electronics

Article

Utilization of Immersive Virtual Reality as an Interactive Method of Assignment Presentation

Martin Krajčovič, Marián Matys, Gabriela Gabajová * and Dávid Komačka

Faculty of Mechanical Engineering, University of Žilina, 010 26 Žilina, Slovakia; martin.krajcovic@fstroj.uniza.sk (M.K.); marian.matys@fstroj.uniza.sk (M.M.); david.komacka@fstroj.uniza.sk (D.K.)

* Correspondence: gabriela.gabajova@fstroj.uniza.sk; Tel.: +421-41-513-2731

Abstract: Virtual reality is a technology with many possible uses and ways to improve various processes, including the presentation of results. This paper deals with the utilization of virtual reality as a tool for assignment presentation. During the classes of manufacturing and assembly systems design, the conventional form of presentation was replaced with immersive virtual reality, where the students would present their work while wearing the virtual reality headset and walking around the 3D model of their design. The main goal was to test whether this approach had a positive impact on the students' motivation and engagement in the presentation creation and presenting itself. To test this approach, a small case study took place at the Department of Industrial Engineering, Faculty of Mechanical Engineering at the University of Žilina. In conclusion, the overall responses to this experiment were positive; the majority of the students felt more comfortable while presenting and more motivated to put more effort into their preparation. Wearing a virtual reality headset caused the students not to have to directly face the audience, giving them more confidence while presenting. Additionally, the novelty of the virtual reality technology made the students more engaged in showing their work. There is a plan to integrate the virtual reality presentation as the stable part of this assignment.

Keywords: virtual reality; education; interactive training

Citation: Krajčovič, M.; Matys, M.; Gabajová, G.; Komačka, D. Utilization of Immersive Virtual Reality as an Interactive Method of Assignment Presentation. *Electronics* **2024**, *13*, 1430. https://doi.org/10.3390/electronics13081430

Academic Editor: Osvaldo Gervasi

Received: 14 March 2024
Revised: 4 April 2024
Accepted: 9 April 2024
Published: 10 April 2024

1. Introduction

The versatility of virtual reality enables it to be used in various ways and circumstances [1]. Its high level of immersion and interactivity creates a great foundation for effective teaching [2–6], simulation [7,8] or development methods [9–11]. Especially in education, the novelty of virtual reality may be the selling point to catch the attention of the students [12].

One of the viable uses of virtual reality lies in the design of manufacturing or assembly systems. Such systems are complex and take a long time to develop, while all weaknesses should be improved before the implementation. When progressing further into new manufacturing or assembly system integration, the cost for any changes increases. Therefore, it is vital to identify any shortcomings of the design as early as possible. Virtual reality can prove to be a powerful tool in this regard [13]. 3D immersive visualization of the design can offer a new perspective and can help to identify any problems or points for improvement [14]. Instead of the conventional top-down look of the designing software, immersive virtual reality offers a point of view of the employee walking through the designed system. This new perspective can enhance the analysis and discoveries of potential improvements. Moreover, virtual reality can also serve as a useful tool to visualize and present the proposed design to the audience. People can walk through the new manufacturing or assembly system before the construction work even begins. For this reason, this potential utilization of virtual reality technology was chosen as a cornerstone for this experiment.

Presenting your work is the most vital part of the entire process to convey all the findings and effort put into all previous steps. Therefore, students should be led to improve their presentation skills on any possible occasion. Even a well-made assignment may be perceived as lacking if important points are not conveyed in the limited time of the final presentation. Since presenting itself is disliked by many students, it is important to find new ways to motivate students and make assignment presentations a more engaging experience.

Virtual reality may be one of the tools suitable for this task [15,16]. In suitable circumstances, an interactive virtual environment can be used as an immersive space for students to present their work [17–22].

With the transition to human-centred Industry 5.0, it is necessary to train employees, and even students during their industrial engineering studies, in complex industrial systems. By leveraging immersive technologies, operators can gain practical experience and training. There is a rapid evolution in the field of industrial engineering towards a focus on people, sustainability and ecology [23–27].

In the presented study, the students were tasked to present their assignments in virtual workplaces that they created themselves (while the design of such virtual workplaces was the goal of the assignment itself). The experiment took place at the Department of Industrial Engineering, Faculty of Mechanical Engineering at the University of Žilina. The students worked on the assignment the standard way; however, instead of presenting their results using a slideshow, their designs were exported into an immersive interactive virtual environment. In a previous study, virtual reality was used to help students with the process of workplace design itself [28].

This time, its focus was solely on work presentation. Instead of pre-made slides, presenters (students) would walk in their virtual design using virtual reality headsets and controllers, while showing the audience all the details of their work on the screen. If a member of the audience (another student or teacher) was curious about a specific part of the design, they could ask the author to move into that area. Moreover, they themselves could put on virtual reality headsets and take a look. In addition, this method of presentation requires the transformation of the regular 3D design into an interactive environment; therefore, the students would also learn the valuable experience of virtual reality application development.

To test these hypotheses, however, firstly the first part of the assignment had to be accomplished using the standard methods according to the study plan. Therefore, the entire assignment was divided into three parts, as shown in Figure 1. The main goal of the assignment was to design a manufacturing system according to the specified parameters using the VisTable software (https://www.vistable.com/ accessed on 15 January 2023). Then, instead of the standard Microsoft PowerPoint presentation used in previous years, the students exported their design as a 3D model into the game engine and transformed it into immersive virtual reality applications. These were then used for the assignment presentation at the end of the semester. The entire assignment was spread throughout eight weeks with one 3 h session each week.

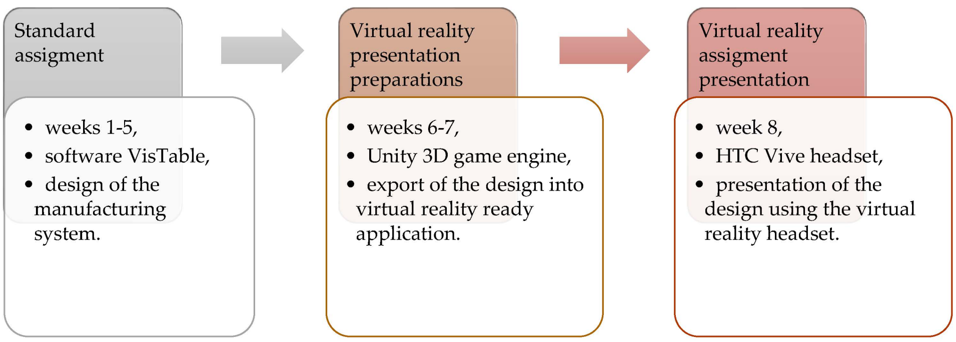

Figure 1. The assignment schedule and content.

2. Related Works

A similar study in the professional literature was published by Ricci et al. [29], examining the impact of the application of mixed reality in the field of industrial design. In their work, they presented an innovative laboratory with an integrated multidisciplinary approach. The laboratory combined theory with practice. The results of the study showed positive feedback in terms of efficiency, usefulness and effectiveness in designing industrial design. Ghazali et al. [30] investigated the use of virtual reality in higher education. Traditional teaching approaches such as diagrams and illustrations have limited capabilities. Visualization using virtual reality can help to better understand the issue, e.g., when teaching electrical engineering. The authors also present their own laboratory, which is intended for electronics engineering students. When comparing the results, the students using virtual reality technology achieved a higher understanding of the issue and higher problem-solving skills. In their study, Jiawei et al. [31] investigated the development trend of virtual reality technology in the fields of product design, art and design.

3. Methodology

The presented study took place between February and May 2023. Two groups of students, with a total of 23 participants, at the Department of Industrial Engineering, took part in classes on manufacturing and assembly system design. The main objective of the case study was to confirm or refute two hypotheses. These hypotheses question the effect of different approaches to assignment presentation and how they can affect the results compared to conventional methods. These hypotheses are as follows:

Hypothesis 1. *Utilization of virtual reality as a form of results presentation increases the engagement and motivation of students, both while presenting their own results and listening to others.*

Hypothesis 2. *Students feel more confident and comfortable showing their results to the audience while using immersive virtual reality to do so.*

The first hypothesis questions whether the technology of virtual reality has a positive impact on the process of assignment presentation, making students more invested in their presentation and the conveying of the results of their work more efficient. The main assumption is that replacing standard slideshow presentations with interactive technology will motivate students to make more effort while feeling more engaged with the presented topic.

The second hypothesis questions whether enhancing presentation with immersive virtual reality technology can help students to be more confident and immersed while presenting, which is often an issue for people with less experience with presenting.

These two hypotheses are based on the fact that with the rapid development of virtual reality, it is becoming more and more popular for mainly younger audiences, while further refining its ability to provide an immersive experience. The study assumes that the utilization of new technologies will make students more engaged, while this unconventional form of presentation can help them with their shyness when presenting in front of an audience.

Since students are not bound to presentation slides, this should give them more options during a presentation and better tools to answer questions from the audience. This is because the virtual reality presentation will encompass the entire assignment (design created according to the assignment parameters) instead of just selected parts. Another of the possible affected parameters is the length of the presentation, which could be increased due to the potential of the enhanced engagement in immersive virtual reality.

The first five weeks took place in the regular settings of the manufacturing system design laboratory. Groups of students performed all the preparation and necessary calculations followed by creating their own design in the VisTable software. The last three weeks took place in the laboratory of the digital enterprise, containing the necessary virtual reality headsets, the Unity 3D software (https://unity.com/ accessed on 15 January 2023) and the required space for the virtual reality presentation. The small number of students in the class allowed them to comfortably watch the presentation on the screen of the monitor. However, in the future, widescreen television will be installed and used for larger-scale virtual reality presentations and other purposes.

3.1. Manufacturing System Design According to the Standard Assignment

The assignment itself utilized the standard approach according to the study plan. The main objective was for the students to design their own manufacturing system while respecting the set parameters. The students worked in groups of two (groups of three sometimes if the number of students was not even), and each assignment had different parameters. The assignment parameters that varied were as follows:

- Products that will be manufactured (two for each assignment);
- Available machine tools;
- The technological method used for each product;
- Production volume for each product per year.

The first two weeks of the assignment focused on the students familiarizing themselves with VisTable software and all the necessary calculations. The students needed to calculate all the necessary components according to the production volume and all the other parameters, such as the number of transportation and storage units or the number of machine tools necessary to cover the production.

In the next step, the students used all the gathered data to make two designs. First was the initial design focusing mainly on creating a functional manufacturing system that covered all the parameters. Second was the improved design (an improved version of the first design), focused on improving various aspects such as material flow or effectiveness of transport. The software VisTable offers various tools for optimization while students can come up with their own improvement ideas. Figure 2 shows one of the assignments being worked on in the VisTable software.

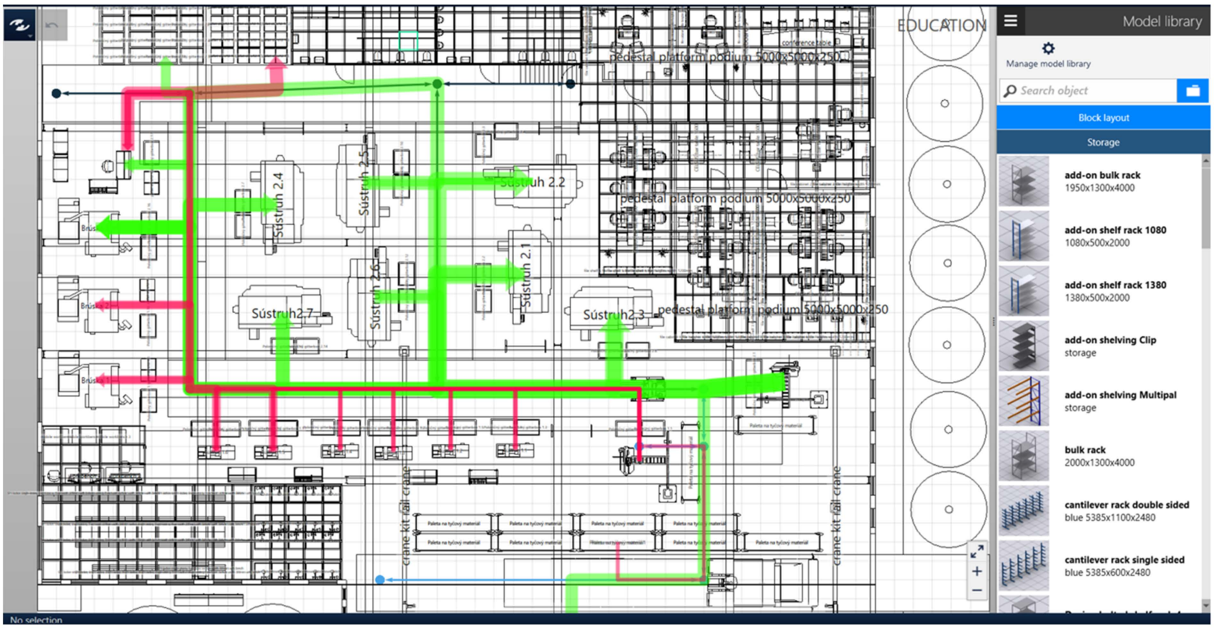

Figure 2. An assignment in the VisTable software.

The students needed to cover all the necessary areas of the manufacturing system design, such as storage, transportation, quality control or material flow. They also needed to take all regulations and standards into account, for example, security areas or security of transportation paths. An effective layout of the machine tools and material flow planning were crucial parts of the assignment and can become useful skills in the future careers of the students.

In addition, each object in the 2D layout was represented by its 3D counterpart. Therefore, the proposed design could be immediately transformed into a 3D form, giving the students a close idea of how the final product would look like. Figure 3 shows the 3D showcase of the created design.

Figure 3. The 3D view of the assignment.

Looking at the assignment from a 3D perspective may give students more ideas, which can be even more effective when paired with immersive virtual reality technology. When students are satisfied with their initial design, they can focus on the optimization and finishing touches. The 3D version of the design is immediately ready to be used, which means that it can be exported from the software and used for various tasks. In this case, the created manufacturing system can be exported in its entirety and transformed into immersive and interactive virtual environments.

3.2. The Creation of an Immersive Virtual Reality Visualization of a Proposed Design

When satisfied with their proposed designs, the students could export the 3D model of the manufacturing system for the preparation of the assignment presentation. Since VisTable software offers a feature of quick export, it is really easy for students to do so (also shown in Figure 3, highlighted with a red square). Designs are exported in a ".obj" format which is commonly used in virtual reality applications. However, before exporting the 3D model to Unity 3D (a game engine that is used for the interactive virtual environment creation), it can be imported into the 3D modelling software to detect and fix potential inaccuracies. Figure 4 shows one of the assignments being modified in Blender 3D modelling software (https://www.blender.org/download/ accessed on 15 January 2023).

The most common problems were the incorrect rotation and scale of the models or their displacement. In rare cases, some parts of the model, such as machine tools, were missing faces (surface of the 3D model), which can be easily fixed either by students or with the teacher's help. Modified 3D models can then be exported again in the same format, and finally imported into the Unity 3D game engine. Importing itself can be easily achieved by dragging and dropping a 3D model file into the project library.

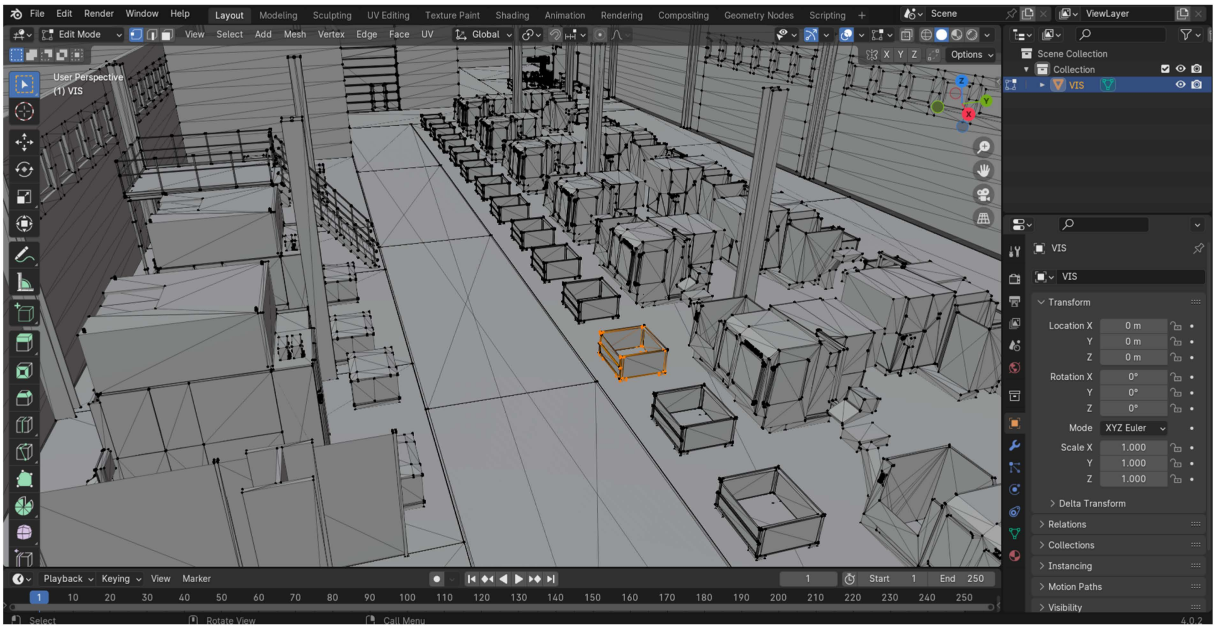

Figure 4. Fixing imperfections in Blender 3D modelling software.

To make things easier, a special project package was created in Unity 3D that contains all the necessary tools and settings to create an interactive virtual environment. It uses the OpenXR toolkit which contains all the necessary basics for virtual reality application creation. Moreover, this project already contains scenes with virtual reality locomotion, virtual reality avatar and other necessary elements preset. Unity 3D itself is also already set up for the development of virtual reality applications. This means that students will spend considerably less time setting up the virtual reality project and can focus on the assignment presentation itself. Instead of creating a new Unity 3D project, students can open their copies of previously prepared projects and import their work into it.

After the 3D model of the designed manufacturing system is imported, students can check for any remaining irregularities for possible additional adjustments. Figure 5 shows the designed manufacturing system imported into the Unity 3D game engine.

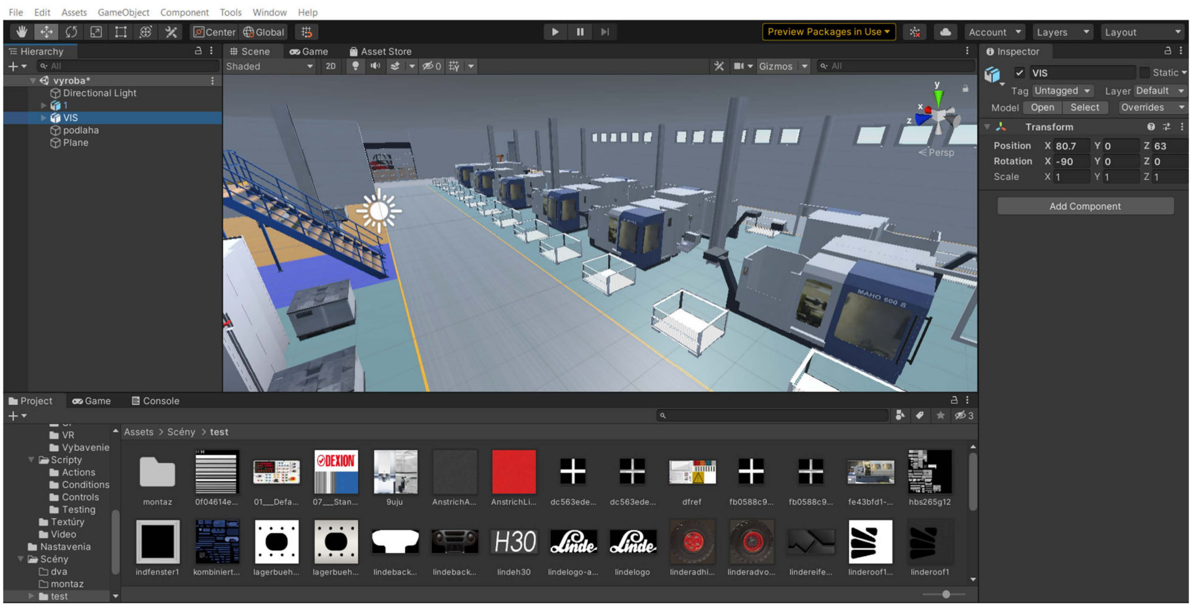

Figure 5. Imported assignment in Unity 3D game engine.

The scale of the 3D model is especially important since its real height will be used in the virtual environment. The next step is securing the locomotion across the entire design. As mentioned before, all necessary tools were prepared in advance; therefore, students do not need any programming knowledge. All necessary locomotion scripts are already included in the project. Students simply apply a selected script to the floor of their design to create a teleportation area, which is the preferred type of locomotion in this case. The project also contains the "XR RIG" which represents the player after the application is launched; it contains the camera for the POV of the players and hand models. Figure 6 shows the teleportation script and XR RIG added to a student's project.

Figure 6. Adding key elements to the project.

At this point, the application is ready to be launched. Students can press play, put on the headset and move across their proposed design using the teleport locomotion. The main goal is to present the second out of two created designs (as mentioned before, the students created a basic and an improved design); however, the students also created buttons which can be pressed to switch between both designs, as shown in Figure 7.

Figure 7. Switching between designs.

With the virtual environment prepared, the students could now focus on the presentation itself. The main focus was to determine how to use the provided time to show all the important parts of the assignment. The students were not blinded by the presentation slides, but could move freely across their design while presenting, which can be overwhelming without proper preparation. Some of the students imported images containing important data, such as material flow visualizations, and used them as presentation slides directly inside the virtual environment. Figure 8 shows one of the students in virtual reality highlighting the data with a virtual reality laser pointer. This proved to be a great help in visualizing the key aspects of the designs. With everything prepared, during the last week of assignment creation, the students presented their work.

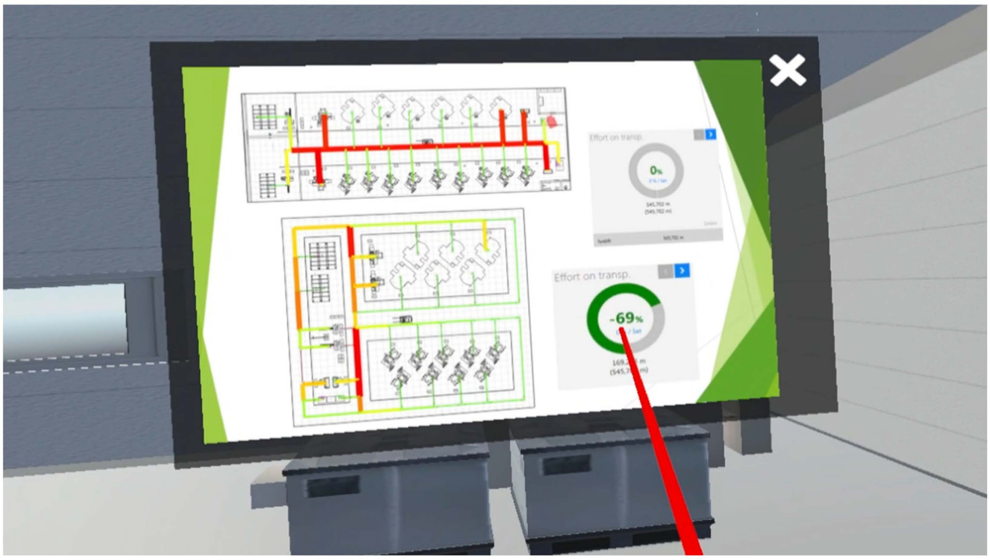

Figure 8. Presenting data in virtual reality.

3.3. The Presentation of the Assignment Using Virtual Reality Technology

In the eighth week of the assignment, the students finally presented their work. Presenting students put on the virtual reality headset to navigate through their design, while the rest of the students watched their movements on the screen. Since the assignments were created mostly by a team of two, halfway through, students switched headsets for both to cover the parts that they had worked on. The presenters showed the students the most important parts of their work, explaining why they decided to choose this design, while backing it up with data (collected from the VisTable software). For example, instead of showing the graph of current material flow, the students could walk from the first operation of the manufacturing system to the last operation, explaining the whole process step by step. Instead of showing the system bottleneck in the picture, they could walk to it in virtual reality and explain the problem and its potential improvement in the context of previous and following operations. After the main part of the presentation ended, the audience (other students) could ask additional questions. Since the entire design was imported in virtual reality, the presenting students could easily navigate to the questioned area and visualize their answers. Any student could also take the virtual reality headset themselves and walk through the design, which often generated more questions.

In previous years, the mandatory length of the presentation was 6 to 10 min. This year, however, the minimum length was still 6 min, but the students were allowed to prolong their presentation, mainly because other students had the opportunity to wear the headsets themselves (after the prepared presentation ended), walk around and ask the authors additional questions. Figure 9 shows the students exploring the designs during the presentation day.

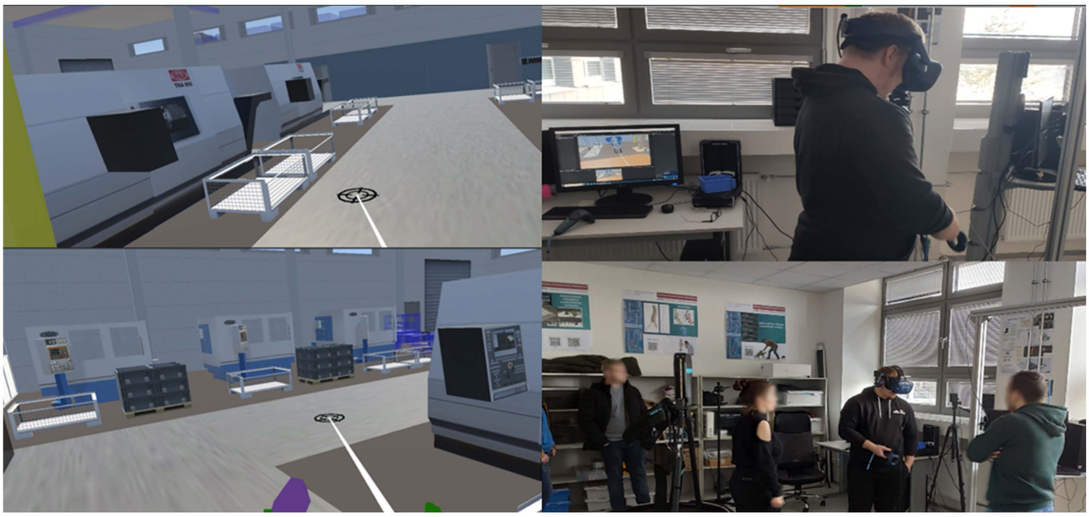

Figure 9. Presentation of the assignments.

After the presentation, the students filled out a short questionnaire to sum up the experience, asking for their opinions on this type of presentation, its positives and drawbacks.

4. Results

The first interesting thing to note is the length of the presentations. As mentioned before, the standard minimum length of the presentation was 6 min, while the maximum length of the presentation was 10 min. In previous years, students would often plan their presentations to match the minimum threshold (six minutes). Many students are not fond of presenting before an audience, which explains the short length of the presentation. This time, however, the maximum presentation time limit was removed, and the students were given a free hand on how to utilize the virtual reality technology to present their work effectively.

Among the two study groups, there was a total of 11 groups of students (10 groups of 2 and 1 group of 3), 25 students in total, with 22 male and 3 female participants at the age of 22 or 23. The average presentation time was 21 min, including the post-presentation discussion. The other students (who did not produce the currently presented assignment) would often put on the headset and walk around the design themselves. This encouraged the additional dialogue, where the students would ask questions and give their opinions on how they would further improve the presented manufacturing system. Compared to the classic PowerPoint slides presentation, the engagement of the students was significantly higher, whereas in previous years, students would rarely ask questions after the presentation ended.

The next important pointer for the experiment results is the questionnaire. This questionnaire contained multiple questions, evaluating the students' overall satisfaction. The first part contained closed questions with "yes", "no" or "not sure" options. These mainly questioned virtual reality as a tool for assignment presentation. The second part focused on the positive and negative sides of the utilization of virtual reality for presenting, while students could select from one of the few pre-written answers or write their own. The results for the first part of the questionnaire are shown in Figure 10. After the questionnaire, a short group interview was held, discussing all the stated questions and the reasoning behind the students' answers.

The results of the first part of the questionnaire seemed positive. Even though this was the first immersive virtual reality experience for less than half of the students, the negative effects of virtual reality usage were not as prevalent. Of the students, 87% expressed that utilization of virtual reality made them more motivated to put more effort into their presentation. The main reasoning seems to be the novelty of the technology and the change from the regular PowerPoint presentation model (resulting from the post-questionnaire interview). Of the students, 74% preferred this form of presentation over the conventional method (PowerPoint presentation). Since the majority of the assignments were presented using the same method, the students reacted to the change positively; however, during the interview they expressed their concern about the limited use of this type of presentation. Lastly, 70% of the students were more confident and comfortable with this type of presentation. During the interviews, the main reason given was the fact that they did not have to directly face the audience. Instead, they were immersed in the virtual world and more focused on showing their work to the audience. On the other hand, this was perceived as a negative by a few of the students. Their reasoning was that maintaining eye contact and conventional presenting in front of a crowd is a vital skill, that should be practised as much as possible.

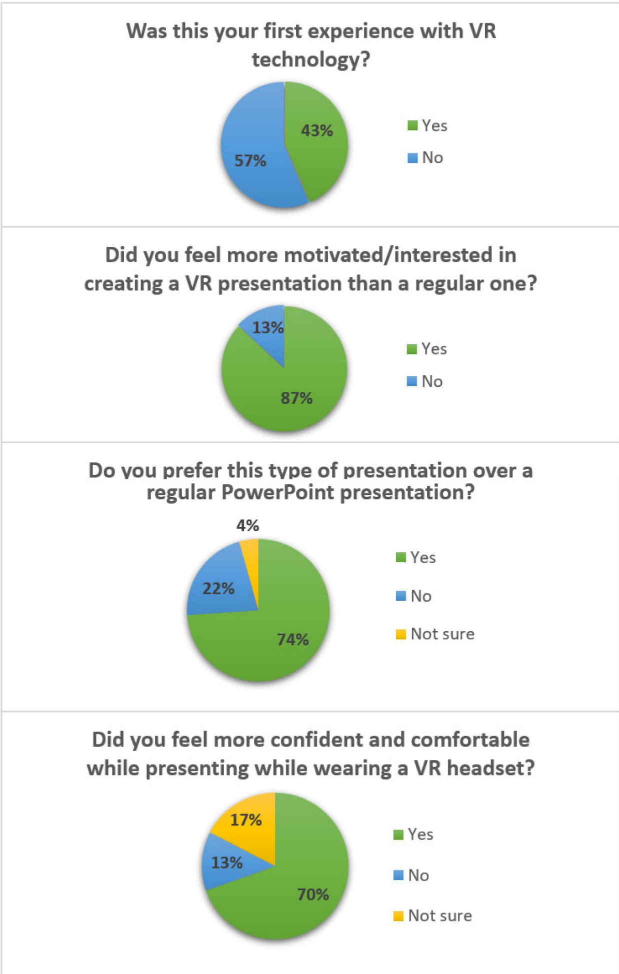

Figure 10. First part of the questionnaire.

The answer for the second part of the questionnaire (shown in Figure 11) corresponded with the interview. As the biggest advantage, the students chose the novelty of the technology which motivated them to put more effort into their work, due to their interest in working with this type of immersive technology. Moreover, the majority considered this type of presentation to be easier and more engaging since they did not have to face the audience while being more flexible with free movement across their designs.

On the other hand, simulator sickness was considered as the main disadvantage. This time, because of the short nature of the presentations, the related problems were not as significant, but the students recognized the potential issues during prolonged use. If virtual reality were to be used as the technology during a longer presentation, simulator sickness could significantly affect the presenter's ability to convey their message. More than half of the students also recognized the limited possible utilization of this type of presentation. In practice, the conventional presentation method will still be much more prevalent. Finally, the smart group of students also saw the elimination of direct contact with the audience as a negative thing. As mentioned before, they considered maintaining eye contact and conventional presentation skills as something that should be frequently practised and not replaced.

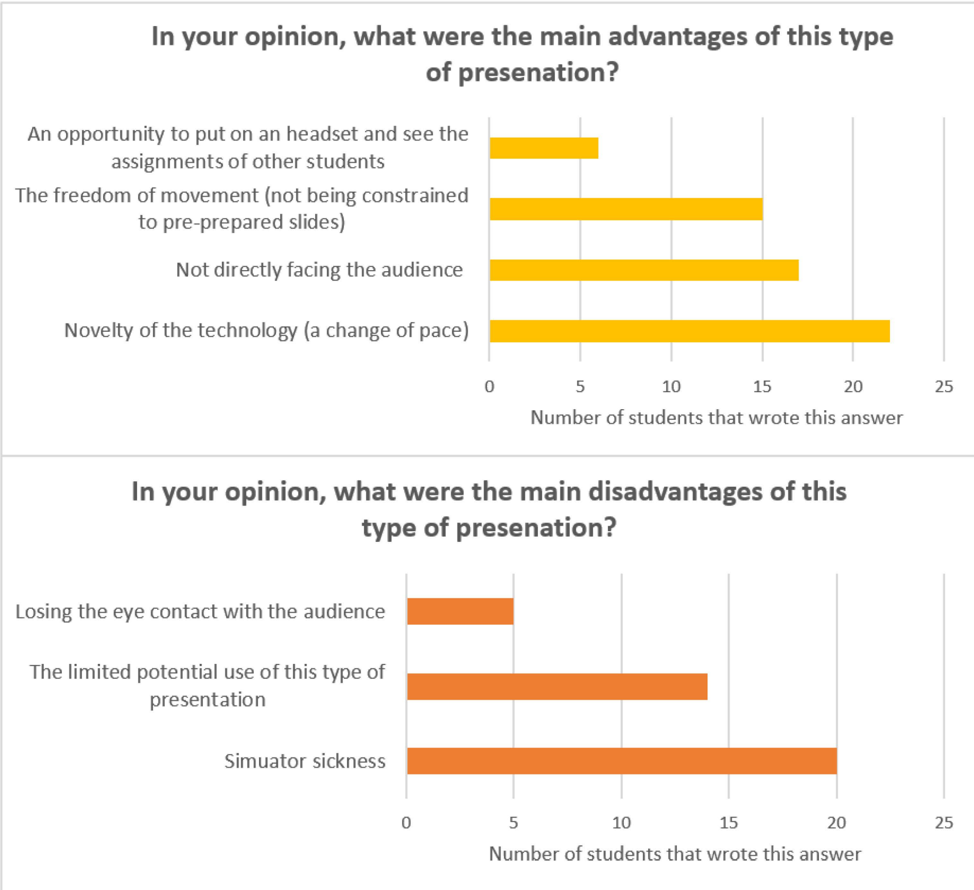

Figure 11. Second part of the questionnaire.

In the end, all assignments were put into one project to create a virtual reality application allowing one to browse all the designs. This means that any user could put on the virtual reality headset, launch the application and walk across all of the designed manufacturing systems. Using the GUI, a player can switch between all the assignments. Pressing the button will instantly teleport them into the desired manufacturing system (assignment).

5. Conclusions

The students seemed more outspoken during the presentation, which could be caused by the presenters not directly facing the audience, thus feeling more comfortable and less nervous. The increased interactivity of the presentation also helped to increase the average length of the presentation and the engagement of the audience (the students).

The main goal of the study was to confirm or refute the two proposed hypotheses.

The first hypothesis questioned whether the technology of virtual reality has a positive impact on the process of assignment presentation and its preparation. The utilization of virtual reality as a tool for assignment presentation seemed to receive overall positive feedback from the students, while visibly increasing the engagement and motivation of the students, manifesting in them putting more effort into their presentations. Therefore, it is possible to consider this hypothesis to be confirmed. However, it is important to note that the usage of virtual reality for presentations may not be suitable in many cases.

The second hypothesis questioned whether enhancing presentations with immersive virtual reality technology can help students to be more confident and immersed. Due to the significant increase in the average length of the presentation, it would seem that the students were more comfortable presenting this way. The results of the questionnaire also support this claim. Although for both hypotheses, the results were positive, due to the small sample size, similar experiments will be conducted in the future to further improve this approach.

In conclusion, the utilization of virtual reality as a presentation tool for students ended up being an effective alternative. On the other hand, it is worth noting that this type of presentation may be limited in potential cases of use. In many circumstances, a regular form of presentation may be necessary, but it is an interesting approach to make students more engaged and motivated for the presentation of their results. Moreover, these different approaches to presentation may help students slowly build confidence that can translate into regular face-to-face presentations.

At the Department of Industrial Engineering, Faculty of Mechanical Engineering at the University of Žilina, many assignments focus on industry-related designs; therefore, this new virtual reality approach can be applied and tested for various classes throughout the curriculum. It is important to always assess the benefits and drawbacks of applying this new approach to the education process.

Author Contributions: Conceptualization, M.M., M.K. and G.G.; methodology, M.M.; software, M.M. and G.G.; validation, M.M. and M.K.; formal analysis, D.K. and G.G.; investigation, M.M.; resources, M.M. and G.G.; data curation, M.K. and D.K.; writing—original draft preparation, M.M. and G.G.; writing—review and editing, M.M. and G.G.; visualization, M.M. and D.K.; supervision, M.K.; project administration, M.K. and G.G.; funding acquisition, M.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by KEGA. Grant number 003ŽU-4/2022. Use of XR (eXtended Reality) spectrum for the creation of interactive trainings and educational games in the education of industrial engineers. This work was supported by the Slovak Research and Development Agency under the contract no. APVV-21-0308. This article was created with the support of VEGA project: VEGA 1/0150/24.

Institutional Review Board Statement: Ethical review and approval were waived for this study due to the full anonymization of the date with no possibility of retrospective deanonymization of individuals.

Data Availability Statement: The data presented in the case study are available from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Viudes-Carbonell, S.J.; Gallego-Durán, F.J.; Llorens-Largo, F.; Molina-Carmona, R. Towards an Iterative Design for Serious Games. *Sustainability* **2021**, *13*, 3290. [CrossRef]
2. Pei, W.; Lo, T.T.S.; Guo, X. Integrating Virtual Reality and interactive game for learning structures in architecture: The case of ancient Chinese dougong cognition. *Open House Int.* **2023**, *48*, 237–257. [CrossRef]
3. Sung, C.; Chin, S. Contactless Multi-User Virtual Hair Design Synthesis. *Electronics* **2023**, *12*, 3686. [CrossRef]
4. Nuño, P.; Bulnes, F.G.; Pérez-González, S.; Granda, J.C. Asterisk as a Tool to Aid in Learning to Program. *Electronics* **2023**, *12*, 1160. [CrossRef]
5. Shin, K.-S.; Cho, C.; Ryu, J.H.; Jo, D. Exploring the Perception of the Effect of Three-Dimensional Interaction Feedback Types on Immersive Virtual Reality Education. *Electronics* **2023**, *12*, 4414. [CrossRef]
6. Marougkas, A.; Troussas, C.; Krouska, A.; Sgouropoulou, C. Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade. *Electronics* **2023**, *12*, 2832. [CrossRef]
7. Mozolova, L.; Grznar, P.; Mozol, S.; Krajcovic, M. Streamlining utilization of the assembly line using computer simulation. *Acta Logist.* **2023**, *10*, 165–173. [CrossRef]

8. Grznár, P.; Gregor, M.; Krajčovič, M.; Mozol, Š.; Schickerle, M.; Vavrík, V.; Ďurica, L.; Marschall, M.; Bielik, T. Modeling and Simulation of Processes in a Factory of the Future. *Appl. Sci.* **2020**, *10*, 4503. [CrossRef]
9. Kamińska, D. Recognition of Human Mental Stress Using Machine Learning: A Case Study on Refugees. *Electronics* **2023**, *12*, 3468. [CrossRef]
10. Mnguni, L.E. The theoretical cognitive process of visualization for science education. *SpringerPlus* **2014**, *3*, 184. [CrossRef]
11. Huang, X.; Zou, D.; Cheng, G.; Xie, H. A Systematic Review of AR and fig Enhanced Language Learning. *Sustainability* **2021**, *13*, 4639. [CrossRef]
12. Rodríguez-Cano, S.; Delgado-Benito, V.; Ausín-Villaverde, V.; Martín, L.M. Design of a Virtual Reality Software to Promote the Learning of Students with Dyslexia. *Sustainability* **2021**, *13*, 8425. [CrossRef]
13. Broo, D.G.; Kaynak, O.; Sait, S.M. Rethinking engineering education at the age of industry 5.0. *J. Ind. Inf. Integr.* **2022**, *25*, 100311.
14. Radianti, J.; Majchrzak, T.A.; Fromm, J.; Wohlgenannt, I. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Comput. Educ.* **2019**, *147*, 103778. [CrossRef]
15. 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]
16. Freina, L.; Ott, M. A literature review on immersive virtual reality in education: State of the art and perspectives. In Proceedings of the the International Scientific Conference Elearning and Software for Education, Madrid, Spain, 26–29 June 2015; Volume 1.
17. Holuša, V.; Vaněk, M.; Beneš, F.; Švub, J.; Staša, P. Virtual Reality as a Tool for Sustainable Training and Education of Employees in Industrial Enterprises. *Sustainability* **2023**, *15*, 12886. [CrossRef]
18. Kavanagh, S.; Luxton-Reilly, A.; Wuensche, B.; Plimmer, B. A systematic review of virtual reality in education. *Themes Sci. Technol. Educ.* **2017**, *10*, 85–119.
19. Ghosh, A.; Brown, V.; Huang, S. Education Applications of 3D Technology. In Proceedings of the Society for Information Technology & Teacher Education International Conference, Washington, DC, USA, 26 March 2018; Association for the Advancement of Computing in Education (AACE): Waynesville, NC, USA; pp. 426–436.
20. Xu, X.; Ke, F. Designing a virtual-reality-based, gamelike math learning environment. *Am. J. Distance Educ.* **2016**, *30*, 27–38. [CrossRef]
21. Bolier, W.; Hürst, W.; Van Bommel, G.; Bosman, J.; Bosman, H. Drawing in a virtual 3D space-introducing VR drawing in elementary school art education. In Proceedings of the 26th ACM International Conference on Multimedia, Seoul, Republic of Korea, 22–26 October 2018; pp. 337–345.
22. Cheng, K.H.; Tsai, C.C. A case study of immersive virtual field trips in an elementary classroom: Students' learning experience and teacher-student interaction behaviors. *Comput. Educ.* **2019**, *140*, 103600. [CrossRef]
23. Mourtzis, D.; Angelopoulos, J. Development of an Extended Reality-Based Collaborative Platform for Engineering Education: Operator 5.0. *Electronics* **2023**, *12*, 3663. [CrossRef]
24. Rakyta, M.; Bubenik, P.; Binasova, V.; Micieta, B.; Staffenova, K. Advanced Logistics Strategy of a Company to Create Sustainable Development in the Industrial Area. *Sustainability* **2022**, *14*, 12659. [CrossRef]
25. Micieta, B.; Binasova, V.; Marcan, P.; Gaso, M. Interfacing the Control Systems of Enterprise-Level Process Equipment with a Robot Operating System. *Electronics* **2023**, *12*, 3871. [CrossRef]
26. Grznár, P.; Burganová, N.; Mozol, Š.; Mozolová, L. A Comprehensive Digital Model Approach for Adaptive Manufacturing Systems. *Appl. Sci.* **2023**, *13*, 10706. [CrossRef]
27. Huang, S.; Wang, B.; Li, X.; Zheng, P.; Mourtzis, D.; Wang, L. Industry 5.0 and Society 5.0—Comparison, complementation and co-evolution. *J. Manuf. Syst.* **2022**, *64*, 424–428. [CrossRef]
28. Krajčovič, M.; Gabajová, G.; Matys, M.; Furmannová, B.; Dulina, Ľ. Virtual Reality as an Immersive Teaching Aid to Enhance the Connection between Education and Practice. *Sustainability* **2022**, *14*, 9580. [CrossRef]
29. Ricci, M.; Scarcelli, A.; Fiorentino, M. Designing for the Metaverse: A Multidisciplinary Laboratory in the Industrial Design Program. *Future Internet* **2023**, *15*, 69. [CrossRef]
30. Ghazali, A.K.; Ab. Aziz, N.A.; Ab. Aziz, K.; Tse Kian, N. The usage of virtual reality in engineering education. *Cogent Educ.* **2024**, *11*, 2319441. [CrossRef]
31. Jiawei, W.; Mokmin, N.A.M.; Shaorong, J. Enhancing higher education art students' learning experience through virtual reality: A comprehensive literature review of product design courses. *Interact. Learn. Environ.* **2024**, 1–17. [CrossRef]