Olokunde, T., Rapolu, D., Stubblefield, M., Street, D., & Kourouma, M. (2024). Cave automatic virtual environment (CAVE) and unity software. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024-- International Conference on Life Sciences, Engineering and Technology* (pp. 107-113), San Francisco, CA, USA. ISTES.

Introduction

In contrast to conventional resources like textbooks, learners may access and project educational content around them by using immersive virtual reality and related technology. Being virtual allows educational material to be presented in creative ways that may be advantageous to students because it is not limited by the rules of the real world. For instance, readers of textbooks might have trouble understanding a visually and spatially complicated topic like neuroanatomy because there is only a limited amount of 2D representations of anatomical structures available (Henn et al., 2002).

Virtual Reality Headsets

Immersion-based virtual reality learning settings, including those accessed through virtual reality headsets, are projected to enhance the advantages of non-immersive virtual environments for learning. Heeter (1992) and Steuer (1992) highlight existence as an example of this, which is the experience of being in a computer-generated setting. While utilizing standard 2D desktop monitors, participation may be limited; but, when employing virtual reality headsets, which completely submerge the user in the simulated content, presence is substantially increased. Research studies have shown that the use of virtual reality headsets was linked to improved learning outcomes in a ten-year virtual learning environment (Mikropoulos & Natsis, 2011). In addition to enabling users to view objects and surroundings in immersive 3D and at real size, immersive virtual reality with virtual reality headsets has been shown to improve spatial understanding.

Considering the limits of virtual reality headsets, it is maybe not surprising that there are not many studies on collaborative learning with them. Despite their apparent ability to facilitate collaboration, they lack the ability to recognize and communicate the kinds of facial expressions necessary for authentic real-time interpersonal communication.

Cave Automatic Virtual Environment (CAVE) Learning

CAVE is a virtual environment where the images are projected onto the walls and the users view these images by using transparent 3D glasses. Virtual Environments provide a fully immersive virtual reality experience. An immersive virtual reality environment is created for one or more people in a CAVE system using stereoscopic displays, motion-tracking technologies, and room-sized computer graphics. When a CAVE is in operation, the room is fully dark. Within the VR CAVE, three-dimensional (3D) visuals seem to float in space. The 3D glasses worn by the viewers are in sync with the CAVE sensors, allowing them to explore an image from every perspective. A tracking system is provided by sensors in the space to keep track of the viewer's location and accurately match the perspective.

CAVEs are perfectly positioned for interactive educational experiences in groups due to several features that they have. Since CAVEs allow users to observe their own bodies and that of others, as well as the virtual world concurrently, they eliminate the requirement for an avatar to represent the user because see-through glasses are used. By using CAVEs, on the other hand, groups of students can participate in collaboratively immersing themselves in educational virtual environments while maintaining their facial reactions and body language.

Overall, of the few published CAVE research, those that found advantages of CAVE circumstances over traditional learning techniques were the ones that reported these differences.

Figures 1 and Figure 2 below are the CAVE room at the College of Sciences and Engineering, Southern University and A&M College. There are six projectors as well as six walls.

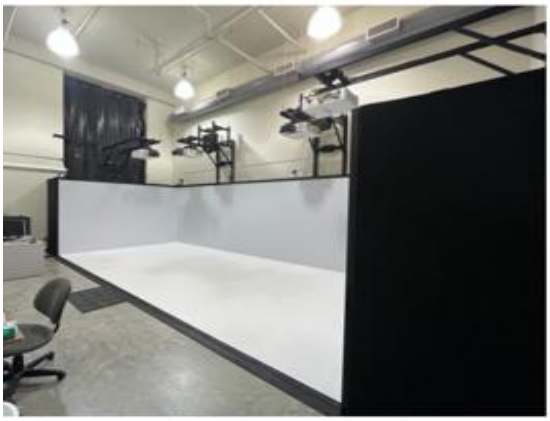


Figure 1. CAVE room (Left Side of the CAVE)

Figure 2. CAVE room (Middle of the CAVE)

Unity Software

Unity has grown to be an open-source gaming engine for creating virtual worlds (Marvin, 2018; Kuhn, 2014). It is a full-featured cross-platform game software for creating virtual reality (2D or 3D). When compared to some other 3D design programs, the content design interface is very user-friendly, and there is a comprehensive toolset for working with common 3D environment elements consisting of models, animated characters, particle effects, physics, and terrains. Unfortunately, there is some support available for using Unity3D on immersive projection-based virtual reality display devices, but it comes at an extra financial expense.

The technology that is being presented, called Uni-CAVE, modifies Unity3D to work with a variety of immersive display systems that are not head-mounted, such as tiled displays and CAVEs. Several stereo approaches, including side-by-side stereo, passive stereo, and OpenGL quad-buffered stereo, are supported by the Uni-CAVE plugin.

A Unity3D package called Uni-CAVE may be imported into an existing scene and includes several pre-configured immersive projection-based virtual reality display system settings as part of Unity3D prefabs. Unity C# scripts and assets are used to construct prefabs while using the plugin. Projection surfaces are built directly within the Unity3D editor to improve user-friendliness in the setting.

Many assets created by other developers are available to be reused and many plugins like getReal3D are embedded inside the Unity project. Asset stores have both free and commercial components to create any kind of gaming project. Unity provides many built-in packages and assets that are freely available and expand the engine's effectiveness. Unity software has been used to build interactive 3D models including VR. A viewer using virtual reality can get totally engaged in a virtual environment without having to interact with the real world.

With getReal3D for Unity, developers can build complex worlds with simplicity in the well-known game engine

and experience them in virtual reality (VR) environments like Head Mounted Displays (HMDs) and CAVEs. Users can experience their VR content in a life-sized setting with getReal3d's creation environment inside an extensive VR display. GetReal3D, when used with Unity, offers dynamic content that includes physics, animation, and excellent visual effects. Figures 3 and 4 below are the applications using Unity and getReal3D.

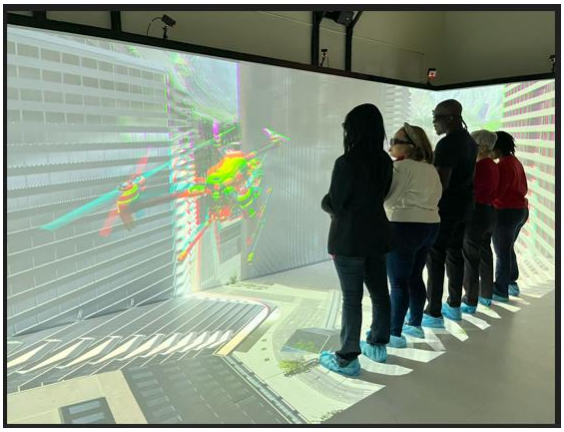


Figure 3. Drone Application

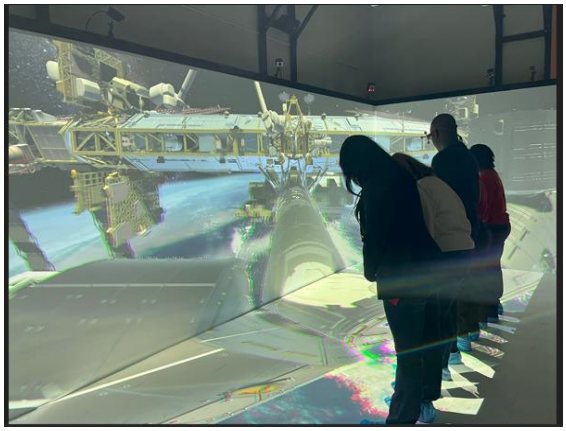


Figure 4. International Space Station (ISS)

A computer's ability to render graphics to the screen is not an easy task, and the way it does it can have a big impact on how well games run. Unity has several pre-configured render pipeline options that the developers can employ to move the game from scene to play screen. This gives developers the option to select the render pipeline that best fits their projects' graphics requirements. Furthermore, Unity provides the Scriptable Render Pipeline API, enabling developers to create their pipelines if they so choose. Also, a wide range of animation tools for both 2D and 3D visuals are available in Unity. Unity gives the option to animate the projects directly within the engine but also can import animations from other programs, like Blender.

CAVE System for Students' Perception and Behavioral Intention (BI) to Use VR Technology

CAVE can offer an extensive immersive and engaging virtual reality learning setting, which is designed for exploring visual educative materials and facilitating communication between professors and students. Applications in the fields of sciences, physics, engineering, and information technology have attracted the attention of students. When compared to students learning through presentations, those using the CAVE environment achieved higher learning outcomes, and most students had a favorable attitude toward technology and the immersive CAVE learning setting (Wang et al., 2024).

Behavioral Intention (BI)

According to Sniehotta (2005), behavioral intentions are motivational such as "desire", and to change these motivations into behavior, a voluntary process such as planning relating to behavioral intention implementation is needed.

Method

Experimental Setup

Fifty-four students participated in this experimental setup. SPSS Statistics was used to generate a group Statistics table containing descriptive statistics for two groups – "Female" and "Male". There were an equal number of participants in each of the gender groups: Female (27), and Male (27). Table 1 shows group statistics. Statistics for the dependent variable, behavioral intention, are displayed in each row of the table for the different independent variable categories which is gender. The male group's mean of behavioral intention (12.2963) is higher than the female group's mean of behavioral intention (11. 4815). The standard deviations of the female group and male group are 2.34 and 2.034 respectively; that is, females scored rather more widely than males.

Table 1. Group Statistics

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Intention to Use	Female	27	11.4815	2.34308	.45093
	Male	27	12.2963	2.03460	.39156

Table 2 shows the independent sample test results. For testing of equality of variances, Levene's test the null hypothesis, which is that the two samples are taken from populations with the same variance, or the population variances are identical. In Table 2, the significance value is ".452" (p = .452). This test will yield a p-value greater than 0.05 (p >.05) if the population variances of the two groups are equal, meaning that the homogeneity of variances assumption is satisfied. Table 2 also presents the observed "t" (t-value) column, the "df" (degrees of freedom) column, and the statistically significant. if p > 0.05, there is no statistically significant mean difference between the two groups. In this case, the p-value is .178. Consequently, it can be said that there is no statistically significant difference in the mean behavioral intention scores between males and females.

Table 2. Independent Samples Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Intention to Use	Equal variances assumed	.574	.452	-1.364	52	.178	-.81481	.59720	-2.01319	.38356
	Equal variances not assumed			-1.364	50.997	.178	-.81481	.59720	-2.01375	.38412

Results

The experiment setup showed that an independent-sample t-test was run to determine if there were differences in behavioral intention between males and females. The behavioral intention was higher for male students

(12.30 ± 2.03) than female students (11.48 ± 2.34), and there were no statistically significantly different mean behavioral intention scores between female and male groups.

Discussion

Immersion in virtual reality is becoming more and more recognized as a practical way to enhance education. Cave Automatic Virtual Environments, or CAVEs, are a potentially interesting option for colleges and universities looking for new ways to enhance student learning. CAVEs facilitate immersive learning in groups of learners. Applications for virtual environments utilizing the Cave Automatic Virtual Environment (CAVE) technology are varied and include scientific research, business training, medical, architectural, and military weaponry systems.

How can we teach complicated subjects effectively and efficiently in a way that motivates students? This answer is provided by the usage of immersive virtual reality. According to De Back et al. (2020), their study made use of a variety of CAVE advantages, such as gamification, deep spatial data, embodied engagement, and interactive learning. In comparison to a textbook condition, the results showed a much larger improvement in learning following collaborative learning in the CAVE, with significant impact sizes. Moreover, the powerful visuals offered by immersive virtual reality (CAVE) helped low spatial skills learners the most, improving their level of achievement to that of advanced spatial ability learners (De Back et al., 2020).

Conclusion

The CAVE immersive system is a major virtual reality system that offers excellent interactions and high immersion. CAVE is widely utilized in fields requiring high standards for space sense and visual effects, such as scientific study, training in simulations, and construction demonstration. It may integrate sound, touch, vision, and other senses. The virtual world in the CAVE immersion system must display several screen images simultaneously based on the configuration and number of projection displays. However, the current multiscreen display techniques are extremely complicated and even need extra-cost plugins. To resolve this issue, a Unity 3D-based approach for creating an immersive virtual environment for CAVE was required. This approach was incredibly easy to use and could quickly produce virtual reality apps that worked with different CAVE systems.

Notes

This paper was supported by the Southern University Reaching Across the Digital Divide (SURADD) project, which is funded by the US Department of Commerce, NTIA (National Telecommunications & Information Administration). To promote minority student understanding and accomplishment and to boost the number and quality of minority students, the SURADD proposes reforming the instructional approach in the fields of science, technology, engineering, [agriculture], and mathematics (STEM/STEAM).

References

De Back, T. T., Tinga, A. M., Nguyen, P., & Louwerse, M. M. (2020). Benefits of immersive collaborative learning in CAVE-based virtual reality. International Journal of Educational Technology in Higher Education, 17(1). https://doi.org/10.1186/s41239-020-00228-9

Heeter, C. (1992). Being there: the subjective experience of presence. Presence: Teleoperators & Virtual Environments, 1(2), 262–271. https://doi.org/10.1162/pres.1992.1.2.262

Henn, J. S., Lemole, G. M., Ferreira, M. a. T., Gonzalez, L. F., Schornak, M., Preul, M. C., & Spetzler, R. F. (2002). Interactive stereoscopic virtual reality: a new tool for neurosurgical education. Journal of Neurosurgery, 96(1), 144–149. https://doi.org/10.3171/jns.2002.96.1.0144

Kuhn, P. (2014). Calling all VR enthusiasts: target the Oculus Rift with Unity Free. PCMag. https://www.pcmag.com/news/how-unity-is-building-its-future-on-ar-vr-and-ai.

Laerd Statistics (2015). Statistical tutorials and software guides. Retrieved from https://statistics.laerd.com/

Marvin, R. (2018). How Unity Is Building its Future on AR, VR, and AI. PCMag. https://blog.unity.com/technology/calling-all-vr-enthusiasts-target-the-oculus-rift-with-unity-free.

Mikropoulos, T. A., & Natsis, A. (2011). Educational virtual environments: A ten-year review of empirical research (1999–2009). Computers & Education, 56(3), 769–780. https://doi.org/10.1016/j.compedu.2010.10.020

Sniehotta, F. F. (2009). Towards a theory of intentional behavior change: Plans, planning, and self-regulation. British Journal of Health Psychology, 14(2), 261–273. https://doi.org/10.1348/135910708x389042

Steuer, J. (1992). Defining virtual reality: dimensions determining telepresence. Journal of Communication, 42(4), 73–93. https://doi.org/10.1111/j.1460-2466.1992.tb00812.x

Wang, X. X., Chou, M., Lai, X., Tang, J., Chen, J., Kong, W., Chi, H., & Yam, M. C. (2024). Examining the Effects of an Immersive Learning Environment in Tertiary AEC Education: CAVE-VR System for students' perception and Technology Acceptance. Journal of Civil Engineering Education, 150(2). https://doi.org/10.1061/jceecd.eieng-1995

Designing Virtual Reality Learning Content Using the Unity Software Platform: A Reverse Engineering Approach

Mussie Samuel, Patrick Mensah, Brian Warren, Ratana Warren, Michael Stubblefield, Deidre Street, Temitope Olokunde, Opeyemei Ojajuni, Devender Rapolu, Sri Mettu, Jahnavi Balaji, Nikhilrao Pendyal, Amaka Ojieh, Sirisha Nallaguttahalli Byrareddy, Jaden Martin

Southern University Reaching Across the Digital Divide (SURADD) Project, Southern University and A&M College, 801 Harding Blvd, Baton Rouge, LA, USA

Abstract: Virtual reality (VR) has been a rapidly growing technology in the past decade, with more people having access to it with each passing year. VR has found its use in many fields, including for military, medical, and recreational purposes. This project focuses on the development of VR applications using the Unity engine to enhance delivery of various forms of education. In this project, VR applications were primarily developed for a cave automatic virtual environment (CAVE), using Mechdyne Corporation's "getReal3D" VR content development tool. Various demos showcasing the use of getreal3D and its interaction with the Unity engine were carefully examined and were used in tandem to "reverse engineer" simple & interactive VR applications to further the development pipeline for educational curriculums incorporating VR. An application was created using this method- an immersive simulation showing the properties of various objects, in which the user could interact with said objects. The application itself was very limited, mostly due to issues with certain assets, issues with the Unity Asset Store, and time constraints. Nonetheless, the application served as a foundation for developing VR learning content for use in a CAVE, using Unity. This project's results can inform educators, curriculum developers, and policymakers about the benefits and challenges associated with integrating VR into educational curriculums. By bridging the gap between technology and education, this project can contribute to the ongoing discussion on innovative approaches to education. The use of VR in classrooms can help teach abstract topics, create immersive learning environments, and foster a dynamic, technology-driven education for students of all ages.

Keywords: virtual reality, unity, 3D, reverse engineering

Citation: Samuel, M., Mensah, P., Warren, B., Warren, R., Stubblefield, M., Street, D., Olokunde, T., Ojajuni, O., Rapolu, D., Mettu, S., Balaji, J., Pendyal, N., Ojieh, A., Byrareddy, S. N., & Martin, J. (2024). Designing Virtual Reality Learning Content Using the Unity Software Platform: A Reverse Engineering Approach. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024-- International Conference on Life Sciences, Engineering and Technology* (pp. 114-118), San Francisco, CA, USA. ISTES.

Introduction

Virtual reality (VR) has, in recent years, seen significant improvements and advancements to the point of becoming easily accessible and available to the public in the form of VR headsets such as the Meta Quest, Valve Index, and HTC Vive. Though this recent boom in VR innovations has been geared more towards consumers for entertainment and video games purposes, these advancements laid the foundation for a more modernized approach to VR, which can also be applied to other areas, such as healthcare, construction/architecture, military, and especially education (Hamad & Jia, 2022).

VR excels and can exceed many traditional approaches to teaching and learning. For example, advanced or theoretical concepts can be taught using a VR approach, helping the student understand said concepts in a more immersive and interactive way. Hands-on learning without proper materials (i.e. doing a lab experiment without the materials) can be solved used a VR approach, and can be particularly helpful in institutions that may not have the means to provide disposable materials, as well as be helpful for the environment (School of Education, American University. 2019). However, it should be noted that VR technology should be used as a supplement to traditional education, as VR can never fully replace in-person human interaction and hands on experience. By combining the immersive capabilities of VR with the domain of education, students can transcend the physical barriers of learning and engage in interactive learning scenarios as a supplementary that creates a deeper understanding of many subject matter (Kennedy, 2018).

A computer automated virtual environment (CAVE) system is the VR headset's larger, room-scale relative. Rather than utilizing headsets, CAVE systems will often use special stereoscopic 3D glasses for multiple screens set up to create a room-sized projection. While CAVE systems offer a higher level of immersion and interaction, they also come with larger requirements for dedicated physical space and higher costs with both setup and maintenance. The choice between VR headsets and CAVE systems often depends on the specific use case, budget constraints, and level of collaboration. While VR headsets are more portable and cost-effective for individual experiences, CAVE systems excel in scenarios where both shared immersive experiences and large-scale interactions are desired. Like VR headsets, CAVE systems can still offer interactive educational experiences, though offered as a shared or collaborative experience. Geographical/construction studies, cultural immersion, medical & scientific training, special education, and virtual field trips are some of the things that can be made possible using CAVE systems.

Developing individual & small-team created software for CAVE systems had been long and challenging in the past, due to the novelty of these technologies, as well as their interactions with various hardware. However, due to developments and additions in CAVE-specific software, creating software for CAVE systems has been much easier. One of these developments, a toolkit for the Unity game engine, called "getReal3D" and developed by Mechdyne Corporation, alleviates the difficulties in creating an interactive VR program (Hamad & Jia, 2022, Ritter & Chambers, 2015). The focus of this paper is to understand getReal3D's interactions with Unity, and to

create a simple interactive program to be used in a CAVE system, using a “reverse engineering” approach.

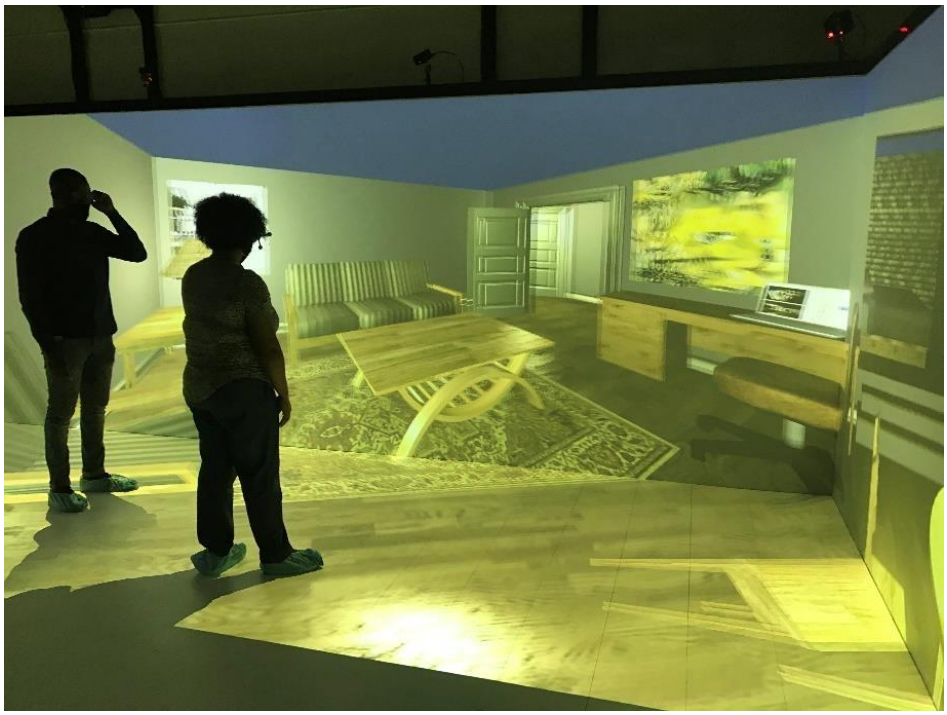


Figure 1. Southern University A&M’s CAVE system running a getReal3D demo in the P.B.S. Pinchback Engineering Building

Methods

Hardware with all of the required software as outlined in Mechdyne’s Developer Guide was used for initial ease of access (Mechdyne Corporation, 2015).

1. Unity Hub was launched, and a new 3D project was created under Unity Editor 2022.3.10f1.
2. After the Editor opened, getReal3D was imported by clicking the “Assets” tab → “Import Package” → “Custom Package” → (Path to getReal3D plugin) → “Open” → “Import”
    a. Correct Importation should result in a “getReal3D” tab added to the top of the Unity Editor
3. Using getReal3D’s built in demo assets, an extremely simple scene was created. Default Camera object was deleted.
4. getRealPlayerController.prefab (Generic Player) was dropped into the scene, along with WandManager.prefab under the “Hand” object of the former prefab.
5. trackd simulator was started to simulate VR controls.
6. The application was tested by pressing “Play” in the Unity Editor.
7. After successfully testing, getReal3D scripts, especially those related to the getRealPlayerController.prefab and WandManager.prefab, were analyzed.

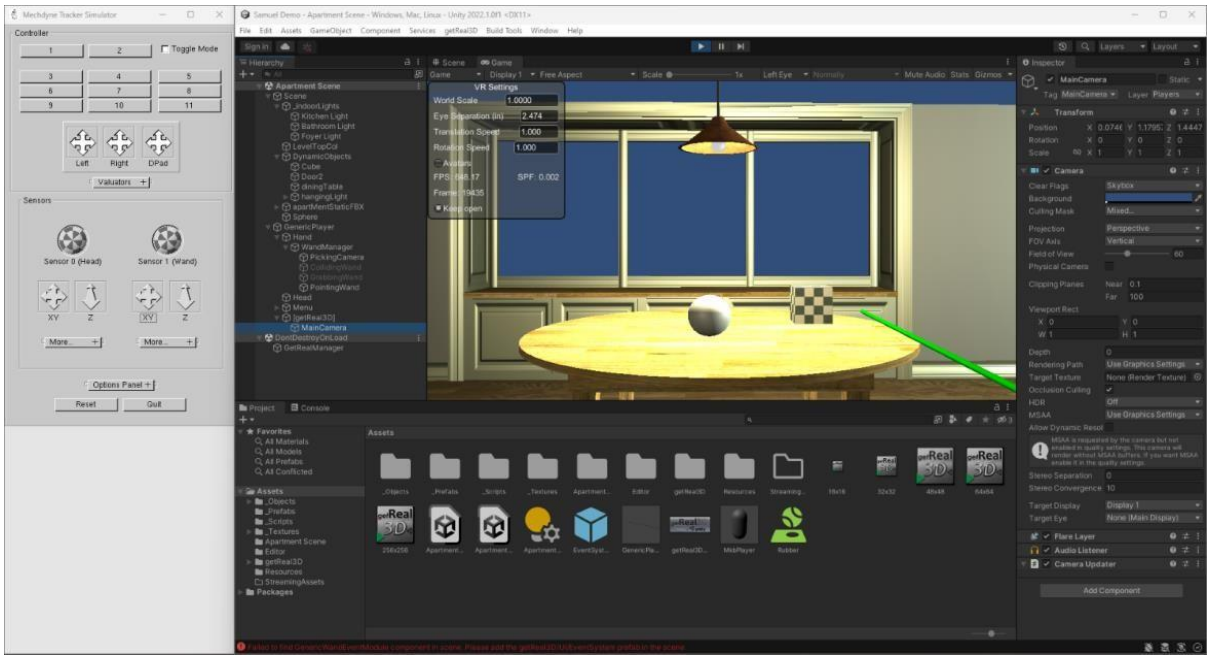


Figure 2. Completed scene showcasing the use of trackd to simulate getReal3D VR controls within the Unity Editor

.cs Scripts analyzed:

CharacterMotor, GenericNavigation, GenericHeadUpdater, GenericWandUpdater, GenericGrabbingWand, getRealExit, GenericPlayer_Hand_WandManager_PickingCamera, getReal3DPlayerInputs, getRealCameraUpdater

Conclusions

The getReal3D toolkit provides adequate tools to potentially create a rich educational VR interactive application. Though the scene created in this paper was simple, with the creation and/or implementation of more relatable assets can again prove to be very useful in creating an educational application. The scripts provided in getRealPlayerController.prefab and WandManager.prefab make it extremely straightforward in creating an application for walking around a scene and interacting with objects thanks to its Raycasting-like wand (Unity Technologies, 2024). However, in order to create more complex VR applications surpassing simple walking and object interactions, modification to these scripts, as well as creation of additional scripts, are required. Nonetheless, getReal3D supports quick and simple “drag and dropping” of prefabs to create simple VR interaction programs.

Notes

This study is funded by the National Telecommunications and Information Administration (NTIA).

References

Hamad, A., & Jia, B. (2022). How Virtual Reality Technology Has Changed Our Lives: An Overview of the Current and Potential Applications and Limitations. *International Journal of Environmental Research and Public Health*.

Kennedy, E. (2018, November 1). [CNN Health]. Retrieved from https://www.cnn.com/2018/11/01/health/virtual-reality-education/index.html

Mechdyne Corporation. (2015, April). getReal3D for Unity3D Developer Guide. Retrieved from https://webs.cs.fiu.edu/wp-content/docs/icave/DeveloperGuide.html

Ritter, K., & Chambers, T. (2015). Overview and Assessment of Unity Toolkits for Rapid Development of an Educational VR Application. *International Journal for Innovation Education and Research*, Vols. 3-7.

School of Education, American University. (2019, December 16). Virtual Reality in Education: Benefits, Tools, and Resources. Retrieved from https://soeonline.american.edu/blog/benefits-ofvirtual-reality-in-education/

Unity Technologies. (2024). Unity Documentation. Retrieved from https://docs.unity3d.com/ScriptReference/Physics.Raycast.html

Cybersecurity: Implications of Side-Loading Applications on Mobile Devices

Robert Wahl
Concordia University Wisconsin, United States of America

Abstract: Apple iPhones have long instituted restrictions against the use of side loading applications onto devices. The reasons for these restrictions were to control the iPhone infrastructure and prevent dangerous applications from being installed on iPhones. Side loading is the process of being able to install applications from a third-party source rather than the manufacturer of the equipment. These restrictions were recently challenged by the European Union under the Digital Markets Act (DMA). As a result of this ruling, Apple will now allow sideloading of applications only within the European Union starting with iOS release 17.4 which is scheduled to be released in early March 2024. As part of this research, I will incorporate articles from scholarly sources, focusing on the risks associated with sideloading applications and detail the cyber security concerns for both individuals and organizations with the goal of determining the impact on reducing the security restrictions on these devices.

Keywords: cybersecurity, iPhone, sideloading

Citation: Wahl, R. (2024). Cybersecurity: Implications of Side-Loading Applications on Mobile Devices. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024-- International Conference on Life Sciences, Engineering and Technology* (pp. 119-125), San Francisco, CA, USA. ISTES.

Introduction

Since 2007, with the debut of the Apple iPhone, society worldwide has benefited from the availability of low-cost computing devices that are extremely portable (Werthner , 2024). While many applications are preinstalled on these devices when they are manufactured, users have found that it is beneficial to be able to load additional software to customize their devices. The two major operating systems for smart phones are Apple's iOS and the Android operating system. The typical way that new applications are added to smart phones is to visit either Apples or Google's (Android) App Store.

Sideloading applications on smartphones is a technique where users can download and install applications on their devices through sources other than the vendor's online store. For example, a user might visit a webpage and download an application directly to their device. This technique has been blocked since the iPhone's inception because of potential security risks. Side-loading is allowed on smartphones running the Android operating system. Sideloading applications can lead to potential security risks is a potential attack vector

(Marorio, 2016). Users of Apple's iOS operating system needed to either jailbreak or root their devices in order to sideload applications which voids the warranty and opens up possible avenues of attack. This restriction against sideling applications on iOS is all changing because of new regulations in 2024 for users in some parts of the world. A further risk of rooting or jailbreaking an iOS device is the possibility that the device becomes unusable. In an additional risk to security, the Android operating system allows for applications to download additional code when applications are being run. In this way, an application that has been verified by the App Store can still download malicious code after the fact (Poeplau, et al., 2014). Android application security is further impacted by and users, failing to update their devices regularly, as well as, security flaws inherent in the Android software architecture (Zinkus, et al., 2021).

Background

Since the inception of the Apple iPhone in 2007, Apple Inc. has restricted the availability of software on its devices to software downloaded from the official Apple App Store. The stated reason for this restriction was to protect users from potentially bad applications and malware. The use of the App Store rest customers any availability of applications because there are no alternatives available (Angerhofer, et al., 2021). These restrictions are largely enforced through the use of proprietary technology. For providing the service and marketplace, Apple charges a 30% commission application developers (Angerhofer, et al., 2021). Other smart phone devices, such as those running the android operating system or the windows mobile operating system, allowed users to go to webpages to obtain software and download it to their devices. Apple's App Store has been called "the most important innovation platform to arise in the digital economy" (Bostoen, 2023, p. 263). Application stores, such as used by Apple, are designed to provide quality software products and help ensure the security of applications. A secondary function is to provide a good user experience (Cabral et al., 2021). Additionally, having a single App Store provides and users with a single point of contact to download any and all new applications, so the user benefits from having to only look in one location (Raymond, et al., 2022). One negative of having only a limited number of companies able to provide App Store environments is that the typical end user needs to fully entrust their security and personal privacy to these vendors (Groschupp, et al., 2021).

While side loading of applications has gone on since the first smartphones were developed and marketed, the term "side loading" increased in popularity the Pokémon Go application was released in phases in 2016 (Goodwin, et al., 2022). Since this application was wildly popular and received extensive media coverage, many people around the globe wanted to install the application in advance of its official release date in a particular country. This led to people discovering the possibilities of side loading applications onto their devices.

Without the availability to sideloading applications, as it is the case with Apple's devices, there is a possibility of conflicts of interest since the manufacturer is both a retailer of products and applications, and at the same time, controller of the marketplace. This could potentially lead to some applications from a competitor being

excluded from the app store (Wörsdörfer, 2023). If a competitive application is not excluded from the App Store, it could be impacted by receiving less advertising or being shown lower in search results.

The European Union's Digital Markets Act (DMA)

In the first half of 2024, individuals located within the EU countries will be allowed to use third-party vendors to load applications onto their smart phones. This is a major change for Apple iPhones, which previously blocked the side loading of applications. This change is the result of a law called the digital markets act DMA, which was adopted by the European Union in September 2022. Note, that while similar bills to the DMA act have been proposed in the United States and other countries, they have not yet been enacted (Bostoen, 2023).

It is interesting to note that the DMA act was designed to both protect people from illegal content and malicious software and at the same time, to facilitate the advancement of software development for smart phones (Chiarella, 2022). While the European Union's Digital Market Act (DMA) is groundbreaking legislation. It only affects countries in the European Union and their members. There is a possibility that it is insufficient to "ensure complete device and platform neutrality" (Wörsdörfer, 2023, p. 4). A further goal of the DMA act was to restrict the economic power of these two large companies (Apple and Google), as well as, to limit monopolistic behavior (Chiarella, 2022).

Risks

Manufacturers of smart phones can experience risks by either maintaining a closed environment to side loading of applications or risks by opening their devices to allow side loading. In addition to the risk described below, the smart phone industry is a whole has displayed some reasons for security concerns as the manufacturing of products is tightly integrated with Chinese manufacturers (Ellis, et al., 2022). Among the many potential security issues with smart phones include problems with side loading, rooting, updated versions of the operating system and physical security through lost devices (Li, et al., 2017).

Risks of Remaining Closed

The main risk associated with maintaining the closed environment for smart phone updates is a potential loss of market share to other manufacturers that allows side loading of applications. The use of having a closed ecosystem risks alienating smartphone application developers by adding the 30% commission fee to application purchases. At the same time, developers benefit from being part of a centralized marketplace for new applications.

In addition to the restrictions placed on application, developers, the closed environment for iOS devices, adds to the complexity of doing forensics on these devices in several ways. In some cases, the iOS device needs to be jailbroken in order to do forensics work on a device but in doing so it actually alters the forensics evidence

(Bullock, et al. 2020). As a result of the closed iOS, environment, some forensic investigations need to result on iTunes backups. Forensics work is also hampered using AES–256 encryption on iPhones, which makes data recovery more difficult but does provide better protection for the owners of the devices (Bullock, et al. 2020). Companies that utilize a closed environment for applications act as gatekeepers to either allow or deny access to applications and in this way control what users can be presented (Cabral, et al., 2021).

The negative side of having gatekeeper organizations is that these organizations can require that software purchases use their own payment systems so the entire infrastructure is self-contained, owned, and managed by either Google or Apple (Groschupp, et al., 2021). This can also lead to more challenges for small companies and startup organizations to make an entrance into the marketplace for new software applications. The European Union DMA act was designed to help reduce some of these challenges for small companies and startups.

Because of the risks associated with maintaining closed environments, such as the Apple App Store, or Google Play, some governments and organizations are calling for more restrictive laws, governing these companies in an attempt to make the software development and marketing environments fair for all players in the industry and to eliminate with some see as anti-competitive conduct. In some cases, there have been even requests for new antitrust rules, and better enforcement of laws to deal with the potential unfair advantages given to these gatekeeper organizations (Cowls, et al., 2023). These requests have been met with a pushback from Google and Apple resisting attempts to form new laws to eliminate these inherent advantages for owners of the online stores over third-party application, developers (Ellis, et al., 2022).

While all of the above-mentioned risks do exist, there are some potential benefits from maintaining a closed ecosystem. These include better quality control and improve security. In addition, overall, reliability may be improved (Wörsdörfer, 2023).

Apple's closed infrastructure for the iOS operating system was initially challenged in 2016 by the United States FBI, when an iPhone was discovered to have potential information that could prove to be evidence in a murder trial (Zinkus, et al., 2021, Burum, et al.).

Risks of Opening

Just as there are risks associated with maintaining a closed environment to side loading there are risks associated with opening the smart phone environment to allow smart loading. One of the foremost risks the potential for an increase in malware on loaded devices. Android operating system devices and iOS operating system devices take diametrically opposing stances in regard to application security. "Apple instead, made the decision early on… to tightly control both hardware and software stacks, using a closed-source proprietary licensing model" (Jasek, 2015, p. 158). One of the key risks associated with the Android operating system and its open environment is a higher concentration of malicious software when compared to Apple's iOS environment (Jasek, 2015).

Observations

Some research indicates that there are potentially positive ramifications with the current iOS and android mobile application ecosystems. This includes "accelerating innovation and encouraging the development of new applications" (Mandel, 2023, p. 3). The implementation of more restrictive laws and increased regulations against these two large App Store may lead to less innovation and less new features in their attempts to open the market (Mandel, 2023).

Potential benefits have also been noted as a possibility with opening up development environment to third-party applications. For example, an open, more competitive market, may lead to lower fees for placing software onto a marketplace (currently around 30%). It may also lead to lower software prices, better competition, and possibly new features (Morton, 2023).

The negative side of allowing the sideloading of applications onto iOS devices is potentially very large. In the past, the manufactures of smart phones served as the gatekeepers of new software applications and maintained tight controls on what was allowed onto the marketplace. It is unclear at this point who will assume the role of gatekeeper now that the manufacturer are being asked to loosen the reins on the app stores. It is possible that this role will be served by the individual governments or potentially placed in the hands of the end-user. If the protection of device security is placed into the hands of end users, research has indicated that this can be problematic as it places the burden for a technical understanding of devices on end users (Furnell, et al., 2015). End users might not become aware of security risks, unless they have already been the victim of a security incident of similar nature (Furnell, et al., 2015). Additional research discovered that in some cases users were aware of potential security issues, but "were not explicitly concerned about them" (Zeng, et al., 2017, p. 70).

Opportunities for future research

An opportunity for future resource exists in comparing the number of malware attacks that were successful on EU based iPhones compared to the number of attacks that were successful against iPhones that were not allowed to be side loaded. This future research would allow the quantification and determination of the risks associated with sideloading applications on smart phones. The predicted outcome of this research would be an increase in the number and severity of attacks European Union versus phones and other parts of the world. Additional metrics could be gathered to see if there is a correlation between sideloading and the life expectancy of smart phone devices.

Additionally, if other nations enact similar legislation, forcing Apple to allow the side loading of applications for users in their countries, research should be expanded to see the security implications of those changes. The impact from switching from corporate gatekeepers to placing the obligation on end users to maintain security for smart phone applications is another potential area for additional research.

Conclusions

This research article presented a review of scholarly literature pertaining to the use of smart phone application loading through a process known as side loading. A comparison was made between the iOS operating system, and the android operating system. These two distinct operating systems have inherently different approaches to loading applications and overall device security. It describes the potential dangers associated with allowing the side loading of applications and recent rulings for the European Union to allow sideloading of iOS applications. This legislation change could prove to have long lasting effects on the overall security of Apple's iOS operating system, and impact users inside the European Union. As of 2024, this is a very active and dynamic situation with recent laws going into effect and the potential for additional future legislation. Additional research options abound in this rapidly, changing, smart phone application environment.

References

Angerhofer, T. J., & Blair, R. D. (2021). Economic Reality at the Core of Apple. Antitrust Bulletin, 66(2), 308–321. https://doi.org/10.1177/0003603X21997030

Bostoen, F. (2023). Understanding the Digital Markets Act. *Antitrust Bulletin*, *68*(2), 263–306. https://doi.org/10.1177/0003603X231162998

Bullock, D., Aliyu, A., Maglaras, L., & Ferrag, M. A. (2020). Security and privacy challenges in the field of iOS device forensics. In AIMS Electronics and Electrical Engineering (Vol. 4, Issue 3, pp. 249–258). American Institute of Mathematical Sciences. https://doi.org/10.3934/ElectrEng.2020.3.249

Burum, S., & Holmes, G. (2016). *Apple v. FBI: Privacy vs. Security?* https://www.researchgate.net/publication/315652360

Cabral, L., Haucap, J., Parker, G., Petropoulos, G., Valletti, T., & van Alstyne, M. (2021). *The EU Digital Markets Act A Report from a Panel of Economic Experts*. https://doi.org/10.2760/139337

Chiarella, M. L. (2022). Digital Markets Act (DMA) and Digital Services Act (DSA): New Rules for the EU Digital Environment. *Athens Journal of Law*, 1–25. https://doi.org/10.30958/ajl.X-Y-Z

Cowls, J., Morley, J., & Floridi, L. (2023). App store governance: Implications, limitations, and regulatory responses. Telecommunications Policy, 47(1). https://doi.org/10.1016/j.telpol.2022.102460

Ellis, M. J., & Frederick, K. (2022). Big Tech's National Security Red Herring. http://report.heritage.org/lm311

Furnell, S., Jusoh, A., Katsabas, D., & Dowland, P. (2015). *Considering the Usability of End-User Security Software*.

Goodwin, C., & Woolley, S. (2022, July 1). Sideloading: An exploration of drivers and motivations. 35th British HCI Conference Towards a Human-Centred Digital Society, HCI 2022. https://doi.org/10.14236/ewic/HCI2022.37

Groschupp, F., Schneider, M., Puddu, I., Shinde, S., & Capkun, S. (2021). Sovereign Smartphone: To Enjoy Freedom We Have to Control Our Phones. http://arxiv.org/abs/2102.02743

Jasek, R. (2015). Security Deficiencies in the Architecture and Overview of Android and iOS Mobile Operating Systems.

Li, Y., Kobsa, A., Knijnenburg, B. P., & Carolyn Nguyen, M.-H. (2017). Cross-Cultural Privacy Prediction. Proceedings on Privacy Enhancing Technologies, 2017(2), 113–132. https://doi.org/10.1515/popets-2017-0019

Mandel, M. (2023). How the Economics and Regulation of Mobile Platforms affects Japan's Digital Transformation and Cybersecurity. https://www.progressivepolicy.org/wp-content/uploads/2023/03/PPI_JapanAppEconomy_English_Web.pdf

Marorio, C. (2016). Smartphone Security: New Applications and Challenges. https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/155494/eth-48762-02.pdf

Morton, F. (2023). Entry and Competition in Mobile App Stores. https://www.bruegel.org/sites/default/files/2024-01/WP%2003%202024_0.pdf

Poeplau, S., Fratantonio, Y., Bianchi, A., Kruegel, C., & Vigna, G. (2014). Execute This! Analyzing Unsafe and Malicious Dynamic Code Loading in Android Applications. http://dx.doi.org/doi-info-to-be-provided-later

Raymond, A. H., & Kouper, I. (2022). Loyola Consumer Law Review Loyola Consumer Law Review Misplaced Trust, Failure of Contract, and the Need to Create Misplaced Trust, Failure of Contract, and the Need to Create Robust Options for Consumers Robust Options for Consumers. https://lawecommons.luc.edu/lclr/vol34/iss3/9

Werthner, H., Ghezzi, C., Kramer, J., Nida-Rümelin, J., Nuseibeh, B., Prem, E., & Stanger Editors, A. (2024). *Introduction to Digital Humanism*.

Wörsdörfer, M. (2023). Apple's antitrust paradox. European Competition Journal. https://doi.org/10.1080/17441056.2023.2262870

Zeng, E., Mare, S., & Roesner, F. (2017). End user security and privacy concerns with smart homes. In *thirteenth symposium on usable privacy and security (SOUPS 2017)* (pp. 65-80).

Zinkus, M., Jois, T. M., & Green, M. (2021). Data Security on Mobile Devices: Current State of the Art, Open Problems, and Proposed Solutions. http://arxiv.org/abs/2105.12613

Developing Virtual Reality Content Using Reality Capture Technology

Sirisha Nallaguttahalli Byrareddy, Sri Mettu, Amaka Ojieh, Jahnavi Balaji, Dr. Brian Warren, Dr. Ratana Warren, Dr. Temitope Olokunde, Dr. Opeyemi Ojajuni, Deidre Street, Dr. Michael Stubblefield, Mussie Samuel, Devender Rapolu

Southern University and A&M College, USA

Abstract: Virtual reality (VR) content development has surged in popularity across industries, leveraging Reality Capture technology to create detailed 3D models from laser scanning data and photos. After processing, these models are exported for integration with VR platforms like Unity or Unreal Engine, enabling real-time exploration and interaction. Integration of Reality Capture with VR offers diverse opportunities: in architecture, stakeholders can virtually tour designs, while cultural heritage preservation benefits from digital documentation. Additionally, training simulations, urban planning, and virtual tourism benefit from realistic experiences. The central research question guiding this study is: how VR content can be developed using Reality Capture technology. This abstract outline the process and applications of VR content development with Reality Capture. The study also includes demonstrations using Leica Geosystems laser scanners for reality capture technology in virtual reality content creation.

Keywords: VR, Reality Capture, 3D model, laser scanning, Leica Geosystems.

Citation: Byrareddy, S. N., Mettu, S., Ojieh, A., Balaji, J., Warren, B., Warren, R., Olokunde, T., Ojajuni, O., Street, D., Stubblefield, M., Samuel, M., & Rapolu, D., (2024). Developing Virtual Reality Content Using Reality Capture Technology. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024--International Conference on Life Sciences, Engineering and Technology* (pp. 126-138), San Francisco, CA, USA. ISTES.

Introduction

In recent years, virtual reality (VR) technology has emerged as a powerful tool with transformative potential across various industries. From architecture and construction to cultural heritage preservation, VR content development has gained significant traction, offering immersive experiences that transcend traditional boundaries. Central to this evolution is the utilization of Reality Capture technology, a cutting-edge tool capable of generating detailed 3D models from laser scanning data and photographs. This paper explores the process of developing VR content using Reality Capture technology, shedding light on its applications, benefits, and implications across diverse domains.

As VR continues to permeate different sectors, the integration of Reality Capture technology holds immense promise for revolutionizing workflows and enhancing user experiences. By seamlessly incorporating Reality Capture content into VR environments through software solutions like Unity or Unreal Engine, stakeholders can

unlock new possibilities for visualization, simulation, and interaction. From virtual walkthroughs of architectural designs to digital documentation of historical landmarks, the synergistic relationship between Reality Capture and VR opens avenues for innovation and exploration.

The advent of virtual reality (VR) has transformed how we interact with digital content, offering unprecedented immersive experiences that captivate users in various fields such as entertainment, education, and professional training. Despite its potential, the process of creating VR content remains encumbered by significant challenges: it is time-consuming, costly, and often lacks the precision necessary for truly immersive experiences. Traditional methods, predominantly reliant on manual modeling, fail to meet the growing demand for high-quality, realistic VR experiences due to their inefficiencies and limited scalability. This study explores the potential of reality capture technology as a revolutionary approach to VR content development. By integrating laser scanning, reality capture technology promises to enhance the visual fidelity, accuracy, and production efficiency of VR content

Problem Statement

Despite the growing demand for immersive and realistic virtual reality (VR) experiences across various industries, the development of VR content faces significant challenges due to the complexities involved in accurately and efficiently replicating real-world environments and objects. Traditional VR content creation methods often rely on manual modeling, which is time-consuming, costly, and can lack the precision needed for high-quality realism. This gap hinders the scalability of VR applications and limits the potential for broader adoption and technological advancement. Therefore, there is a critical need to leverage reality capture technology, which utilizes advanced methods such as photogrammetry, laser scanning, and sensor data integration, to streamline the VR content creation process. By doing so, we aim to enhance the visual fidelity, accuracy, and production efficiency of VR experiences, making them more accessible and effective for users across entertainment, education, heritage conservation, and professional training.

Purpose of Study

The purpose of this study is to uncovering how Reality Capture technology, including advanced tools like the "Leica Geosystems" laser scanner, can be harnessed to capture and transform real-world data into immersive VR environments. By exploring the technical nuances of Reality Capture tools and processes, this study intends to demonstrate their capability to enhance the fidelity and interaction within VR experiences.

Further, the research aims to provide practical demonstrations and document case studies where Reality Capture technology has been successfully utilized, highlighting its impact and effectiveness across various industries. Through this approach, the study seeks to illustrate the transformative potential of Reality Capture technology in not only enhancing user engagement but also in reshaping industry practices by facilitating the creation of more realistic and engaging VR content. This comprehensive exploration will offer valuable insights into the

integration of Reality Capture in VR development, showcasing its practical applications and setting a foundation for its future advancements.

1.4 Aims and Objectives

This research seeks to demonstrate the transformative potential of Reality Capture technology in reshaping industries and redefining user engagement through the development of immersive content. Here are the study objectives:

- To examine the technical components and operation of Reality Capture tools such as the "Leica Geosystems" laser scanner.
- To understand the data acquisition and processing involved in translating real-world information into VR environments.
- To showcase practical demonstrations of VR content development using Reality Capture technology, emphasizing real-world applications.
- To provide case studies or examples where this technology has been successfully implemented.

Based on the detailed purpose of the study and objectives as described, here are some specific research questions that can guide the investigation into the use of Reality Capture technology in virtual reality content development:

- How does Reality Capture technology, specifically tools like the "Leica Geosystems" laser scanner, enhance the fidelity of virtual reality environments?
- What are the technical processes involved in converting real-world data captured through Reality Capture technology into immersive VR environments?

The first research question aims to explore the technical capabilities and the extent to which Reality Capture technology can improve the visual and interactive quality of VR content. The second research question seeks to understand the data acquisition, processing, and transformation procedures that translate physical reality into digital formats suitable for VR. By examining the technical intricacies and practical applications of this process, we aim to provide insights into the potential of Reality Capture technology to reshape industries and redefine user engagement. Additionally, this research showcases demonstrations utilizing "Leica Geosystems" laser scanner as a form of Reality Capture technology, offering tangible examples of its capabilities and impact.

Through this exploration, we seek to offer a comprehensive understanding of the symbiotic relationship between Reality Capture and VR, highlighting its transformative potential and paving the way for future advancements in immersive content development.

Background of Study

Overview of existing research on VR content development.

Virtual reality (VR) technology has undergone significant evolution since its inception, from the primitive

stereoscopic viewers of the early days to the sophisticated systems available today. The historical development of VR is marked by notable technological milestones, including substantial enhancements in graphics hardware, motion tracking, and haptic feedback, which have collectively contributed to more immersive VR systems. These advancements laid the groundwork for the contemporary VR landscape, characterized by an array of high-performance headsets and interactive devices that significantly enhance user experiences such as Meta quest 3, Apple Vision Pro, and computer automatic virtual environment . Additionally, the advent of powerful software platforms like Unity and Unreal Engine has democratized VR content development, enabling creators to build complex and dynamic virtual environments with greater ease and precision.

In terms of content creation methodologies, VR has benefitted immensely from innovations in 3D modeling and animation, as well as the integration of photogrammetry and reality capture technologies. These techniques have not only improved the realism and detail of VR environments but have also streamlined the content creation process, reducing the gap between real-world and virtual experiences. Applications of VR are now widespread across various fields, transforming entertainment, gaming, education, and training with engaging and interactive virtual experiences. For instance, VR is used in educational settings to create immersive simulations for medical and military training, providing practical learning experiences that are both effective and risk-free. Similarly, in industries like architecture and engineering, VR aids in visualization and design processes, allowing for meticulous planning and virtual walkthroughs before physical construction begins.

Despite these advances, VR content development still faces several challenges, including high hardware requirements, latency issues, and resolution limitations that can detract from user experience. Issues such as motion sickness and suboptimal user interface designs also pose significant barriers to user engagement and widespread adoption. However, recent research trends show promising developments, with a focus on incorporating artificial intelligence to make VR environments more interactive and responsive. The ongoing interdisciplinary research across psychology, human-computer interaction, and visual arts continues to push the boundaries of what VR can achieve. Looking forward, the VR industry is expected to grow substantially, driven by continuous technological innovations and increasing adoption across sectors, suggesting a vibrant future for VR content development that is increasingly realistic, accessible, and impactful.

Reality Capture Technology.

Reality Capture technology, which encompasses methods such as photogrammetry, laser scanning, and 3D imaging, has increasingly become integral in various sectors due to its precision and efficiency in capturing real-world conditions. This technology has been particularly transformative in fields such as archaeology, construction, and entertainment, where accurate 3D representations are crucial. Below is a detailed overview of how Reality Capture technology has been applied across different disciplines, reflecting its versatility and the depth of its impact.

In the construction and architecture industry, Reality Capture has revolutionized the planning and monitoring

processes. Through high-resolution 3D scans, architects and engineers can create highly accurate models of construction sites, buildings, and landscapes. This aids immensely in volume calculations, structural analysis, and risk management throughout the lifecycle of a building project. Furthermore, it enhances communication between stakeholders by providing a precise visual representation of projects, thereby reducing errors and streamlining the decision-making process.

For engineering projects, especially in infrastructure and public works, Reality Capture facilitates the assessment and maintenance of bridges, highways, and large structures. It allows for precise measurements and condition assessment without the need for physical access, which can be costly and dangerous. This capability is critical in ensuring the safety and longevity of infrastructure while minimizing downtime and disruption. In the medical field, Reality Capture technologies like 3D scanning are used to create detailed models of body parts for surgical planning and custom medical devices like prosthetics. This application ensures a higher degree of customization and fit, significantly improving patient outcomes.

Reality Capture Technology in Virtual Reality (VR)

Reality Capture technology has been pivotal in enhancing virtual reality (VR) environments by providing detailed and accurate reproductions of real-world objects and spaces. This integration has been extensively explored in various studies, highlighting its application across multiple VR domains. Here's an overview of significant research focusing on the use of Reality Capture technology to develop and refine VR content.

Enhancing Realism in VR Simulations: Numerous studies have demonstrated how Reality Capture, through high-resolution 3D scanning and photogrammetry, greatly enhances the realism of VR simulations. This is particularly evident in fields like historical preservation and tourism, where users can explore ancient sites and museums in immersive 3D that replicates the real locations with exceptional detail. Researchers have focused on the ability of these technologies to not only capture minute details but also to preserve the textures and colors of the scanned objects, which are crucial for creating a convincing VR experience.

Training and Education: In education and training sectors, Reality Capture has been studied for its effectiveness in creating realistic training environments for medical, military, and industrial applications. For instance, medical training benefits from highly accurate anatomical models obtained via Reality Capture, allowing students to practice complex procedures in a risk-free, virtual environment. Similarly, in military training, realistic battlefield simulations are created using terrain and building data captured by drones and laser scanners, providing soldiers with immersive preparatory experiences.

Architectural Visualization and Urban Planning: Studies in architectural visualization have explored how Reality Capture can transform the way architects and urban planners design and visualize their projects. By creating detailed 3D models of buildings and urban landscapes, these professionals can immerse themselves and their clients in the proposed spaces, facilitating better understanding and communication of architectural

concepts and plans. This application is crucial for large-scale developments where spatial awareness and aesthetic integration play significant roles.

Interactive Art and Exhibitions: Research in the art world has embraced Reality Capture to create interactive VR exhibitions that allow users to experience artworks and installations in novel ways. These studies focus on the potential for VR to democratize access to art and cultural heritage, enabling people from around the world to engage with exhibits they might not otherwise be able to visit, thus broadening educational and cultural appreciation.

Environmental and Ecological Studies: In environmental sciences, VR combined with Reality Capture is being studied for its ability to simulate diverse ecosystems and natural environments, offering researchers, students, and policymakers a tool to virtually explore and analyze ecological scenarios without physically impacting the sites. This application is significant for training and planning in environmental management and conservation efforts.

The body of research collectively highlights a trend toward integrating Reality Capture with VR to push the boundaries of how virtual environments are created and used. These studies underscore the technology's transformative potential across various sectors, enhancing not only the fidelity and immersion of VR experiences but also their practical applications in professional, educational, and recreational contexts.

Despite significant advancements in integrating Reality Capture technology with virtual reality (VR) content development, several research gaps remain that hinder the efficiency and broader application of these technologies. Interactivity within VR environments created using Reality Capture technology is another area that lacks depth. Most models provide detailed visual replication but do not support dynamic interaction, which is crucial for user engagement and the overall VR experience. The integration of diverse sensor data from various Reality Capture techniques into a unified VR model also poses significant challenges, which affects the creation of comprehensive and immersive environments. Moreover, the accessibility of Reality Capture technology for VR content creators, particularly those without specialized training in data handling and software manipulation, is insufficient. This limits the technology's broader application and utility in fields such as education, training, and entertainment. Lastly, there is a scarcity of empirical research on the effectiveness of these VR applications in real-world settings, which is necessary to validate their practical utility and impact on user experience across various domains.

Methodology

This ongoing project is dedicated to a comprehensive examination of the technical aspects of Reality Capture technology, which includes exploring its methodologies, tools, and processes. The focus is on understanding how Leica RTC360 can be effectively harnessed to create highly accurate 3D models of physical environments

and objects. The technical investigation uncovered the capabilities and limitations of current Reality Capture systems, optimize their application, and enhance their integration into the creation of virtual reality (VR) content.

Fieldwork and Preprocessing of Lieca Scanner

Instruments

Figure 1 below illustrates the instruments that were utilized. The handling, standards, and data processing methods differ amongst them. The necessary instrument specifications for the project under consideration are compiled in Table 1.

Figure 1. From left to right: 3D scanner - Leica RTC360 - Leica Geosystems

Table 1. Instrument specifications according to the data sheet

	RTC360
Imaging Speed	1min
Scan Speed	Up to 2,000,000 pts / sec
Weight	5.35 kg / 11.7 lbs
Env. Robustness	IP54 (IEC 60529)
Temp Range	-5° to +40°C
Range	Min. 0.5 - up to 130 m
3D data quality	Better
Field Registration	VIS based

The Leica RTC360, manufactured by Leica Geosystems, is a state-of-the-art 3D scanner renowned for its precision, speed, and versatility. This cutting-edge instrument is designed to capture high-resolution 3D images with exceptional detail and accuracy, making it ideal for a wide range of applications in fields such as architecture, construction, engineering, and forensics.

One of the key features of the Leica RTC360 is its advanced laser scanning technology, which allows for rapid data acquisition without compromising on quality. With its ability to capture up to 2 million points per second, the RTC360 can efficiently scan large areas while maintaining precise measurements and detailed imagery. This capability enables users to quickly and accurately document complex environments, including building interiors, construction sites, and outdoor landscapes.

The RTC360 is also renowned for its user-friendly interface and intuitive workflow, making it accessible to both novice and experienced users alike. Its ergonomic design and lightweight construction ensure ease of handling and maneuverability, allowing operators to navigate tight spaces and challenging environments with ease. Additionally, the scanner is equipped with automated features such as automatic point cloud registration and HDR imaging, further streamlining the scanning process and enhancing productivity.

Data Collection

In the Leica RTC360 by Leica Geosystems, data collection occurs through a combination of laser scanning and imaging technology. The scanner emits laser pulses in various directions, measuring the time it takes for the pulses to return after hitting surfaces in the environment. This data is then used to generate precise 3D point clouds, capturing detailed spatial information about the scanned area. Additionally, high-resolution images are captured simultaneously, providing texture and color information to enhance the visual quality of the point cloud. The RTC360 is equipped with advanced sensors and algorithms to ensure accurate and efficient data collection, making it suitable for a wide range of applications in industries such as architecture, construction, and cultural heritage preservation.

Data Acquisition

Data acquisition involves the process of gathering and capturing data from various sources and sensors for analysis and interpretation. It encompasses a range of techniques and technologies used to collect data in real-time or from stored sources, depending on the application requirements. In the context of the Leica RTC360 by Leica Geosystems, data acquisition refers to the capturing of 3D laser scanning data from the surrounding environment. The RTC360 emits laser pulses and measures the time it takes for the pulses to reflect off surfaces and return to the scanner, generating precise point cloud data representing the scanned objects and structures. This data acquisition process is highly accurate and efficient, allowing for the rapid capture of detailed information about the scanned environment. The acquired data serves as the foundation for various applications, including architectural and engineering design, construction planning, virtual reality content development, and cultural heritage preservation. Overall, data acquisition with the Leica RTC360 enables the creation of comprehensive and detailed representations of physical spaces, facilitating informed decision-making and enhancing visualization and analysis capabilities in diverse fields.

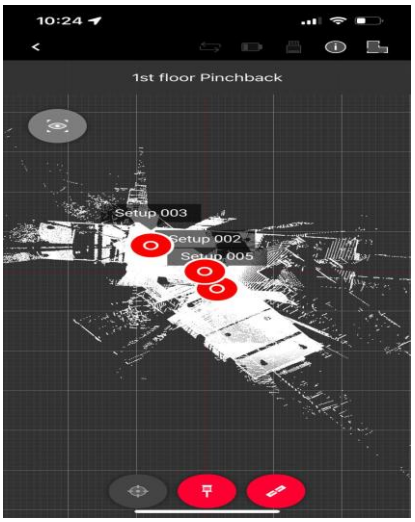
Point Cloud Processing

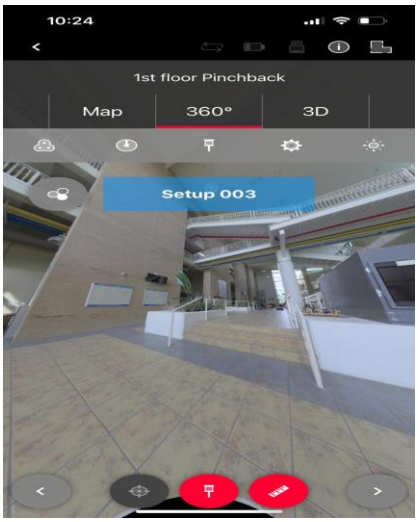
Point cloud processing involves manipulating and analyzing large sets of 3D points captured by laser scanners or other sensing devices. The process begins with registration, where multiple scans are aligned to create a unified point cloud representing the scanned environment. Following registration, various processing steps are applied to enhance the quality and usability of the data. These steps may include noise reduction to remove

unwanted points, outlier removal to eliminate erroneous data, and filtering to extract specific features or objects of interest. Additionally, point cloud processing may involve segmentation, where the point cloud is divided into meaningful subsets based on geometric properties or other criteria. Other common tasks include feature extraction, where key points or structures are identified within the point cloud, and surface reconstruction, where the points are used to generate a mesh representation of the scanned surfaces. Ultimately, point cloud processing aims to transform raw scan data into accurate and informative 3D models that can be used for a variety of applications, including visualization, analysis, and virtual reality.

Results & Discussion

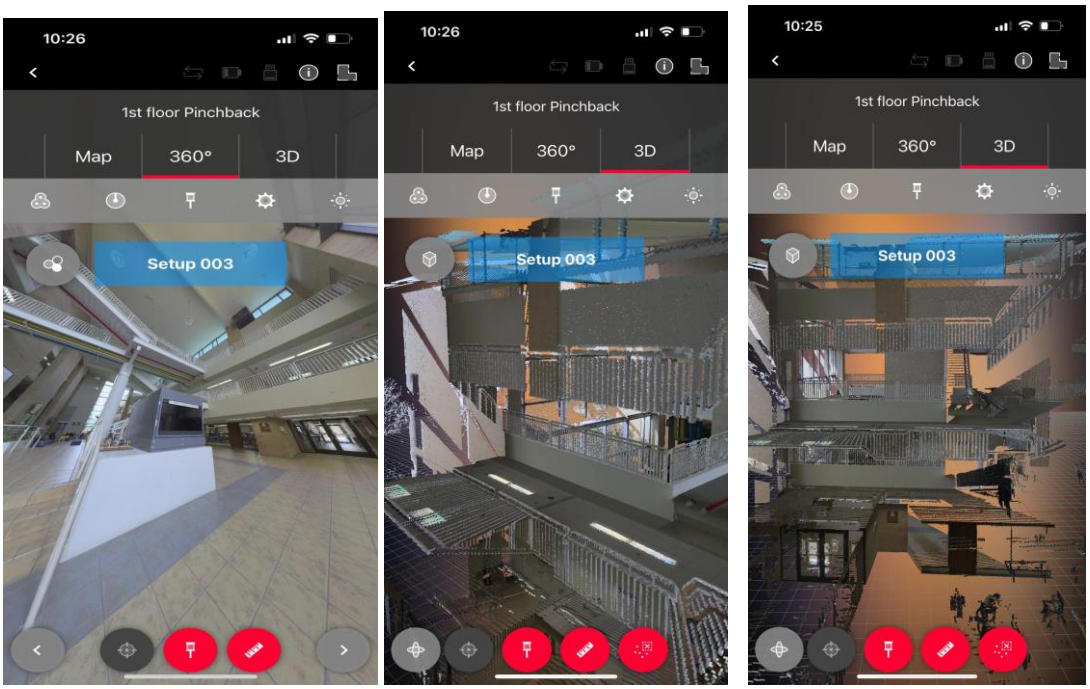
The Leica RTC360, developed by Leica Geosystems, delivers precise 3D scanning capabilities. With advanced technology and intuitive design, it enables efficient data acquisition and processing for various applications. Its high-speed scanning, superior accuracy, and seamless integration with software solutions make it an ideal choice for professionals in industries such as architecture, construction, and cultural heritage preservation. The RTC360 empowers users to capture detailed 3D models with ease, facilitating accurate documentation and analysis of spatial environments. Overall, it represents a cutting-edge solution for capturing reality and transforming it into actionable insights. Bellow I'm adding few images captured by Leica scanner geosystem.





Once you setup your Leica scanner in the application of Cyclone FIELD 360 it will shows how many setups you have done, I had showed in the above figure.

The Leica RTC360, developed by Leica Geosystems, represents a significant advancement in 3D scanning technology. Its compact design, coupled with high-speed data acquisition capabilities, makes it a versatile tool for various applications. The device offers exceptional accuracy and precision, capturing detailed point clouds with minimal effort and setup time. Additionally, its integrated imaging system provides valuable contextual information, enhancing the overall quality of scanned data.



One notable feature of the Leica RTC360 is its user-friendly interface and intuitive workflow, enabling both novice and experienced users to efficiently operate the device. Furthermore, its robust construction and durability make it suitable for use in challenging environments, including construction sites and outdoor settings.

The Leica RTC360's compatibility with industry-standard software platforms simplifies data processing and analysis, facilitating seamless integration into existing workflows. Its ability to generate high-quality 3D models and accurate measurements makes it indispensable for applications such as architectural documentation, forensic analysis, and heritage preservation.

Overall, the Leica RTC360 represents a pinnacle of innovation in 3D scanning technology, offering unparalleled performance, reliability, and ease of use for professionals across various industries. Its combination of advanced features and practical design makes it a valuable asset for any project requiring precise spatial data capture and analysis.

As the project progresses, it has already reached several key achievements, including the effective mapping and digitization of a building via laser scanning. Moving forward, the project will concentrate on:
Enhancing the scalability of Reality Capture techniques to handle more extensive and complex environments.
Integrating greater interactivity with VR models created from Reality Capture data to boost user engagement and realism.

Recommendations and Future Work

Developing virtual reality content using Reality Capture Technology offers unparalleled potential for immersive experiences. Leveraging advanced scanning capabilities, such as those provided by Leica Geosystems, ensures high-fidelity 3D models. Integrating these models into VR environments through platforms like Unity or Unreal Engine enhances interactivity and realism. The process enables diverse applications, from architecture and construction to cultural heritage preservation and training simulations. Professionals seeking to create captivating VR experiences should consider Reality Capture Technology for its ability to deliver detailed and accurate virtual environments, fostering engagement and innovation across various industries.

The potential of reality capture technology to revolutionize virtual reality (VR) content creation is significant, warranting further investigation to fully harness its capabilities. Future studies will focus on enhancing the precision and realism of VR environments by conducting comparative analyses between reality capture and traditional modeling methods. This will help quantify improvements and identify key factors that contribute to heightened user immersion. Additionally, exploring how reality capture technology can streamline VR content creation processes will be crucial. Developing a model for reduced production time and costs could potentially standardize this advanced technology across the VR industry.

Future research will focus on evaluating how Reality Capture technology can revolutionize key sectors, including entertainment, education, and heritage conservation. This involves not only documenting successful case studies but also measuring the qualitative and quantitative impacts of VR technologies in these areas.
Further studies are needed to analyze how enhanced VR experiences influence user engagement and interaction. This will include user feedback sessions, engagement metrics, and comparative studies to understand the benefits and limitations of VR content developed with Reality Capture technology.

Addressing barriers to the widespread adoption of reality capture technology is also essential for its integration into mainstream VR content development. Future work will involve identifying technological, economic, and operational hurdles, proposing actionable strategies to overcome these challenges. Furthermore, assessing the impact of improved VR content quality on user engagement and learning outcomes, especially in educational and training contexts, will provide valuable insights. By linking enhanced VR experiences with better learning outcomes and higher retention rates, the broader application and investment in reality capture technologies can be justified, facilitating its adoption across various sectors.

Conclusion

In conclusion, the Leica RTC360 by Leica Geosystems stands as a cutting-edge solution for precise and efficient 3D scanning applications. With its advanced technology and user-friendly interface, the RTC360 offers unparalleled accuracy and speed in data acquisition. Its seamless integration with data processing software

ensures streamlined workflows and enhanced productivity. Additionally, the RTC360's versatility and durability make it a preferred choice for a wide range of industries, from architecture and construction to cultural heritage preservation. Overall, the RTC360 represents a pinnacle of innovation, empowering users to capture detailed 3D data with ease and precision.

Acknowledgements

The work is supported and part of collaborative research at the SURAAD, Southern University and A&M College, Baton Rouge, USA. The authors wish to acknowledge the Southern University and A&M College, Baton Rouge, USA for their invaluable support and provision of resources during the development of virtual reality content using Reality Capture technology.

References

E. Southgate, "Using Screen Capture Video to Understand Learning in Virtual Reality," *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, Atlanta, GA, USA, 2020, pp. 418-421, doi: 10.1109/VRW50115.2020.00089.

T. H. D. Nguyen *et al*., "Real-time 3D human capture system for mixed-reality art and entertainment," in *IEEE Transactions on Visualization and Computer Graphics*, vol. 11, no. 6, pp. 706-721, Nov.-Dec. 2005, doi: 10.1109/TVCG.2005.105.

D. W. Carruth, "Virtual reality for education and workforce training," *2017 15th International Conference on Emerging eLearning Technologies and Applications (ICETA)*, Stary Smokovec, Slovakia, 2017, pp. 1-6, doi: 10.1109/ICETA.2017.8102472.

A. Bierbaum, C. Just, P. Hartling, K. Meinert, A. Baker and C. Cruz-Neira, "VR Juggler: a virtual platform for virtual reality application development," *Proceedings IEEE Virtual Reality 2001*, Yokohama, Japan, 2001, pp. 89-96, doi: 10.1109/VR.2001.913774.

C. Anthes, R. J. García-Hernández, M. Wiedemann and D. Kranzlmüller, "State of the art of virtual reality technology," *2016 IEEE Aerospace Conference*, Big Sky, MT, USA, 2016, pp. 1-19, doi: 10.1109/AERO.2016.7500674.

C. E. Hughes, C. B. Stapleton, D. E. Hughes and E. M. Smith, "Mixed reality in education, entertainment, and training," in *IEEE Computer Graphics and Applications*, vol. 25, no. 6, pp. 24-30, Nov.-Dec. 2005, doi: 10.1109/MCG.2005.139.

Z. Zhang, C. Wang, D. Weng, Y. Liu and Y. Wang, "Symmetrical Reality: Toward a Unified Framework for Physical and Virtual Reality," *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, Osaka, Japan, 2019, pp. 1275-1276, doi: 10.1109/VR.2019.8797970.

Y. Rehman, H. M. A. Uddin, T. H. M. Siddique, Haris, S. R. U. N. Jafri and A. Ahmed, "Comparison of Camera and Laser Scanner based 3D Point Cloud," *2019 4th International Conference on Emerging Trends in Engineering, Sciences and Technology (ICEEST)*, Karachi, Pakistan, 2019, pp. 1-5, doi:

10.1109/ICEEST48626.2019.8981708.

I. Wijayanto, S. Hadiyoso and T. M. Gunawan, "Video Processing for Dual Laser 3D Scanner Prototype based on Cloud to Cloud Method," *2018 International Conference on Control, Electronics, Renewable Energy and Communications (ICCEREC)*, Bandung, Indonesia, 2018, pp. 149-153, doi: 10.1109/ICCEREC.2018.8712107.

Enhancing Engineering Students' Confidence with Industrial Skill Acquisition in through Virtual Reality: A Confidence-Based Learning Approach

Sri Divya Reddy Mettu, Dr. Temitope Olokunde, Dr. Opeyemi Ojajuni, Dr. Ratana Warren, Amaka Ojieh, Jahnavi Balaji, Sirisha Nallaguttahallibyrareddy, Samuel Mussie, Dr. Brian Warren, Dr. Luria Young, Dr. Albertha Lawson, Dr. Yasser Ismail, Dr. Michael Stubblefield, Deidre Street
Southern University and A&M College, Baton Rouge, United States

Abstract: This paper explores the integration of Virtual Reality (VR) technology as an innovative pedagogical tool for imparting crucial Industrial Skills to engineering students. In response to this challenge, we present a novel educational framework that leverages VR to simulate industrial environments, allowing students to engage in hands-on learning within a safe and controlled virtual space. The study focuses on the incorporation of Confidence-Based Learning strategies to assess and enhance students' self-assurance in applying acquired skills. By integrating confidence metrics into the learning process, we aim to gauge the students' perceived proficiency in executing tasks within the VR environment. This approach not only provides valuable insights into the learners' confidence levels but also enables the identification of specific areas where additional support and reinforcement may be needed. The paper presents the results of a comprehensive analysis conducted on engineering students undergoing VR-based industrial skills training. Quantitative data will be presented, showcasing the impact of the confidence-based learning approach on students' skill retention, application, and overall confidence. Insights gained from this study contribute to bridging the gap between academia and industry demands. Ultimately, our findings underscore the potential of VR and confidence-based learning in shaping a more competent and self-assured engineering workforce.

Keywords: Virtual Reality, VR, Industrial Skills, Confidence-Based Learning

Citation: Mettu, S. D. R., Ismail, Y., Lawson, A., Young, L., Olokunde, T., Ojajuni, O., Warren, R., Ojieh, A., Balaji, J., Nallaguttahallibyrareddy, S., Mussie, S., Warren, B., Stubblefield, M., & Street, D (2024). Enhancing Engineering Students Confidence with Industrial Skill Acquisition in through Virtual Reality: A Confidence-Based Learning Approach. In M. Shelley, Y. Bertiz, & E. Cakir (Eds.), *Proceedings of ILSET 2024--International Conference on Life Sciences, Engineering and Technology* (pp. 139-148), San Francisco, CA, USA. ISTES.

Introduction

In recent years, virtual reality (VR) has emerged as a promising technology in engineering education, offering immersive and interactive learning experiences. This paper investigates the role of VR in enhancing engineering students' confidence through industrial skill acquisition. Confidence is a crucial factor in students' ability to

transfer theoretical knowledge into practical skills, particularly in engineering disciplines where hands-on experience is paramount. By leveraging VR for skill development, educators can create dynamic learning environments that bridge the gap between classroom learning and real-world applications.

Literature Review

Virtual Reality in Engineering Education

Virtual reality (VR) technology holds great promise for transforming engineering education by providing immersive and interactive learning experiences. VR simulations offer engineering students opportunities to engage in hands-on training within realistic virtual environments, allowing them to bridge the gap between theoretical knowledge and practical application (Lee et al., 2020; Ojajuni et al., 2023). By interacting with virtual models and scenarios, students can gain valuable insights into complex engineering concepts and processes, enhancing their understanding and retention of key principles.

Research has shown that VR-based education can significantly improve learning outcomes and student engagement in engineering disciplines (Brown & White, 2019). VR facilitates experiential learning by enabling students to manipulate objects, simulate experiments, and visualize abstract concepts in three-dimensional space (Johnson et al., 2021; Ojajuni et al., 2023). This technology not only enhances technical skills but also fosters critical thinking, problem-solving, and collaboration among students (O'Neil & Patel, 2017).

Incorporating VR into engineering curricula has the potential to revolutionize traditional teaching methods and better prepare students for the demands of modern industries (Smith & Jones, 2018). By leveraging VR tools and simulations, educators can create dynamic learning experiences that empower students to apply their knowledge in practical contexts and develop the skills needed to excel in diverse engineering fields.

Industrial Skills

Industrial skills play a critical role in preparing engineering students for professional success in today's workforce. These skills encompass a broad spectrum of competencies, including technical proficiencies such as equipment operation, maintenance, and troubleshooting, as well as essential soft skills like teamwork, communication, and project management (Smith & Jones, 2018). In the context of virtual reality (VR)-based education, industrial skills are cultivated through immersive simulations that replicate real-world scenarios and challenges (Lee et al., 2020). For example, students can engage in virtual tasks such as machinery assembly, safety inspections, or system troubleshooting, providing them with hands-on experience in a risk-free environment (Brown & White, 2019).

By integrating VR technology into engineering curricula, educators can enhance students' ability to apply theoretical knowledge to practical situations and develop a deeper understanding of industrial processes (O'Neil

& Patel, 2017). VR simulations offer a dynamic platform for students to acquire and refine industrial skills, ultimately equipping them with the competencies needed to thrive in diverse industrial settings and contribute meaningfully to innovation and development in their respective fields.

Confidence- Based Learning

Confidence-based learning is a pedagogical approach that emphasizes the development of students' self-efficacy and belief in their abilities to succeed academically and professionally. In education, fostering confidence is essential for promoting motivation, persistence, and achievement among learners (Bandura, 1997). Confidence-based learning strategies involve creating supportive environments where students are encouraged to take risks, learn from failures, and celebrate successes (Zimmerman, 2000).

Research has demonstrated that confidence-based learning positively impacts student performance and well-being across various disciplines (Harter, 1999). By promoting a growth mindset and cultivating self-assurance, educators empower students to approach challenges with resilience and determination (Dweck, 2006). In the context of engineering education, confidence-based learning can be particularly beneficial for equipping students with the mindset and skills needed to tackle complex problems and navigate dynamic professional environments (Lee & Bong, 2021).

Implementing confidence-based learning strategies involves providing constructive feedback, setting achievable goals, and promoting a growth-oriented classroom culture (Hattie & Timperley, 2007). By fostering a sense of competence and autonomy, educators can enhance students' confidence and ultimately support their long-term success in education and beyond.

Research Gap

The research gap identified in the intersection of confidence-based learning and virtual reality (VR) within engineering education underscores the need for focused investigation. While existing literature emphasizes VR's efficacy in enhancing technical skills and conceptual understanding among engineering students (Lee et al., 2020; Brown & White, 2019), there is a notable absence of studies exploring how VR can specifically impact students' self-efficacy and confidence levels.

This research gap highlights the opportunity to develop and evaluate innovative instructional strategies that integrate confidence-building approaches into VR simulations, ultimately enhancing students' belief in their abilities and preparing them for successful careers in industry. Future research should explore the interplay between confidence-based pedagogies, VR technologies, and industrial skill development within the engineering education context, contributing to the advancement of effective teaching practices and holistic student development.

Research Methodology

Aim

This study aims to investigate the effectiveness of VR technology combined with confidence-based reinforcement learning in enhancing engineering students' confidence in industrial skill acquisition.

Research Question: Does Virtual Reality impact students' confidence in industrial skills acquisition within a Virtual Reality Learning Environment at an HBCU?

Purpose statement

The purpose of this study is to investigate the integration of virtual reality (VR) technology as a pedagogical tool for imparting essential industrial skills to engineering students. Specifically, the study focuses on implementing confidence-based learning strategies within VR environments to assess and enhance students' self-assurance in applying acquired skills. The research aims to evaluate the impact of VR-based training on skill acquisition and overall confidence levels among engineering students. By contributing insights into effective teaching methodologies in engineering education, this study seeks to inform curriculum design and promote the development of industry-relevant skills necessary for future engineering professionals.

Research Design

This study utilizes a quasi-experimental design with a pre-test/post-test control group to examine the influence of VR-based training on skill development and confidence levels among a sample of 10 students enrolled in Engr 120. The intervention involves implementing a structured VR training program that focuses on key industrial tasks and scenarios. To measure changes in confidence, a subset of the Fennema-Sherman Attitude Scales is employed, consisting of 12 items that assess both positive and negative attitudes, with six items dedicated to each category. This quantitative approach aims to investigate the impact of VR on engineering students' confidence in industrial skill acquisition. A pre-post design will assess changes in self-reported confidence levels before and after VR-based training sessions. Quantitative data will be collected through questionnaires administered to groups to gain insights into students' confidence levels regarding VR interaction within the engineering education context.

Results

The results of the study indicate that students demonstrated positive outcomes following the use of virtual reality (VR) technology in their learning experiences. Through VR-based training, students exhibited enhanced engagement, understanding, and retention of key concepts and skills related to engineering tasks and scenarios. Specifically, participants reported increased confidence in their abilities to apply theoretical knowledge to

practical situations within a simulated environment. Moreover, the immersive nature of VR facilitated a deeper level of experiential learning, allowing students to interact with complex engineering systems and processes in a hands-on manner. These positive results suggest that integrating VR into engineering education has the potential to significantly benefit students' learning outcomes and overall academic performance. Further research is warranted to explore the long-term effects and scalability of VR-based interventions in educational settings.

Implementation of VR in Lesson Plan

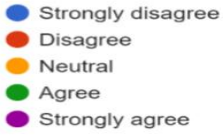
The implementation of VR training sessions utilizes a Computer Automated Virtual Environment (CAVE), where participants engage with and navigate through virtual environments projected onto the CAVE walls. To enhance immersion, participants wear goggles equipped with sensors that interact with emitters to track their presence within the virtual space. The CAVE system comprises six projectors that display stereoscopic images onto four walls, creating a fully immersive 3D environment. This setup allows for realistic and interactive experiences, enabling students to interact with complex engineering scenarios in a dynamic and engaging manner. The use of CAVE technology enhances the effectiveness of VR-based training by providing a highly immersive and realistic simulation environment for engineering education.

Lesson Plan with Virtual Reality

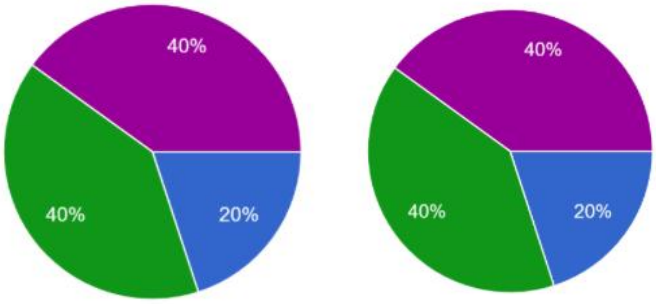
The implementation of virtual reality (VR) within the lesson plan incorporates a structured sequence of activities to enhance learning and engagement. The lesson plan begins with a traditional lecture to introduce foundational concepts. Following the lecture, participants engage in an activity focused on additive manufacturing, specifically 3D printing, to apply theoretical knowledge in a practical context. Subsequently, participants complete a quiz or survey to assess understanding before transitioning into the VR experience. The VR component provides an immersive and interactive simulation related to the lesson topic, allowing students to visualize and interact with complex engineering scenarios. After the VR experience, participants complete another quiz or survey to evaluate the impact of the VR activity on learning outcomes and comprehension. This integrated approach leverages VR technology to enhance the effectiveness of the lesson plan, providing a comprehensive and engaging learning experience for participants.

Discussion

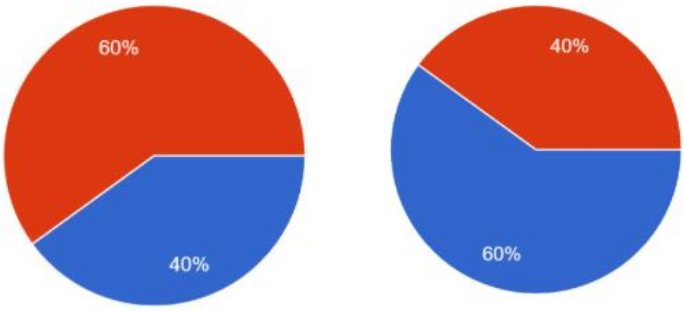
The responses are based on 5-point likert scale which are color coded. The first graph under each question is the response for pretest and the second graph represents the response for the post-test after the intervention.



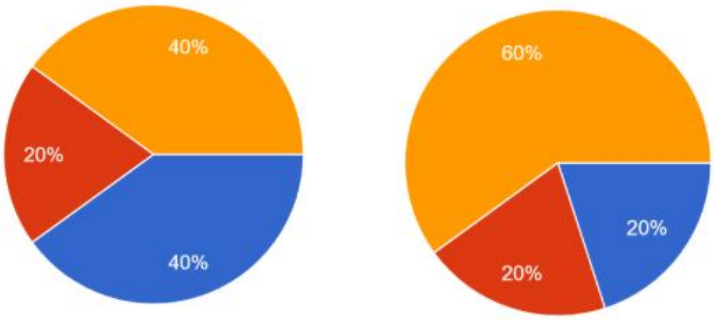
1. I am sure that I can learn engineering design and concepts.



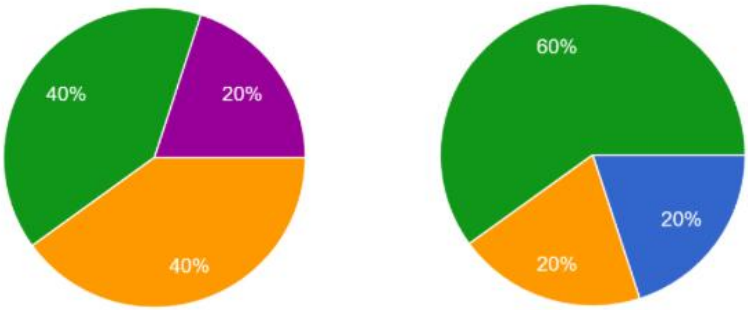
2. I don't think I could do advanced engineering design and concepts.



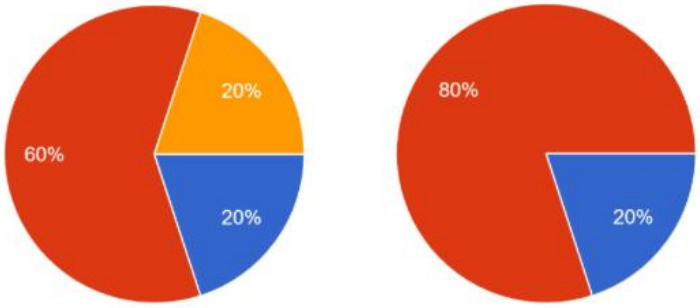
3. Engineering design and concepts is hard for me.



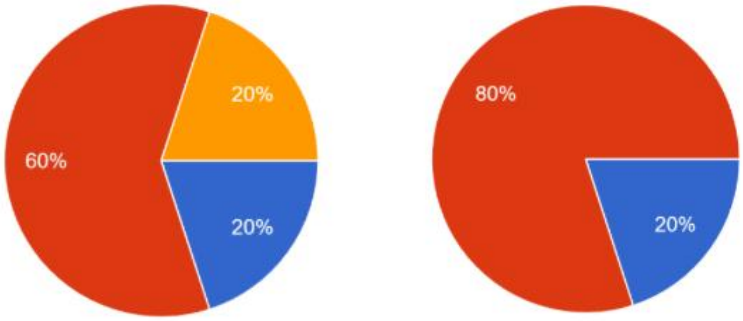
4. I am sure of myself when I do engineering design and concepts.



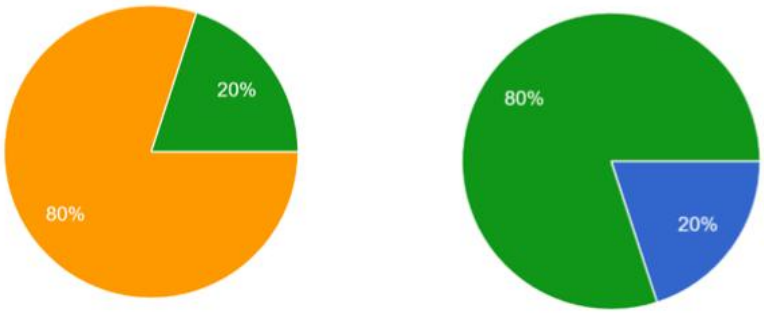
5. I'm not the type to do well in engineering design and concepts.



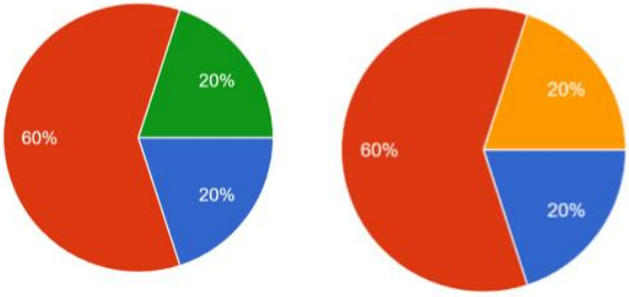
6. Engineering design and concepts has been my worst subject.



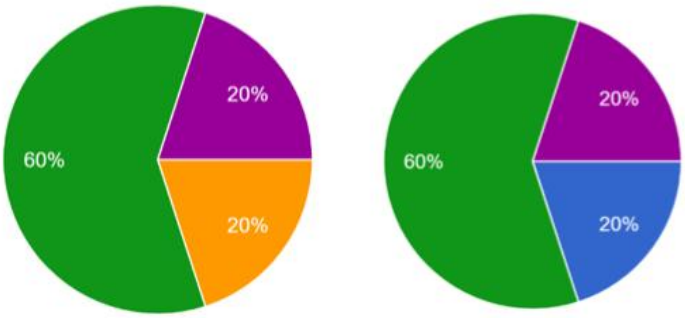
7. I think I could handle more difficult engineering design and concepts.



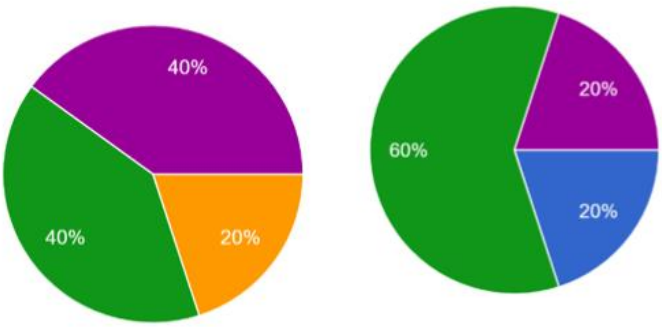
8. Most subjects I can handle OK, but I just can't do a good job with engineering design and concepts.



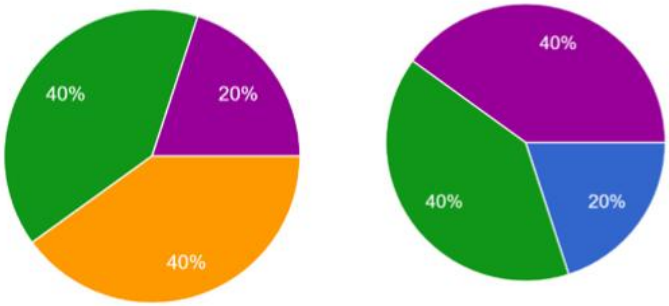
9. I can get good grades in engineering design and concepts.



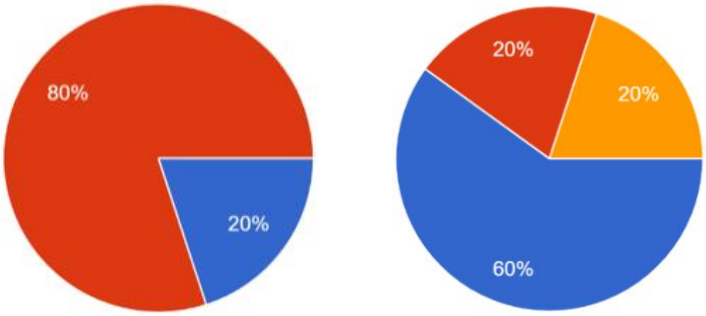
10. I know I can do well in engineering design and concepts.



11. I am sure I could do advanced work in engineering design and concepts.



12. I'm no good in engineering design and concepts.



Conclusion

In conclusion, this paper advocates for the adoption of a confidence-based learning approach using VR technology to enhance engineering students' skill acquisition and self-efficacy. By incorporating immersive simulations into curricula, educators can cultivate a new generation of confident and competent engineers capable of meeting industry demands. Future research should further explore the long-term effects of VR integration on students' career readiness and professional development.

References

Bandura, A. (1997). Self-efficacy: The exercise of control. W.H. Freeman and Company.

Brown, A., & White, B. (2019). Enhancing engineering education through virtual reality: A case study. Journal of Engineering Education, 108(3), 398-410.

Dweck, C. S. (2006). Mindset: The new psychology of success. Ballantine Books.

Harter, S. (1999). The construction of the self: A developmental perspective. Guilford Press.

Hattie, J., & Timperley, H. (2007). The power of feedback. Review of Educational Research, 77(1), 81-112.

Johnson, E., et al. (2021). The impact of virtual reality on engineering learning outcomes: A systematic review. Journal of Engineering Pedagogy, 15(2), 67-82.

Lee, C., et al. (2020). Virtual reality in engineering education: A systematic review of the literature. IEEE Transactions on Learning Technologies, 13(1), 16-31.

Lee, J., & Bong, M. (2021). Enhancing engineering students' confidence through a growth mindset intervention. Journal of Engineering Education, 110(2), 234-247.

Ojajuni, O., Ismail, Y., Mellieon-Williams, F. & Lawson, A. (2023). Factors contributing to student experience in the Cave Automatic Virtual Environment (CAVE) for Computational Thinking (CT) development. In E. Langran, P. Christensen & J. Sanson (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 65-74). New Orleans, LA, United States: Association for the Advancement of Computing in Education (AACE). Retrieved March 16, 2024 from https://www.learntechlib.org/primary/p/221853/.

Ojajuni, O., Ismail, Y., Mellieon-Williams,, F. & Lawson, A. (2023). Investigating student and faculty attitudes and perceptions towards using Virtual Reality (VR) to improve Computational Thinking (CT) levels in Cybersecurity-Additive Manufacturing (CAM) training. In E. Langran, P. Christensen & J. Sanson (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 75-84). New Orleans, LA, United States: Association for the Advancement of Computing in Education (AACE). Retrieved March 16, 2024 from https://www.learntechlib.org/primary/p/221854/.

O'Neil, J., & Patel, R. (2017). Leveraging virtual reality for experiential learning in engineering education. International Journal of Engineering Education, 33(4), 1234-1245.

O'Neil, J., & Patel, R. (2017). Leveraging virtual reality for industrial skill development. International Journal of Engineering Pedagogy, 8(2), 45-56.

Smith, J., & Jones, K. (2018). Bridging the gap: Integrating industry skills into engineering education. Journal of Applied Engineering Education, 12(4), 123-135.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), Handbook of self-regulation (pp. 13-39). Academic Press.