VR In CS Education
An Annotated Bibliography

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References

[1] J. C. Adams and J. Hotrop, "Building an economical vr system for cs education," *SIGCSE Bull.*, vol. 40, no. 3, p. 148–152, jun 2008.

This article presents a practical approach to constructing a virtual reality (VR) system for computer science (CS) education at a reduced cost, making it more feasible for educational institutions with limited financial resources. Adams and Hotrop outline the necessary hardware and software components to create a functional VR system while highlighting affordable alternatives to high-end VR technologies. Additionally, they discuss how VR can enhance the learning experience by providing immersive environments that aid in understanding complex topics, such as data structures and algorithms. Through step-by-step guidance, the authors demonstrate how to build a VR system with commonly available resources, stressing the importance of hands-on learning and interactive experiences in CS education.

The article is relevant to current research on VR in educational settings, as it underscores the potential of VR to create engaging and effective learning environments without requiring significant financial investment. Its focus on affordability

and accessibility makes it an essential resource for institutions seeking to implement VR for teaching purposes. Moreover, the study provides insight into both the technical and educational aspects of integrating VR, which could be beneficial for researchers and educators looking to adopt or study VR systems in CS education. Furthermore, this research paper supports the systematic review by demonstrating the feasibility of VR as a tool for widespread use in education and addressing the economic challenges that might hinder its adoption.

[2] C. Berns, G. Chin, J. Savitz, J. Kiesling, and F. Martin, "Myr: A web-based platform for teaching coding using vr," in *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, ser. SIGCSE '19. New York, NY, USA: Association for Computing Machinery, 2019, p. 77–83. [Online]. Available: https://doi.org/10.1145/3287324.3287482

This paper introduces MYR, a browser-based platform designed to teach computer science using virtual reality (VR). Specifically, MYR features an integrated development environment (IDE) that supports real-time rendering of three-dimensional scenes generated by code. The platform aims to make VR programming accessible to both educators and students. Notably, pilot testing with middle school students demonstrated MYR's strengths in accessibility and real-time synchronization. However, it also revealed difficulties with advanced coding concepts like functions, which pose challenges for younger users.

Furthermore, the platform offers an engaging introduction to coding and VR, with the authors concluding that MYR positively influences student attitudes toward programming. Despite some challenges, the positive feedback and sustained student interest suggest that MYR could become a valuable educational tool. In addition, this study is relevant as it highlights an innovative method of combining VR and computer science education, while addressing both the potential and challenges of immersive learning environments.

Moreover, MYR builds on previous educational computing and VR research, focusing on creating accessible tools for amateur programmers. While the study's small sample size limits the

applicability of the findings, the real-time feedback and insights from the pilot test provide valuable qualitative data. The authors, partnered with prominent institutions in educational computing, add credibility to the research. Thus, this paper offers a meaningful perspective on how VR can enhance programming education, demonstrating potential to connect traditional and modern teaching methods despite the challenges. Overall, MYR highlights the evolving role of VR in shaping future educational practices.

[3] M. Bricken, "Virtual reality learning environments: potentials and challenges," *SIGGRAPH Comput. Graph.*, vol. 25, no. 3, p. 178–184, jul 1991. [Online]. Available: https://doi.org/10.1145/126640.126657

In this paper, Meredith Bricken explores the potential of Virtual Reality (VR) as an innovative tool for education, providing immersive and interactive learning environments. The study highlights how VR aligns with constructivist educational theories, which focus on learners actively constructing their own knowledge. While VR offers significant promise in transforming education, Bricken acknowledges challenges such as high costs, usability issues, and resistance to adopting new technologies in traditional classrooms. The paper proposes that, if these hurdles are overcome, VR could reshape educational methods by offering a deeper understanding of how students learn through hands-on, experiential environments.
This article supports the systematic review by demonstrating the connection between educational theories and VR's role in enhancing learning outcomes. Although high costs initially hindered VR's widespread adoption in education, technological advancements have made VR more affordable and accessible over time. The paper also emphasizes how VR's alignment with constructivism contrasts with traditional objectivist methods, positioning it as a tool that fosters active learning and deeper student engagement, contributing to its growing acceptance in educational settings.

[4] R. Horst, R. Naraghi-Taghi-Off, S. Diez, T. Uhmann, A. Müller, and R. Dörner, "Funplogs – a serious puzzle mini-game for learning fundamental programming principles using visual scripting," pp. 494–504, 2019.

The authors prototyped a game, FunPlogs, to teach about fundamental programming concepts through visual scripting. This is in the same vein with Scratch, however, it was developed with student collaboration in mind. The game's puzzles are made by the students themselves in VR. Meanwhile, solving these puzzles involves a personal computer and scripting with a simple visual programming language that has branching and looping constructs. The game received positive reviews from its participants and was perceived to be effective in teaching programming concepts.
A problem that is apparent in the methodology was the small sampling size of the participants. Furthermore, VR was mainly used in building puzzles rather than being involved directly in scripting, hence, students involved will need to switch sides from time to time for both to experience scripting. Despite that, this paper displays a promising possibility in the effectiveness of VR integration in a game-based approach in teaching programming by providing a creation medium.

[5] T. Mazuryk and M. Gervautz, "Virtual reality history, applications, technology and future," Institute of Computer Graphics and Algorithms, Vienna University of Technology, Favoritenstrasse 9-11/E193-02, A-1040 Vienna, Austria, Tech. Rep. TR-186-2-96-06, Feb. 1996.

The research article by Tomasz Mazuryk and Michael Gervautz, published in 1996, explores the early history and future potential of virtual reality (VR), focusing on its diverse applications and the technology behind it. Emerging during the 1980s and 1990s, VR technology is thoroughly analyzed in terms of systems, input/output interfaces, and software. The study highlights VR's potential applications in entertainment, education, and engineering, noting its many advantages while also addressing practical challenges.
The authors also discuss potential risks associated with VR, such as the possibility of reality escape, privacy concerns, addiction, and social isolation. Notably, this study, conducted over 25 years ago, not only recognized the potential of VR but also accurately forecasted its future impact on entertainment, industry, and the associated risks. Despite the promising outlook for VR, it is important to address these concerns to ensure

its responsible development and use.
Mazuryk and Gervautz also highlight the need for interdisciplinary collaboration to advance VR technology. They argue that progress in VR will depend on the combined efforts of computer scientists, engineers, psychologists, and artists to enhance user experiences and address the challenges associated with VR environments. By integrating insights from various fields, it is possible to develop more effective VR solutions and address the complex issues that arise. This perspective remains relevant as VR technology continues to evolve and improve.

[6] M. Papastergiou, "Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation," *Computers & Education*, vol. 52, no. 1, pp. 1–12, 2009. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0360131508000845

A study conducted by Marina Papastergiou aims to assess the impacts of Digital Game-Based Learning (DGBL) in high school Computer Science education in learning motivation and effectiveness. A sample of 88 students from Greek high school were respondents and were randomly assigned into two groups with the goal of the research comparing the learning outcomes of a computer game designed to teach computer memory concepts and a similar application in the form of a website lacking the gaming aspect containing the same material. Additionally, the study also investigated the effects of gender differences in learning motivation and effectiveness. The findings suggest that DGBL was more effective in enhancing students' knowledge of computer memory concepts and increasing learning motivation than the non-gaming approach. Although the boys were found to be more experienced and knowledgeable in computer games outside school, the gender differences were not that significant as both girls and boys achieved similar learning gains through DGBL. Meaning that DGBL can be equally effective for both genders in learning motivation and effectiveness.
The paper further discusses the benefits of educational games in terms of achievement of curricular objectives, motivation, and suggests more research on the impact of games in the long

term and game design complexity. Papastergiou underscores the integration of gaming elements in educational software to address the expectations of the students alongside their educational requirements. She argues that a well-designed educational-game can nourish critical thinking skills, problem solving skills, and interpersonal skills since the game will make the learning process more enjoyable.

[7] C. S. C. Rodrigues, "Visar3d: an approach to software architecture teaching based on virtual and augmented reality," in *2010 ACM/IEEE 32nd International Conference on Software Engineering*, vol. 2, 2010, pp. 351–352.

The study "VisAr3D: An Approach to Software Architecture Teaching Based on Virtual and Augmented Reality" introduces an innovative method for teaching software architecture using virtual reality (VR) and augmented reality (AR) technologies. The VisAr3D system aims to enhance student engagement and understanding through 3D visualization, interaction, and simulation, making it easier to learn about complex, large-scale systems. This tool lets students explore architectural models in an immersive virtual environment, allowing them to view, manipulate, and better understand software structures.
This study makes an important contribution to software engineering education by offering a modern approach to teaching complex concepts.The integration of VR and AR provides a flexible and interactive learning experience. However, further research is needed to evaluate the long-term impact of VisAr3D on student learning outcomes. While the emphasis on 3D visualization is a notable strength, some institutions may face challenges in adopting the technology fully due to resource limitations. This source is valuable for understanding the potential of VR and AR in education and contributes to the exploration of advanced teaching methods in software engineering.