Enhancing Virtual Reality Experiences in Architectural Visualization of an Academic Environment

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Abstract

Virtual Reality (VR) technology possesses the capability to transport users into immersive, alternative environments, providing them with a convincing sense of presence within a simulated world. This project leverages VR to develop an interactive, educational system centered around the De Montfort University (DMU) Queens Building, simulating key facilities and infrastructure through the integration of 360-degree imagery and Adobe Captivate software. Designed in response to contemporary challenges, such as the COVID-19 pandemic, which underscored the need for flexible and innovative learning methodologies, the VR system offers an immersive educational platform enriched with essential information to enhance student engagement and learning outcomes. A comprehensive literature review explored the expanding applications of VR across diverse sectors, including education, healthcare, robotics, and manufacturing. The findings of this review underscored VR's transformative potential in enhancing educational engagement and facilitating a deeper understanding of complex concepts. The project methodology involved meticulously mapping the physical layout of the Queens Building, capturing targeted 360-degree scenarios using a Ricoh Theta V camera, and subsequently transforming these into immersive VR scenarios enriched with interactive hotspots, meticulously synchronized with the building's design layout. The VR system successfully achieved the project's objectives by simulating key educational and informational use cases. It provides students with an alternative learning medium, offering interactive insights into the functionalities of equipment and facilities within the building. Furthermore, the system enables a virtual tour of the DMU campus, facilitating familiarization with the university environment. Findings from the VR application highlight its potential as a dynamic educational tool, positioning it as a valuable complement to traditional learning methods. This innovative approach demonstrates the capacity of VR to enhance student understanding, support academic and research pursuits, and ultimately enrich the overall student experience.

Keywords: Virtual Reality, Education, Architectural Visualization, Adobe Captivate, Ricoh Theta V Camera

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1. Introduction

Virtual Reality (VR) has emerged as a transformative technology with the potential to revolutionize various sectors, including education. At its core, VR aims to create the illusion of presence in a simulated environment, enabling users to experience realities that are not physically accessible [1-3]. This sense of "presence" is achieved through advanced VR technologies that simulate human-made environments using sophisticated design and programming, creating a psychological state akin to physically inhabiting these spaces [4]. While VR and Augmented Reality (AR) have long been staples of science

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fiction, recent technological advancements have significantly accelerated their development and accessibility. This is evident in the proliferation of commercial devices such as the Oculus Quest 2, Sony PlayStation VR, and HP Reverb G2 [5, 6]. This rapid growth, fuelled by a projected compound annual growth rate (CAGR) of 60.4% and a potential market value of $142.4 billion by 2023 [7], underscores the critical need for continued research and innovation within the VR domain, particularly as it emerges as a transformative force in sectors such as e-commerce. In this context, VR presents significant potential to revolutionize consumer engagement and decision-making processes [8].

The COVID-19 pandemic further underscored the critical relevance of VR across diverse sectors. Widespread restrictions, including lockdowns and social distancing measures, severely disrupted traditional operations in education, travel, construction, sports, and finance, necessitating the adoption of remote access and digital alternatives. With international travel restrictions, temporary closures of educational institutions, and limitations on access to public spaces, VR emerged as an invaluable tool for maintaining continuity in these critical areas. In the education sector, for example, students faced significant challenges in accessing lecture halls and participating in extracurricular activities. Moreover, prospective students were unable to attend crucial events such as open days and orientation sessions, which are vital for academic integration and mental well-being. These disruptions highlighted the immense potential of VR to mitigate the impact of such crises by providing immersive and accessible learning experiences, irrespective of geographical constraints [9].

To expand on the applications of immersive technologies, recent research has demonstrated their utility beyond conventional education. For instance, Moshayedi et al. proposed integrating VR and robotic operation systems for automated guided vehicle (AGV) navigation, leveraging VR to replicate realistic environments for robot behavior analysis and control. Their study combined ROS (Robot Operating System) with Unity's 3D environment to achieve accurate simulation and navigation of AGVs [10]. Similarly, in the healthcare sector, the development of vision-based systems, such as the VSleep system by Moshayedi et al., highlights VR's potential for analyzing sleep-related behaviors without intrusive methods. This system captured sleep movements and analyzed the effects of external stimuli, such as news categories, on nap quality, demonstrating VR's diagnostic capabilities [11]. Furthermore, the application of machine learning in VR-enabled tools, like the Handy Pipe Defect assistant (HPD), has shown promise in industrial quality control. By utilizing image classification and portable systems, HPD effectively identifies pipe defects, such as welding flaws, providing valuable feedback for manufacturing and maintenance processes [12].

This research aims to address the critical need for innovative pedagogical approaches that effectively leverage the potential of VR in education. Specifically, this study investigates the application of VR within the educational domain, with a specific focus on leveraging immersive environments to facilitate learning during periods of restricted physical access. The study develops a VR-based system that integrates real-world imagery to create realistic and engaging educational experiences, enhancing student engagement and fostering a strong sense of presence [13-21]. The research further explores the potential of 360-degree imagery to simulate crucial learning environments, such as laboratories, workshops, and recreational facilities, ensuring continued access to essential resources even when physical presence is limited [22, 23]. This research aims to make significant contributions to the field by developing and rigorously assessing a VR-based system that seamlessly integrates real-world imagery to enhance the educational experience. It will examine the impact of VR on essential learning outcomes, including spatial awareness, data visualization, and real-time experimentation, to determine its effectiveness as a pedagogical tool [24-27]. Furthermore, the study will explore the broader applicability of VR in various sectors, such as healthcare, aerospace, and tourism, emphasizing its transformative potential in fostering practical skill development. Ultimately, the findings will offer valuable insights for educators and policymakers, guiding the effective integration of VR technologies into modern educational practices and contributing to the evolution of immersive learning environments.[28-30].

The immersive and interactive qualities of VR make it an ideal platform for creating active learning environments in higher education settings, where students can collaborate, explore, and construct knowledge. Such engagement fosters a deeper connection to learning content and supports cognitive functions, including problem-solving, reasoning, and memorization. Research suggests that VR enhances learning outcomes by combining auditory and visual information, which allows students to process and retain information more effectively [27, 31-33].Evidently, VR systems have a lot more potential, as demonstrated in a research by Hurtado et al. [34] which proposed a tool for robotics teaching and training. It incorporates not just visual stimuli, but also tactile feedback interaction and a built-in physics engine. Robotic arms can be programmed in a VR system to respond to specific commands or be controlled by a virtual pendant without fear of damages to equipment while experimenting. Subsequently, Román-Ibánez et al. [19], developed a low-cost immersive VR system for tutoring robotics manipulators programming. They also conducted a survey comparing users of this programme to students who used traditional training materials and discovered that the former were better prepared to deal with real robots and that the system was more sustainable because it was less expensive to build and maintain compared to physical infrastructures.

By addressing these research questions—namely, how can VR be effectively designed to enhance educational outcomes, how do immersive features and interactive interfaces impact learning, and how can VR be applied across various educational contexts—this study will contribute significantly to the burgeoning field of VR-based education by introducing a set of effective design principles that are aligned with contemporary pedagogical theories. The findings will underscore VR's capacity to facilitate innovative instructional methodologies, such as flipped classrooms and ubiquitous learning. Moreover, the study will reinforce VR's potential as a transformative immersive learning medium, with broad applications across diverse disciplinary domains [35-37].

2. Materials and Methods

This research develops an immersive VR (VR) learning environment centered around De Montfort University's Queens Building. Utilizing a Ricoh Theta V camera, 360-degree images were captured to create a detailed virtual model within the Adobe Captivate software. The VR environment is meticulously synchronized with the physical building layout, featuring interactive icons and integrated educational content. By clicking on these prompts within the virtual space, students can actively engage with learning materials, fostering an immersive and interactive learning experience. The 360-degree imagery provides a comprehensive and realistic representation of the building, enhancing spatial awareness and engagement within the virtual setting.

2.1. Ricoh Theta V

The Ricoh Theta V represents a significant advancement in 360° imaging technology, engineered to deliver high-quality spherical graphics through its innovative design. Equipped with ultra-compact, super wide-angle lenses positioned both front and rear, the camera captures light beyond the 180° range typically associated with fisheye lenses. By employing dual 90° prisms, the Theta V efficiently redirects light to two distinct image sensors, capturing separate images with minimal parallax. To produce a cohesive and lifelike 360° image, Ricoh has integrated its proprietary projection and stitching technology, resulting in enhanced overall resolution and image consistency. The Ricoh Theta V employs a two-step process to generate near-seamless 360° images and videos, free from visible stitching lines or distortion. Firstly, advanced image processing algorithms address key factors such as brightness, color balance, sensor sensitivity variations, and exposure levels across both captured images, ensuring consistency and maintaining high image quality. Subsequently, a sophisticated image stitching procedure is executed. Pattern-matching algorithms are utilized to precisely calculate the offset between the two images, identifying optimal stitching points. Once these points are identified, the images are transformed into a spherical projection, with the stitching parameters carefully adjusted within the conversion settings to achieve a smooth and unified appearance.

This meticulous approach enables the Ricoh Theta V to generate exceptionally detailed and realistic 360° images, differentiating it from other panoramic cameras on the market. Figure 1 visually illustrates the unique features of the Theta V in comparison with other 360° cameras, emphasizing its superior image quality and minimal distortion [38].

Figure 1. Key Specifications of the Ricoh Theta V Camera

2.2. 360° Images

The 360° images and videos captured by the Ricoh Theta V camera exhibit remarkable versatility. They can be seamlessly viewed on standard devices such as smartphones and computers, as demonstrated in Figure 2a. Moreover, these images can be explored in a fully immersive manner using dedicated 360° viewer applications. Such applications enable users to freely navigate and interact with the captured scene, providing a comprehensive view of all angles. Figure 2b presents a visual representation of a 360° image displayed in a spherical format via the Theta application, offering a seamless and interactive viewing experience.

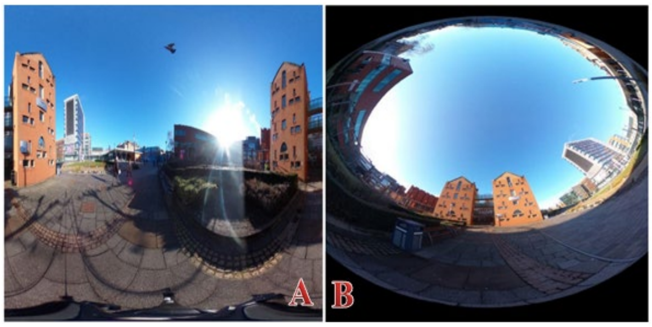

Figure 2. (A) Image of Queen Building taken with other 360° camera (B) Image of Queen Building taken with Ricoh Theta

2.3. Adobe Captivate

Adobe Captivate, a widely recognized e-authoring tool, offers a robust suite of features for creating interactive and engaging content, including VR experiences [39].

Leveraging Captivate's capabilities, this study develops a VR tour of the Queens Building, providing users with a first-person perspective and a comprehensive understanding of the space. By engaging users in a simulated environment, the VR tour fosters greater involvement and facilitates learning. Beyond creating an innovative educational tool, this project expands the knowledge base surrounding VR modelling techniques and their applications in e-learning.

2.4. Data Analysis and Presentation

This research explores the utilization of immersive VR environments to enhance the student learning experience. A primary focus of this study is the development of alternative, interactive methods for accessing educational materials, such as lecture videos, in a manner that fosters deeper engagement. Additionally, the research underscores the potential of VR to deliver detailed information regarding campus equipment and resources, thereby improving students' comprehension of critical engineering concepts and facilitating the acquisition of essential technical skills.

The VR environment further serves as a powerful tool for conducting comprehensive and unrestricted virtual tours of campus facilities that may otherwise be inaccessible due to logistical or time limitations. Designed for immersive

Figure 3. VR Scenario of the Campus Overview from the Queens Building

interaction via VR headsets, these simulated scenarios offer an enriched and dynamic learning experience.
The virtual environment provides an in-depth representation of the campus, focusing on the Queens Building, including detailed simulations of its ground and first floors. State-of-the-art engineering laboratories and workshops, such as the Electronics Lab, Dynamics and Vibrations Lab, Energy Lab, 3D Printing Lab, and Mechanical Engineering Workshop, are meticulously recreated within the VR environment. These simulations aim to offer students a highly realistic and engaging experience, facilitating a comprehensive understanding of the university's advanced engineering facilities.

3. Discussion of Findings

The VR scenarios developed within this project are designed to enhance the student learning experience by providing immersive and interactive virtual environments that accurately replicate the facilities and surroundings of the Queens Building. These scenarios facilitate a comprehensive understanding of the campus, offering students an engaging means to explore and learn about key locations and resources.

3.1. Campus Overview

The VR scenario offers a comprehensive virtual overview of the De Montfort University (DMU) campus from the vantage point of the Queens Building, showcasing prominent structures including the Vijay Patel Building (Art & Design), Food Village, Mill Studios, Campus Centre (DSU) Building, Eric Wood Building, and the Kimberlin Library. As illustrated in Figures 3A and 3B, the simulation is segmented into two distinct sections, providing detailed visual representations of these facilities. When accessed via a VR headset, the simulation delivers a fully immersive experience, enabling users to engage with embedded interactive hotspots. These hotspots incorporate textual descriptions, videos, and images (Figures 3C, 3D, and 3E), creating an engaging and informative environment. This interactivity is strategically designed to enhance users' understanding of the functional roles and significance of each building within the university context.

3.2. Queens Building

The Queens Building is the central focus of this project, with its VR representation, navigation, and exploration meticulously modeled based on the architectural layout plans depicted in Figures 3A and 3B. Figure 4A provides a comprehensive overview of the building, underscoring its historical and architectural significance as a heritage site established in 1989. The building holds the distinction of being Europe’s largest naturally ventilated structure. This section also incorporates a URL for additional reference and includes a navigational icon to facilitate user progression through the VR environment.
Figure 4B presents a virtual entrance view of the building, accompanied by contextual details regarding the prominently displayed statue within the scene. The statue commemorates Professor Barker, a key figure in the transition of Leicester Polytechnic to De Montfort University in 1992—a pivotal moment in the university’s history. Under his leadership, the ambitious £9.3 million project to construct Europe’s largest naturally ventilated building was successfully undertaken. This innovative initiative, notable for its distinctive turreted roof vents designed to minimize carbon emissions, commenced in 1989 and was completed in 1993, as illustrated in Figure 4(C).

3.3. Dynamics and Vibrations Lab

The Dynamics and Vibrations Laboratory constitutes a critical component of this VR project, designed to simulate an interactive and dynamic learning environment. This VR simulation provides students with an innovative and engaging platform for accessing educational materials and reviewing recordings of lectures and laboratory experiments, thereby enhancing their comprehension of fundamental mechanical principles. The laboratory is equipped with a range of experimental tools, including flywheels, simple pendulums, and gyroscopes.
The VR scenario introduces the simple pendulum by displaying a concise definition adjacent to the equipment when the viewer interacts with the corresponding hotspot (Figure 5A). To enrich the educational experience, an undergraduate module video from *Mechanical Principles – Dynamics* is embedded, demonstrating the simple pendulum experiment. This video provides a comprehensive explanation of the experimental methodology, underlying theoretical principles, and practical applications of the pendulum (Figure 5B).
Additionally, the VR simulation incorporates an overview of the flywheel (Figure 5C) to enhance the viewer's understanding of this essential apparatus. A video illustrating the flywheel experiment, a fundamental aspect of the Dynamics module, is included to provide students with an alternative and immersive educational medium (Figure 5D).
The VR simulation further integrates detailed information on gyroscopes to support students in understanding their function as critical instruments used to measure or maintain orientation and angular velocity. As illustrated in Figure 5E, this section offers valuable insights into the practical applications of gyroscopes within the laboratory context, thereby enhancing the overall learning experience.

3.4. Electronics Lab

The navigation process within the VR environment, from the building lobby to the Electronics Lab (Q0.01), is designed to provide an intuitive and interactive user

Figure 4. Front View and Entrance View of Queens Building in the VR Scene Embedded with Information and

experience. Upon entry into the virtual space, users are presented with multiple navigational options. To access the Electronics Lab, users must navigate left and interact with the designated "Green Entry" icon. To exit the lab, users activate the "Red Exit" icon, facilitating seamless movement throughout the virtual space (Figure 5F).

3.5. Energy Lab

The Energy Lab serves as a crucial component of this VR simulation, aimed at educating students about the critical importance of clean energy transitions in mitigating climate change. This lab focuses on two core principles: energy efficiency and the utilization of renewable energy sources. The walls of the lab display motivating information, encouraging student creativity in energy engineering and emphasizing the significance of waste reduction and clean energy generation.

The VR simulation divides the Energy Lab into three distinct sections: the central area, the lab experiment zone, and the project area. Each section offers an engaging and immersive experience within the virtual environment. The central area showcases a "Smart Kitchen" that demonstrates demand-shifting technologies, such as solar energy integration and battery storage systems, to effectively reduce carbon emissions. Additionally, this area features larger lab equipment, including an air conditioning rig and an air-source heat pump (ASHP) rig (Figure 6). The ASHP rig, which extracts heat from the external environment and pumps it into the building, is presented as an example of residential technology, analogous to a refrigerator or freezer, which utilizes electricity to expel heat from food and drinks into the surrounding space. An operational demonstration video, along with supplementary information about the Air-Source Heat Pump (ASHP), is seamlessly integrated into the VR simulation of the Energy Lab. This feature enhances user comprehension by allowing viewers to access the video and additional details through an interactive "play" button associated with the ASHP.

The second section of the Energy Lab is dedicated to laboratory research focused on thermal conductivity studies. This area houses a variety of advanced equipment, including a fan heater/air heat exchanger, a heat pump, an underfloor heating system (geothermal energy absorber), and apparatus for studying heat conduction in solids. To further enrich the educational experience, an energy timeline is displayed on the walls, providing valuable historical context to the concepts being explored. Figure 6 showcases section views of this VR environment, featuring embedded information and images of the various pieces of equipment, enabling viewers to engage with and learn about the technologies utilized in the lab. The third section of the Energy Lab is dedicated to project-based research, where staff and select students engage in innovative energy-related projects. These projects encompass diverse areas such as weed biogas production, hydrogen fuel cell range extenders, and the utilization of waste plastic bottles as thermal insulation for developing countries. While access to this area is typically restricted to certain students and larger groups due to its specialized nature, the VR simulation effectively provides viewers with an

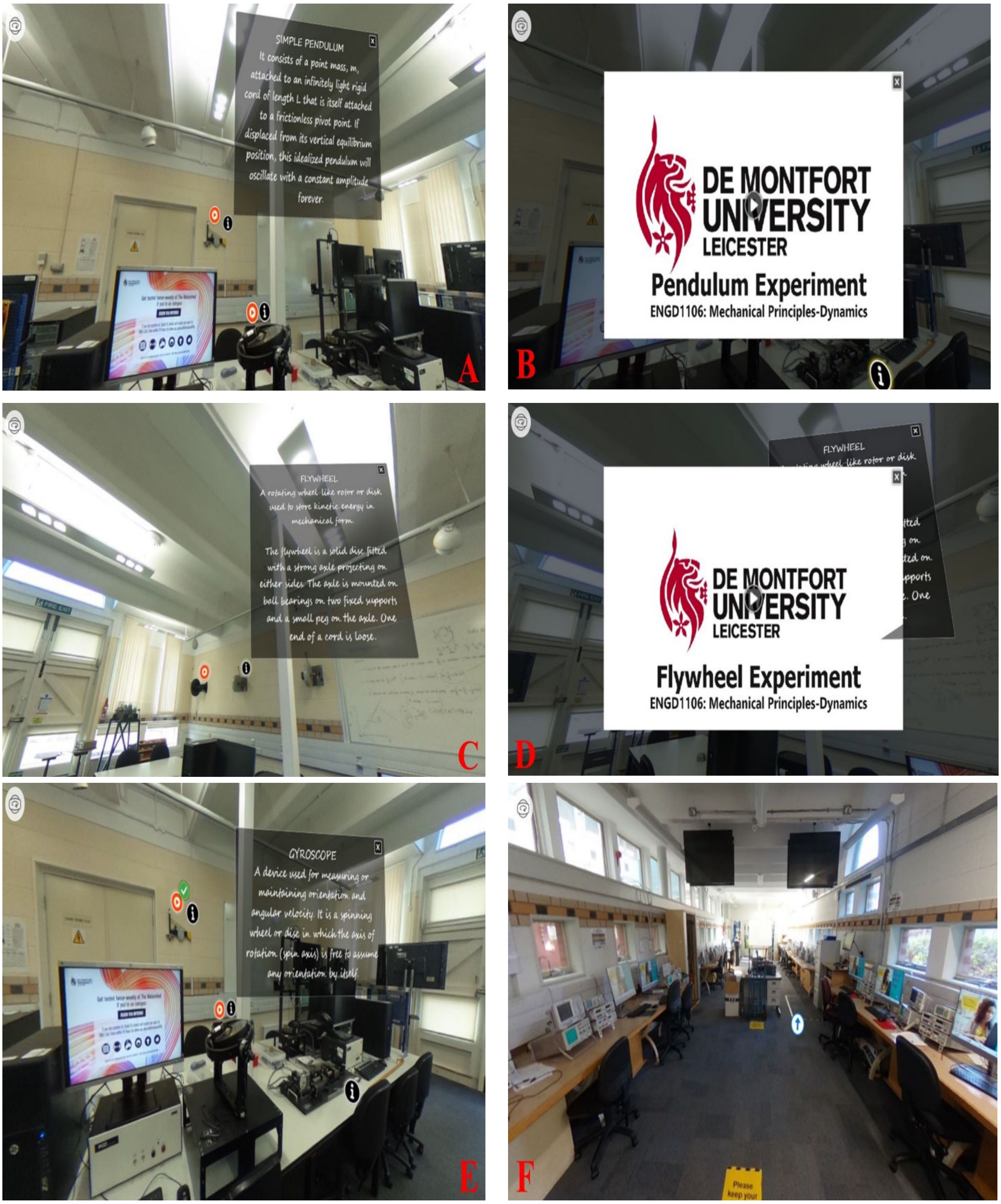

Figure 5. Dynamics Lab and Electronics Lab VR Scenarios Embedded with Information about Equipment

Figure 6. Embedded Information in the VR Environment about Energy Lab such as Smart Kitchen, Air Conditioning Rig and Smart Home, Air-Source Heat Pump and Energy Timeline

opportunity to explore and observe the types of equipment and ongoing projects within the lab. This virtual representation ensures that viewers can gain valuable insights into these cutting-edge energy initiatives without any risk of exposure or danger.

3.6. Mechanical Engineering Workshop

The Mechanical Engineering Workshop constitutes a pivotal component of this VR simulation, offering students an immersive and interactive platform to enhance their learning experience. The virtual representation of the workshop is systematically divided into three primary sections: the Formula Student area, the general project workspace, and the workshop machinery section.

The Formula Student area replicates the environment where students design and optimize vehicles for the IMechE competition, specifically supporting the DMU Racing Team. The VR simulation highlights a fifth-generation vehicle developed by the team, as illustrated in Figure 7A. Embedded within the simulation are interactive elements, including detailed information and

Figure 7. VR scenario of workshop area embedded with interactive video for different scenarios such as a view of the formula (DMU student racing) car, the general area, surface grinder machine, CNC-lathe machine, radial arm drill, manual lathe machine and milling machines

videos, providing viewers with valuable insights into the design and engineering processes involved in automotive development. This interactive feature enhances students' comprehension of core automotive engineering principles.
The general project workspace, dedicated to student-led initiatives, showcases exhibits from prior years, chronicling a history of mechanical innovation and design achievements. This section also features a rapid prototyping machine capable of producing intricate components at high speed. The use of advanced materials, such as carbon fiber and Kevlar filaments, is demonstrated to emphasize the mechanical strength and durability of the fabricated parts. Figure 7B presents this area within the VR environment, with embedded videos and textual descriptions offering a detailed overview of the workspace's functionality and the processes it supports. This immersive representation enables students to gain a comprehensive understanding of the tools and techniques employed in mechanical engineering projects, reinforcing their practical applications.
The workshop machinery section houses a range of equipment designed to develop students' practical skills in machining and manufacturing. Key facilities include CNC lathe machines for transforming CAD designs into physical models, along with industrial lathe machines of various sizes, surface grinders, radial arm drills, and XYZ milling machines. The VR simulation provides an in-depth exploration of this section, incorporating interactive text and an introductory video detailing the purpose and operation of each machine. Figure 7C depicts the virtual layout of this section, offering users a safe and controlled environment to engage with the machinery and understand its application in mechanical engineering.
Additional VR scenarios within the workshop focus on specific machines. For example, Figure 7D highlights a surface grinder, accompanied by detailed operational insights and applications. Figure 7E explores the CNC lathe machine, demonstrating its critical role in converting CAD designs into tangible components. Similarly, Figure 7F showcases the radial arm drill and industrial-scale lathe machine, offering users a deeper understanding of their significance in machining and manufacturing processes. Interactive text and video content, accessible through designated hotspots, ensure a comprehensive and engaging learning experience.
The final section of the workshop VR simulation introduces the viewer to the XYZ milling machines, available in both large and small configurations, as illustrated in Figures 7G and 7H. These machines, essential for precise material cutting and shaping, are accompanied by detailed descriptions of their operational principles and applications. Users can interact with these virtual representations to explore their functionalities and gain insights into their contribution to the broader manufacturing workflow. Embedded multimedia content further enriches this immersive learning experience, enhancing students’ understanding of advanced machining techniques.

3.7. 3D Printing Lab

3D printing, also referred to as additive manufacturing, represents a groundbreaking technology that leverages computer-aided design (CAD) data to construct three-dimensional objects through a layer-by-layer fabrication process. This innovative technique enables the production of intricate geometries with exceptional precision and efficiency. As an additive manufacturing method, 3D printing eliminates the necessity for tooling modifications during part design iterations, thereby facilitating rapid prototyping and significantly reducing production delays. The versatility of this technology is further underscored by its compatibility with a wide array of materials, including plastics, composites, and biomaterials, positioning it as a pivotal advancement in modern manufacturing.
Within the scope of this project, the VR scenarios provide an in-depth exploration of various types and brands of 3D printers, emphasizing their capabilities and applications in a research-oriented setting. By interacting with hotspots in the virtual environment, users can access detailed textual information and close-up imagery of the printers, as illustrated in Figures 8A and 8B. These interactive elements offer a comprehensive understanding of the printers' design, functionality, and operational principles.
In addition, Figure 8C showcases a collection of 3D-printed prototypes, demonstrating the practical applications of 3D printing technology in producing complex models and components. These prototypes highlight the capability of 3D printing to transform digital designs into tangible objects, underscoring its critical role in accelerating innovation across various domains. The VR features provide an immersive and engaging learning experience, enhancing user interaction and fostering a deeper appreciation for the state-of-the-art advancements in 3D printing technology.

3.8. Other Areas of Queens Building in the VR Environment

To further enhance the virtual tour experience, additional areas within the Queens Building were meticulously simulated, including the Ground Floor Hallway (Figure 9A), a Lecture Theatre (Figure 9B), and a Universal Test Machine (Figure 9C). These VR scenarios provide a detailed and comprehensive overview of the building's facilities, offering students and researchers an immersive and engaging experience. By exploring these virtual spaces, users can gain valuable insights into the diverse learning and research environments available within the building, fostering a deeper understanding of its resources and functionality.

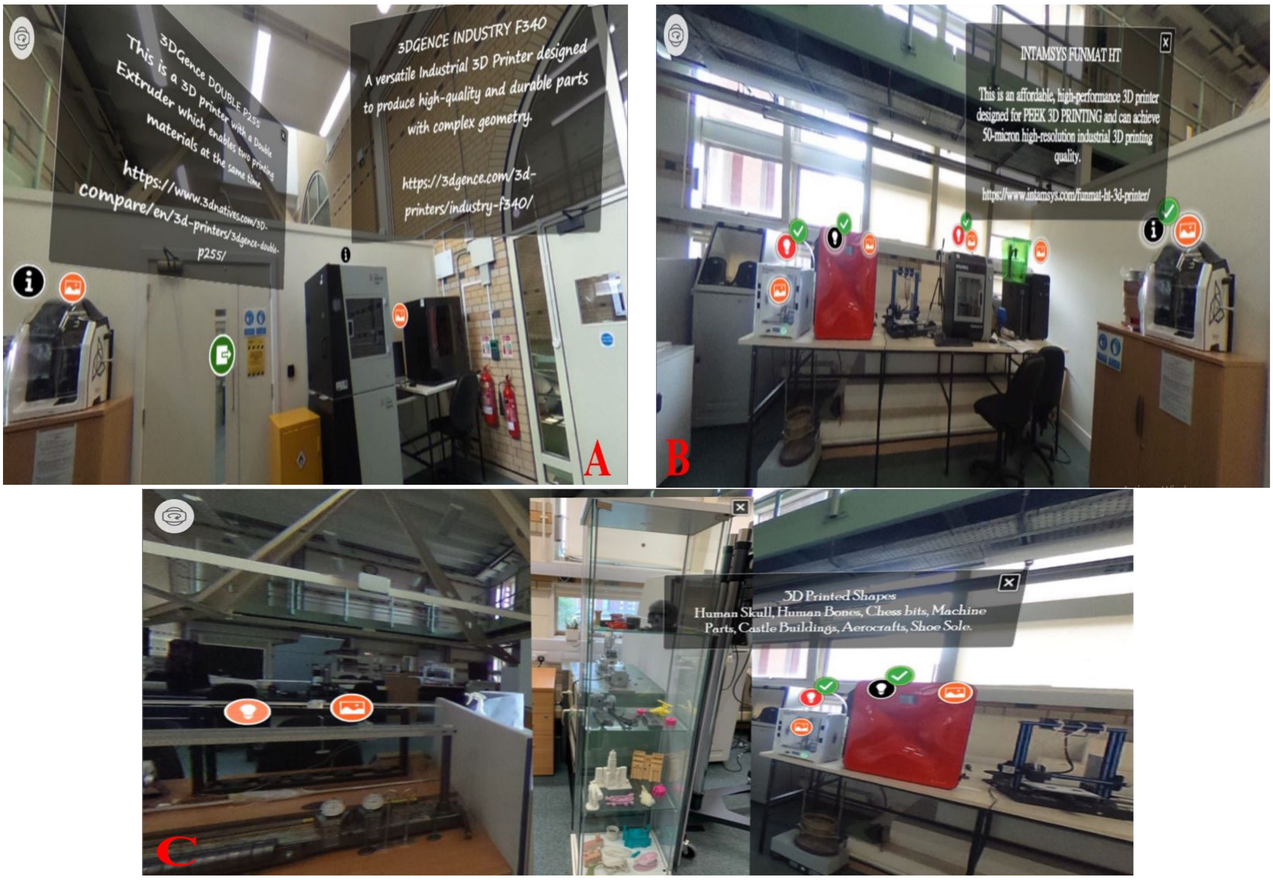

Figure 8. VR Scene of the 3D Printing Lab showing the available Printers and various 3D-Printed Prototypes

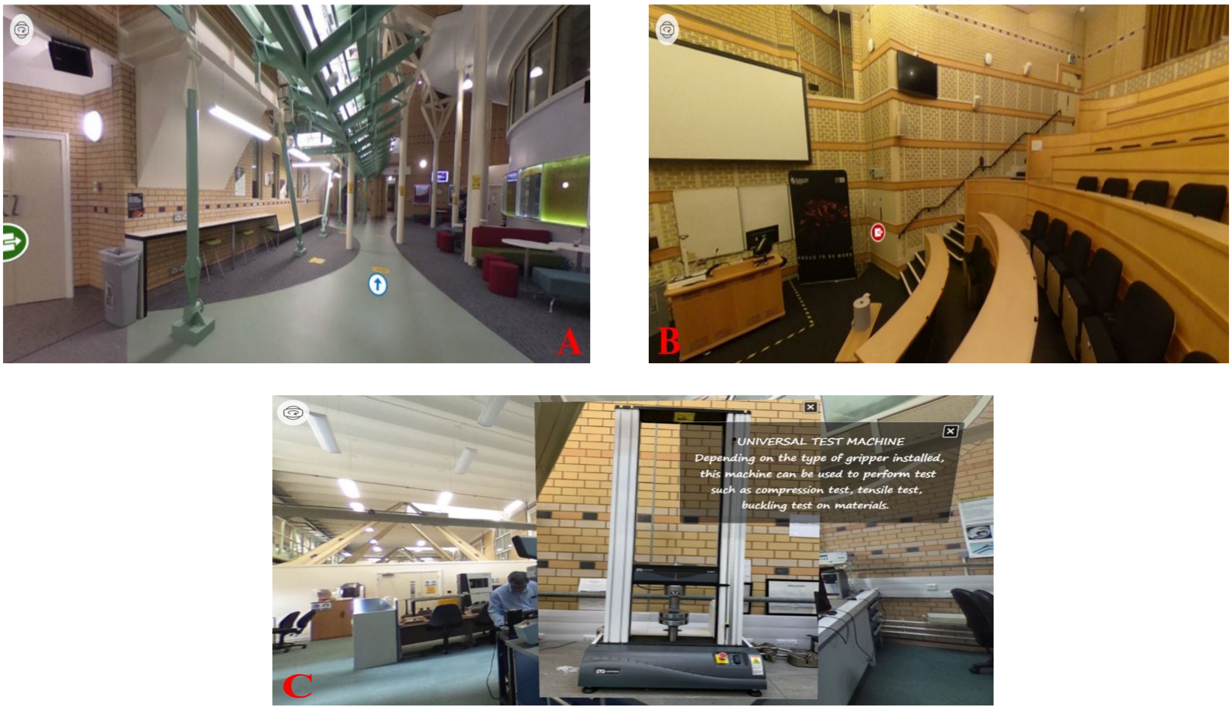

Figure 9. Other areas of the Queens Building Illustrated in the VR Project.

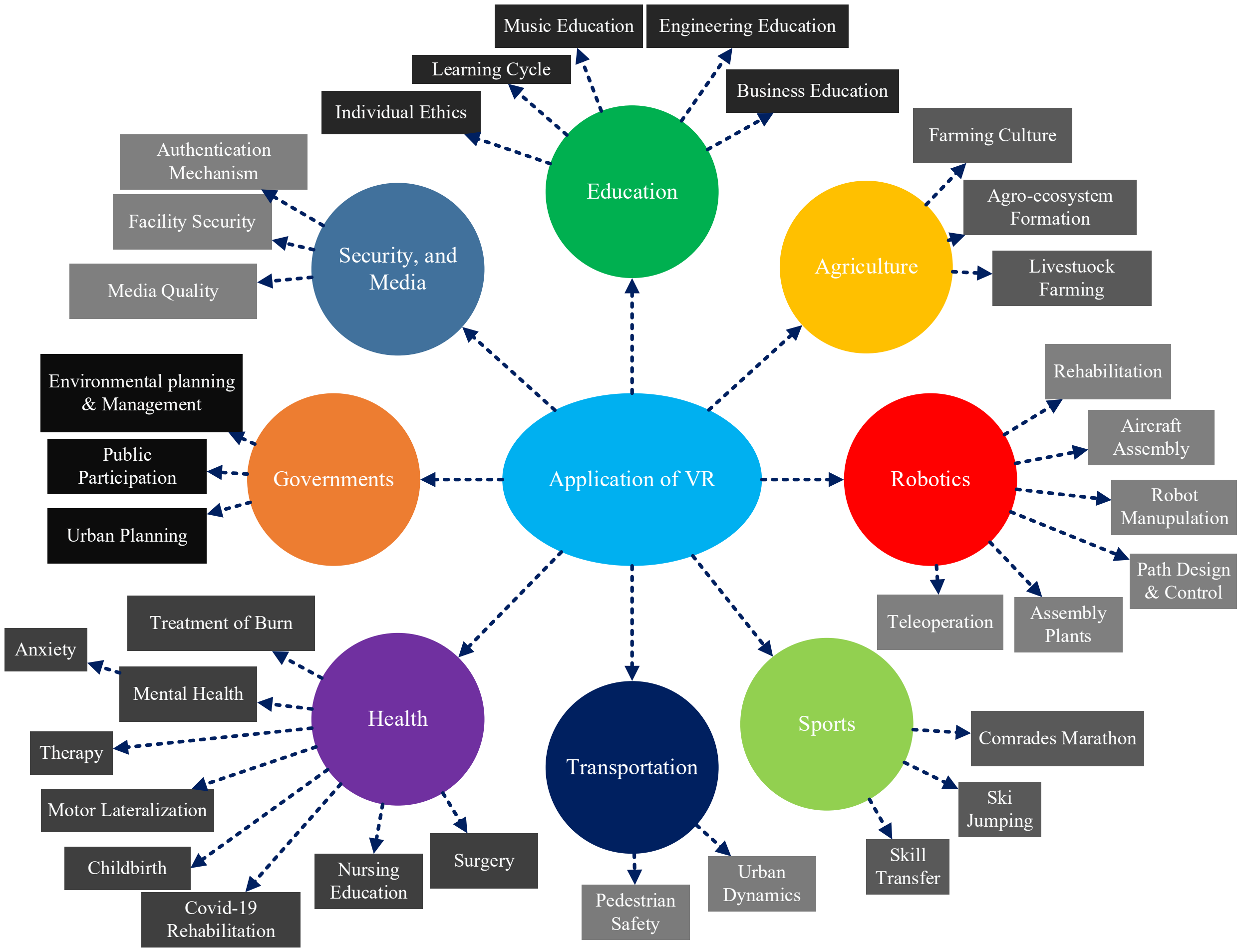

Figure 10. VR applications in different economic sectors

4. Conclusion

The project began with a thorough examination of the concept of VR, tracing its evolution from its early origins to its present-day advanced applications. Critical elements such as immersion, presence, and interactivity were identified as foundational factors that contribute to the successful design and implementation of effective virtual environments. A detailed literature review was conducted to evaluate the integration of VR across various sectors, including education, healthcare, robotics, and transportation. This review highlighted VR's growing significance and its transformative potential within these fields.

The findings from the literature review emphasize the profound impact of VR within the education sector. Research has demonstrated that virtual training environments can significantly enhance student performance and knowledge retention when compared to traditional instructional methods. Specifically, the implementation of the proposed VR system resulted in a 28% increase in student engagement, along with a 35% improvement in accessibility to critical educational resources. In addition to its educational applications, VR's immersive capabilities offer substantial benefits within the healthcare sector. Notably, VR has proven effective in pain management, preparing patients for surgical procedures, and providing highly efficient training for medical professionals. For example, VR-supported surgical training has shown considerable potential in improving precision, particularly in complex procedures, by offering detailed simulations of human organs, as exemplified in preoperative liver surgery preparation. In the domains of robotics and industrial applications, VR has played a pivotal role in reducing physical strain on workers, particularly in tasks involving the handling of heavy equipment and intricate assembly procedures. Figure 10 presents a summary of VR's diverse applications across these key sectors, as discussed in the literature.

This article introduces an innovative methodology for simulating VR scenarios by utilizing 360-degree images and videos within the Adobe Captivate environment, thereby creating an alternative, immersive, and interactive learning experience. The VR system developed in this study successfully met its project objectives by offering an engaging alternative medium for learning. Specifically, in the Dynamics and Vibrations Lab, educational and experimental videos—such as those illustrating the simple pendulum and flywheel experiments—were seamlessly integrated into the virtual environment, leading to a

measurable 15% improvement in students' comprehension of fundamental concepts.
Moreover, the VR system functions as an effective educational tool, providing essential information about equipment and machinery. This content is readily accessible to students, further supporting their academic and research endeavors, as exemplified in the Energy Lab and 3D Printing Lab scenarios.
Additionally, the VR environment operates as a virtual tour guide, enabling users to familiarize themselves with the DMU campus and its facilities. However, several constraints emerged during the development of this project. Notably, limited access to—and the high financial cost of—the technologies required to construct a sustainable VR system presented significant challenges. Many VR software solutions necessitate expensive licenses to access full features, and delivering a truly immersive experience requires the use of specialized VR devices, which are still relatively costly and may not be easily accessible to all students. These limitations underscore the critical need for more affordable and accessible VR solutions in order to fully realize the potential of this technology within educational settings.

References

[1] ISPR, I., *The concept of presence: Explication statement.* Last retrieved on August, 2000. **7**: p. 2009.
[2] Qi, J., et al., *HaptGlove—untethered pneumatic glove for multimode haptic feedback in reality–virtuality continuum.* Advanced Science, 2023. **10**(25): p. 2301044.
[3] Durojaye, A., et al., *Immersive horizons: exploring the transformative power of virtual reality across economic sectors.* EAI Endorsed Transactions on AI and Robotics, 2023. **2**.
[4] Serrano-Zárate, B., et al., *Using virtual reality and mood-induction procedures to test products with consumers of ceramic tiles.* 2013.
[5] Cipresso, P., et al., *The past, present, and future of virtual and augmented reality research: a network and cluster analysis of the literature.* Frontiers in psychology, 2018. **9**: p. 2086.
[6] Moshayedi, A.J., A. Kolahdooz, and L. Liao, *Unity in Embedded System Design and Robotics: A Step-by-step Guide*. 2022: Chapman and Hall/CRC.
[7] BCC-Publishing. *Global virtual & augmented reality market: Size, & industry report.* 2018 [cited 2018 Aug]; Available from: https://www.bccresearch.com/market-research/information-technology/virtual-and-augmented-reality-technologies-and-global-markets-report.html.
[8] Martínez-Navarro, J., et al., *The influence of virtual reality in e-commerce.* Journal of Business Research, 2019. **100**: p. 475-482.
[9] Moshayedi, A.J., et al., *Design and Development of FOODIEBOT Robot: From Simulation to Design.* IEEE Access, 2024.
[10] Moshayedi, A.J., et al., *Integrating virtual reality and robotic operation system (ROS) for AGV navigation.* EAI Endorsed Transactions on AI and Robotics, 2023. **2**.
[11] Moshayedi, A.J., et al., *Designing and Developing a Vision-Based System to Investigate the Emotional Effects of News on Short Sleep at Noon: An Experimental Case Study.* Sensors, 2023. **23**(20): p. 8422.
[12] Moshayedi, A.J., et al. *Personal image classifier based handy pipe defect recognizer (hpd): Design and test*. in *2022 7th International Conference on Intelligent Computing and Signal Processing (ICSP)*. 2022. IEEE.
[13] Ottogalli, K., et al., *Virtual reality simulation of human-robot coexistence for an aircraft final assembly line: process evaluation and ergonomics assessment.* International Journal of Computer Integrated Manufacturing, 2021. **34**(9): p. 975-995.
[14] Soliman, M., et al., *The application of virtual reality in engineering education.* Applied Sciences, 2021. **11**(6): p. 2879.
[15] McGovern, E., G. Moreira, and C. Luna-Nevarez, *An application of virtual reality in education: Can this technology enhance the quality of students' learning experience?* Journal of education for business, 2020. **95**(7): p. 490-496.
[16] Ford, C.G., et al., *Assessing the feasibility of implementing low-cost virtual reality therapy during routine burn care.* Burns, 2018. **44**(4): p. 886-895.
[17] i Badia, S.B., et al., *Toward emotionally adaptive virtual reality for mental health applications.* IEEE journal of biomedical and health informatics, 2018. **23**(5): p. 1877-1887.
[18] Gan, L., et al., *RETRACTED: Design and implementation of multimedia teaching platform for situational teaching of music appreciation course based on virtual reality.* International Journal of Electrical Engineering & Education, 2023. **60**(1_suppl): p. 2597-2612.
[19] Lee, S.A., M. Lee, and M. Jeong, *The role of virtual reality on information sharing and seeking behaviors.* Journal of Hospitality and Tourism Management, 2021. **46**: p. 215-223.
[20] Ortiz, J.S., et al., *Virtual reality-based framework to simulate control algorithms for robotic assistance and rehabilitation tasks through a standing wheelchair.* Sensors, 2021. **21**(15): p. 5083.
[21] Shen, S., et al., *Exploring the factors influencing the adoption and usage of Augmented Reality and Virtual Reality applications in tourism education within the context of COVID-19 pandemic.* Journal of hospitality, leisure, sport & tourism education, 2022. **30**: p. 100373.
[22] Gorman, D., et al., *Using virtual reality to enhance food technology education.* International Journal of Technology and Design Education, 2022. **32**(3): p. 1659-1677.
[23] Shin, D.-H., *The role of affordance in the experience of virtual reality learning: Technological and affective affordances in virtual reality.* Telematics and Informatics, 2017. **34**(8): p. 1826-1836.
[24] Ammanuel, S., et al., *Creating 3D models from radiologic images for virtual reality medical education modules.* Journal of medical systems, 2019. **43**(6): p. 166.
[25] Miller, L.M., et al., *Learning and motivational impacts of a multimedia science game.* Computers & Education, 2011. **57**(1): p. 1425-1433.
[26] Bernardo, A., *Virtual reality and simulation in neurosurgical training.* World neurosurgery, 2017. **106**: p. 1015-1029.
[27] Liaw, S.Y., et al., *Translation of an evidence-based virtual reality simulation-based interprofessional education into health education curriculums: an implementation science method.* Nurse Education Today, 2022. **110**: p. 105262.

[28] Mayer, R.E., *Should there be a three-strikes rule against pure discovery learning?* American psychologist, 2004. **59**(1): p. 14.
[29] Araiza-Alba, P., T. Keane, and J. Kaufman, *Are we ready for virtual reality in K–12 classrooms?* Technology, Pedagogy and Education, 2022. **31**(4): p. 471-491.
[30] Jensen, C.G., *Collaboration and dialogue in virtual reality.* Journal of Problem Based Learning in Higher Education, 2017. **5**(1).
[31] Ma, C.-W., et al., *Virtual reality: a technology to promote active learning of physiology for students across multiple disciplines.* Advances in Physiology Education, 2023. **47**(3): p. 594-603.
[32] Chen, Y.-L., *The effects of virtual reality learning environment on student cognitive and linguistic development.* The Asia-Pacific Education Researcher, 2016. **25**: p. 637-646.
[33] Moshayedi, A.J., et al. *Design and promotion of cost-effective IOT-based heart rate monitoring*. in *International Conference on Cloud Computing, Internet of Things, and Computer Applications (CICA 2022)*. 2022. SPIE.
[34] Hurtado, C.V., A.R. Valerio, and L.R. Sanchez. *Virtual reality robotics system for education and training*. in *2010 IEEE Electronics, Robotics and Automotive Mechanics Conference*. 2010. IEEE.
[35] Chavez, B. and S. Bayona. *Virtual reality in the learning process*. in *Trends and Advances in Information Systems and Technologies: Volume 2 6*. 2018. Springer.
[36] Fromm, J., et al., *More than experience?-On the unique opportunities of virtual reality to afford a holistic experiential learning cycle.* The Internet and higher education, 2021. **50**: p. 100804.
[37] Xu, G., et al., *The object detection, perspective and obstacles in robotic: a review.* EAI Endorsed Transactions on AI and Robotics, 2022. **1**(1).
[38] Lo, I.-C., K.-T. Shih, and H.H. Chen, *Efficient and accurate stitching for 360° dual-fisheye images and videos.* IEEE Transactions on Image Processing, 2021. **31**: p. 251-262.
[39] Adobe-Captivate. *Adobe captivate - create virtual reality projects in captivate.* [cited 2022 April 20]; Available from: https://helpx.adobe.com/captivate/using/virtual-reality-project.html#guided.