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Enhancing Teaching and Learning through Virtual Reality: A Focus on Textile Materials †

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Abstract: Virtual reality (VR) is transforming education by enhancing the teaching and learning experiences. This study addresses the application of VR and focuses on understanding textile structures using a semester project as an example. VR immerses learners in 3D environments, going beyond traditional microscopy. In this project, textiles and partial textiles from vintage cars from the 1950s were converted from 2D microscope data into virtual reality, bringing together students of communication design, apparel technology, conservation, and excavation. Advanced digital microscopy was used to examine textile surfaces, transform the results into dynamic 3D data, and visualize textiles. This interdisciplinary collaboration promoted knowledge exchange, innovative teaching methods, and transformative thinking.

Keywords: virtual reality; 1950s vintage cars; immersive learning; 3D virtual environments; teaching and learning experiences; textile materials; innovative teaching approaches

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1. Introduction

In the dynamic landscape of the 21st century, the paradigms of education are undergoing swift transformation. Traditional didactic methods are being augmented and sometimes replaced by innovative digital tools and platforms. Virtual reality (VR) and augmented reality (AR) are revolutionizing education, offering enhanced teaching and learning experiences [1–3]. Moreover, virtual learning environments (VLEs) offer an encompassing digital setting in which learners can grasp knowledge and skills through multimedia content, interactive tasks, and real-time collaboration [4,5]. Over the past decade, extensive research has illuminated the profound impact of these environments in deepening and broadening the learning experience. Their utilization has been shown to elevate student engagement and retention, especially when they integrate interactive and immersive elements. Moreover, their inherent flexibility and accessibility emphasize their potential to provide equal learning opportunities to a diverse and global audience. The potential of VLEs transcends these foundational attributes. In academic teaching, especially in specialized fields, they present an unparalleled opportunity to simulate intricate environments or scenarios that might be challenging, costly, or impractical within the confines of a traditional classroom [5,6]. This facet is particularly prominent in disciplines such as textile education, where tactile and visual interaction with materials are crucial.

This research delves into VR's application to textile materials, emphasizing its potential to deepen understanding of textile structures. Unlike traditional microscopic views, VR enables immersive 3D exploration of textiles. Advanced microscopy techniques were used to examine textile surfaces, transforming results into dynamic 3D data to visualize textile ageing. This interdisciplinary effort fostered knowledge exchange, innovative teaching methods, and novel thought processes.

2. Materials and Methods

The semester project "Expedition Nano", with a total of 24 bachelor's and master's students from the departments of communication design, conservation and excavation technology, clothing technology, and production engineering at the HTW Berlin-University of Applied Sciences, lasted one semester (SS 2023, from April to July 2023). The results of the project were presented in an exhibition as part of the "Werkschau-HTW Berlin" in July 2023.

The "Expedition Nano" project pursues a number of goals, including the promotion of interdisciplinary cooperation, the application of theoretical knowledge in a practical context, and the development of problem-solving skills among students. Another central goal of the project is to promote creative thinking and innovative solutions. Effective teamwork and communication are also emphasized. The project provides students with insights into project management practices and is supported by the HTW Berlin's Teaching Innovation Fund (LIF), which focuses on innovative teaching methods. The improvement of teaching and learning through virtual reality and a focus on textile materials reflects these goals by emphasizing that virtual reality can be used as a tool to achieve these educational goals in relation to textile materials. It emphasizes the importance of interdisciplinary collaboration and the application of knowledge in a real context, with virtual reality as an innovative element to improve the learning process.

In an interdisciplinary workshop, students collectively defined three key parameters for the virtual learning environments: (1) Stakeholders involved: These encompassed students, teachers, administration, the interested public, and prospective students. (2) Learning objectives: These included understanding material properties, processes, the cultural and historical context of textile materials, and the origins of raw materials. (3) Teaching methods in VR: The options explored encompassed explorative learning, interactions, multiplayer experiences, and transmedia and hybrid-reality enactments. This framework laid the foundation for the creative process. Gradually, in collaboration and in small project groups, the defined goals were pursued and prototypes were developed that represented a virtual reality world in which textile materials played a role.

Textile samples were taken from different parts of 1950s vehicles that had been exposed to the elements for more than 27 years (Neandertal, Mettmann, Germany); these samples were used in one of the prototypes developed. The transition from 2D microscopy of textiles to 3D visualization was performed with the following tools:

RealityCapture (version 1.2, Epic Games, Inc., Cary, NC, USA) is a photogrammetry software used to create ultra-realistic 3D models from a set of images and/or laser scans. To process scanned objects and spaces into 3D models using photogrammetry and lidar scanners, the 3D Scanner App for iPad and iPhone (Laan Labs, version 1.1.4, New York, NY, USA) was used. Unity (Unity Technologies, Unity 2021.3.23f1 LTS, San Francisco, CA, USA) was used to create three-dimensional (3D) and two-dimensional (2D) objects, as well as interactive simulations and other experiences. The plugins used included: Unity URP Core, Mirror Network 78.3.0, TextMesh Pro 3.0.6, VIVE OpenXR Plugin-Android 1.0.5, XR Interaction Toolkit 2.3.1. Microscope Keyence (VHX-970F, KEYENCE Deutschland GmbH, Neu-Isenburg, Germany) was used for the microscope images of textiles.

The transition from 2D microscopy to 3D visualization began with the Keyence microscope's 3D representation method, which, while providing a pseudo-three-dimensional view, was limited to 2.5D, lacking depth for undercuts and overhangs in textile structures. To overcome this limitation, photogrammetry was adopted; photogrammetry is known for its precision in archaeology. A video of the textile sample was captured at a constant magnification, then segmented into frames for processing in RealityCapture, resulting in impressive 3D models. Beyond microscopy, the vintage cars were also scanned using photogrammetry and lidar using iPads and "3d Scanner App" by Laan Labs. Cinema 4D and Blender were employed for basic polygon reduction and complex retopology workflows. The result was a rich library of diverse 3D assets, including textile structures, garments, technical objects, vehicles, and landscapes.

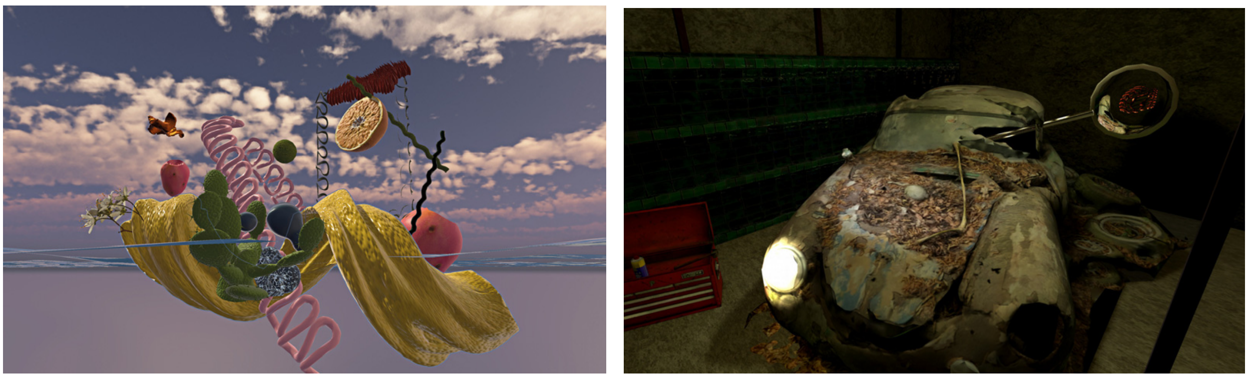
3. Results and Discussion

The journey from idea to reality involved intensive brainstorming in small, dynamic groups. Members rotated to bring in fresh perspectives and stimulate creativity. Four distinct ideas emerged from this creative atmosphere, leading to the formation of design teams and final prototypes. The process of refining these concepts and transforming them into tangible VR experiences was intricate, combining theoretical discussions with hands-on techniques. Methods such as "bodystorming", involving participants acting out scenarios, were crucial for visualizing and comprehending the concepts [7]. Additionally, techniques such as design thinking, scenario development, and rapid prototyping enhanced the creative process [8–10].

The motivation behind the project lies in the question of the possibility of immersing oneself in textile structures and not merely observing them through a microscope. Virtual reality (VR) was used as a tool to realize this possibility and to offer students an immersive experience that goes beyond conventional microscope observations. This emphasizes the importance of interdisciplinary collaboration and the application of knowledge in a real-world context, with virtual reality acting as an innovative element to enhance the learning process.

3.1. Developed Prototypes

The digital transformation of learning spaces has driven the development of immersive environments in educational paradigms. In the sphere of textile and clothing technology, the evolution of these environments aims to foster a deeper understanding and appreciation of materials. The undertaken project has resulted in the creation of four innovative prototypes, each embodying a unique perspective on textile exploration and education. The developed prototypes offer immersive experiences ranging from artistic representations to practical laboratory experiments. Each prototype, though different in its goals and designs, remains true to the overarching theme of textile innovation and education. These four VR works/prototypes were developed by students in collaborative efforts. Two VR works/prototypes are shown in Figure 1.



(**a**) (**b**)

Figure 1. VR Prototypes (**a**) *Morphoscapes: A Surreal Exploration of Alternative Textiles* and (**b**) *VRtex LAB: Virtual Engagement with Textile Testing*, featuring a 1950 Porsche. The images were created with the help of artificial intelligence.

- Morphoscapes: A Surreal Exploration of Alternative Textiles

Morphoscapes immerses users in alternative-textile landscapes, featuring materials such as cactus leather and algae textiles. It invites exploration through a captivating visual narrative and challenges conventional notions of textiles. This prototype is aimed at the general public and aims to showcase the potential of alternative materials (see Figure 1a). A notable feature is the option for self-guided exploration, similar to a hop-on-hop-off tour, ensuring diverse levels of engagement.

- VRtex LAB: Virtual Engagement with Textile Testing

VRtex LAB creates the atmosphere of a high-technology workshop where users immerse themselves in textile testing. They navigate through various experimental stations and gain foundational insights into material analysis. This prototype was specifically designed for first-year students in the textile technology program and serves as an introduction to textile analysis methods (see Figure 1b). A notable feature is the collaborative, multi-user experience that promotes team-based learning and experimentation.

- TEXTILE OASE: A Tactile Dive into Textile Properties

TEXTILE OASE offers an intimate exploration of everyday textiles, combining tactile stimuli with immersive visuals to deepen the understanding of fabric properties. This prototype is primarily targeted at clothing-technology students and aims to enrich their understanding of various fabric types. A unique feature of this prototype is the integration of real-life exhibits, enabling tangible interaction within the virtual realm.

- TRANSZENDENZ: Abstract Journey through Textile Realms

TRANSZENDENZ delves into abstract textile realms through sensory interactions, featuring worlds dedicated to textiles such as cord, denim, and terry fabrics This prototype is designed for textile and fashion students, encouraging innovative thinking. A notable feature is the combination of tactile surfaces and complementary auditory experiences, enhancing immersion and setting this prototype apart.

3.2. Key Learning Gains and Challenges

The process of deploying a VR environment had some challenges. Technically, achieving a seamless fusion of tactile stimuli in virtual domains posed persistent problems. However, advancements in VR frameworks provided solutions, enhancing user immersion. On the design front, the challenge was twofold: preserving the aesthetic allure while ensuring that the educational content was not overshadowed. It was an iterative dance of calibration, where feedback became the compass guiding design modifications to achieve an optimal blend. Notably, the fusion of different disciplinary perspectives, while enriching, introduced communication hiccups. Regular interdisciplinary dialogues, combined with clear documentation, emerged as the keystone for synchronizing visions.

3.3. Feedback and Findings from the Exhibition and Tests

The exhibition illuminated several facets of user interaction. Attendees' enthusiasm validated the project's innovative stance on textile education. However, this excitement came with constructive critiques: a call for improved guidance within VR for novices and occasional reports of motion sickness, pinpointing areas for future refinement. Through an educational lens, the prototypes struck a chord. While immersive, there was a suggestion to entrench structured lesson plans or guided tours in subsequent versions, ensuring consistent learning outcomes. Figure 2 shows the "Werkschau-HTW Berlin" exhibition, where the prototypes were presented.

(**a**) (**b**)

Figure 2. The 1950 vintage Lloyd and the "Werkschau-HTW Berlin" exhibition (**a**), where students explore 3D virtual reality worlds and prototypes (**b**).

Reflecting on the project's trajectory, the primary goals, such as fostering interactive environments and student engagement, were successfully met. Feedback affirmed the experiences as both enlightening and captivating. However, certain nuances, such as universally mitigating VR-induced motion sickness and maintaining intricate educational details, emerged as evolving challenges. These areas, initially earmarked but streamlined for user experience, lay the groundwork for the next iteration's objectives.

Marrying design thinking with iterative development, the project's methodology underscored the importance of continuous refinement. The intricacies of interdisciplinary collaboration spotlighted the imperative for structured communication and role clarity. Looking ahead, embedding early alignment workshops and intensive prototyping sessions might prove pivotal, ensuring a more cohesive development trajectory across varying disciplines.

4. Future Outlook

The exploration into virtual textile education represents only the tip of the proverbial iceberg. The project's success opens a gateway to a myriad of possibilities. The feedback and observations from the initial prototypes underline the potential for a more refined user experience, tailored to different learning styles. Looking ahead, there is potential for:

Expanded Content: Delve deeper into textile topics, perhaps including advanced material science, global textile trade dynamics, or sustainable textile innovations.

Integration with Augmented Reality (AR): With AR, allow users to overlay virtual textile information onto real-world objects, bridging the gap between tactile and digital experiences.

Wider Accessibility: Ensure that the virtual platforms are accessible to a diverse audience, considering factors such as disabilities, ensuring a broader reach.

Collaborative Opportunities: Enhance the multiplayer experiences and facilitate global collaborations, allowing students from different parts of the world to interact, share, and learn together. Moreover, the learning gains from this project could potentially influence and inspire the adoption of similar virtual paradigms in other educational fields.

5. Conclusions

The endeavor to combine textile education with virtual reality marks an innovative stride towards modern educational methodologies. This project, rooted in interdisciplinary collaboration, has not only demonstrated the feasibility of such a merger but also highlighted the rich, immersive learning experiences it can offer. While there were challenges along the way, the resultant prototypes stand as a testament to the synergy of creativity, technology, and domain expertise. As we reflect on this journey, it becomes evident that the fusion of virtual environments with traditional fields such as textile education has immense potential. It not only paves the way for engaging, interactive learning but also sets the stage for the evolution of educational paradigms in the digital age.

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References

1. Rojas-Sánchez, M.A.; Palos-Sánchez, P.R.; Folgado-Fernández, J.A. Systematic literature review and bibliometric analysis on virtual reality and education. *Educ. Inf. Technol.* **2023**, *28*, 155–192. [CrossRef] [PubMed]
2. Burov, O.Y.; Pinchuk, O.P. A meta-analysis of the most influential factors of the virtual reality in education for the health and efficiency of students' activity. *Educ. Technol. Q.* **2023**, *1*, 58–68. [CrossRef]
3. Kuna, P.; Hašková, A.; Borza, L'. Creation of Virtual Reality for Education Purposes. *Sustainability* **2023**, *15*, 7153. [CrossRef]
4. Cho, Y.; Park, K.S. Designing Immersive Virtual Reality Simulation for Environmental Science Education. *Electronics* **2023**, *12*, 315. [CrossRef]
5. Jardin, E.J. Exploring the Use of Technology in Environmental Education: Teachers' and Students' Perspectives. *Excell. Int. Multi-Discip. J. Educ.* **2023**, *1*, 118–126. Available online: http://multijournals.org/index.php/excellencia-imje/article/view/12 (accessed on 20 July 2023).
6. Hamilton, D.; McKechnie1, J.; Edgerton, E.; Wilson, C. Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes and experimental design. *J. Comput. Educ.* **2021**, *8*, 1–32. [CrossRef]
7. Börütecene, A. Bodystorming for VR in the Dark: Using Glow Sticks for Ideation and Rapid Prototyping. In Proceedings of the 2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), Shanghai, China, 25–29 March 2023; pp. 547–550. [CrossRef]
8. Kurek, J.; Brandli, L.L.; Leite Frandoloso, M.A.; Lange Salvia, A.; Mazutti, J. Sustainable Business Models Innovation and Design Thinking: A Bibliometric Analysis and Systematic Review of Literature. *Sustainability* **2023**, *15*, 988. [CrossRef]
9. Kim, J.; Ryu, S.J. Enhancing Sustainable Design Thinking Education Efficiency: A Comparative Study of Synchronous Online and Offline Classes. *Sustainability* **2023**, *15*, 13293. [CrossRef]
10. Katsumata Shah, M.; Jactat, B.; Yasui, T.; Ismailov, M. Low-Fidelity Prototyping with Design Thinking in Higher Education Management in Japan: Impact on the Utility and Usability of a Student Exchange Program Brochure. *Educ. Sci.* **2023**, *13*, 53. [CrossRef]