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Integration of emerging technologies within higher education: design and management of Laboratories exploring VR technology

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Abstract

The integration of VR within educational contexts presents various learning advantages, as resulting from literature. The following paper delineates the procedural steps undertaken by METID Learning Innovation Task Force within Politecnico di Milano university to conceptualize and establish Virtual Reality Laboratories, fostering active engagement of professors, tutors, and students with this emergent technology during instructional sessions.

The paper elucidates the process and optimal methodologies for organizing and administering VR lessons, drawing from the accumulated experience gained through the utilization of these Laboratories over a span of two years.The establishment of these VR Labs provided an opportunity to create an experimental environment wherein professors and students could engage with lesson content in an advanced manner through VR technology.

While a more comprehensive study is needed on the matter, the majority of students, based on post-classroom questionnaires, expressed a desire to repeat a similar activity in other classes.

Keywords: *Virtual Reality; Learning; VR Laboratory; Emerging technologies; VR lessons.*

1. Introduction: Realization of the VR Labs

In 2020, Politecnico di Milano decided to establish two dedicated workstations for an experimentation on the use of Virtual Reality (VR) technology in educational activities to be offered to students. The pilot project from which the experimentation arises is called 'Virtualizing Education', developed with professors R. Rota and L. Duò with the aim of integrating immersive experiences based on Digital Twins into the master's degree program in

industrial engineering. The encouraging outcomes of the experimentation have led to the request for scaling up the solution from a single workstation to a laboratory capable of accommodating multiple students simultaneously, thereby necessitating the identification and preparation of one or more suitable spaces. Several measures, elucidated in the subsequent paragraphs and chapters, were taken for the design and implementation of two dedicated classrooms as VR Laboratories (VR Labs), where students can utilize devices tailored for the use of virtual reality technology in educational settings.

1.1. Virtual Reality in Educational context

The integration of new technologies into learning contexts has been investigated as a factor that facilitates learning methods and enhances learning outcomes by creating and managing suitable technological resources. (Bozkurt, 2020) Ardiny and Khanmirza (2018) have reported VR as a technology potentially occupying the lowest part of the Dale's Cone of Experience that shows the progression of learning experiences. The bottom of the cone is coincident with the most effective learning methods (learning by doing direct experiments) and the top with the less effective ones (learning through abstracts). (Dale, 1969) VR technology enables learners to actively engage with immersive educational experiences, allowing them to interact directly with didactic content. Moreover, VR technology can facilitate the dissemination of educational content that may be challenging to replicate in a traditional classroom setting, such as simulations of external systems or delicate mechanisms.

2. Design and Development of the VR Labs

The design of a space dedicated to a learning experience centered around Virtual Reality necessitates careful consideration (Kavanagh et al., 2017), as it must adhere to specific constraints and criteria, such as technological specifications, the number of workstations, simultaneous user capacity, and available space.

2.1. Criteria for the Design of the VR Labs

The subsequent paragraphs detail the implementation process and the criteria considered for the design of the Laboratories. The definition and choses related to the technical specifications involved initial desk research on dedicated websites and on-site experimentation with the workstations.

2.1.1. Definition of technical specifications for each workstation

The single workstation inside the Laboratory should have medium to high performance. The key component, in addition to a good overall CPU, RAM, and HDD configuration, is the graphics card as it is the most solicited element in processing 3D scenarios. Therefore, the

graphics card should be designed for gaming (applications that normally utilize its computing power) and should be compatible with the Virtual Reality headset in use. The chosen VR headset for content consumption is the Oculus Quest 2 (now Meta Quest 2), due to its availability of materials at a reasonable cost and the high number of information that could be found for support and maintenance of the devices. The headset connects to the PC via a USB port and a DisplayPort thanks to a 5-meter cable. Like other devices of this type, it has two lenses inside that allow viewing LCD screens (one for each eye) in stereoscopic mode. There are motion sensors that manage interaction with the virtual world, allowing total immersion. Interaction with VR content is through the controllers (two, one for each hand) included with the Oculus Quest 2 package. These controllers have various buttons with different functions depending on the required command.

2.1.2. Identification of spaces capable of accommodating an adequate number of students

The classrooms were selected based on specific criteria, including capacity for at least 14/15 fixed workstations, sufficient movement space for headsets and simulations, technical requirements such as electrical outlets and LAN sockets, Wi-Fi coverage, and accessible flooring. The number of workstations can accommodate up to 45 students if used in groups of three. Large windows are essential for air circulation in case of VR sickness. Classroom usage and activities will vary by course and department, requiring adaptable spaces.

2.1.3. Identification of constraints related to equipment and activities to be carried out

To accommodate multiple students per workstation and manage space effectively, colored adhesive tape delineates areas for headset use, ensuring clear boundaries. Empirical measurements resulted in a 2 x 2 meters area for each workstation. Finally, suitable cabinets and containers are needed for equipment storage when not in use. See Figure 1 for an illustrative layout of the classrooms, showing workstation arrangement and headset boundary areas.

2.1.4. Definition of the roles for the set up and managing of the Labs

Particular attention is then given to the organizational and managerial aspects of these spaces, as they are specialized environments where a wide variety of often incompatible applications must be used. For this reason, several working groups are involved, each dealing with different aspects including logistics (space reservation and collection of technical and methodological requirements), technological aspects (creation of the necessary software stack for the dedicated exercise), methodology (design of the educational experience and its corresponding lesson plan activities, observation of the methods and their effects on educational efficiency), and organizational aspects (classroom supervision by technicians capable of intervening in case of unforeseen events, providing technical support, and offering more detailed explanations to teachers). These working groups all collaborate togheter in the displacement of the lessons and dialogue with the teachers and tutors who manage the lessons.

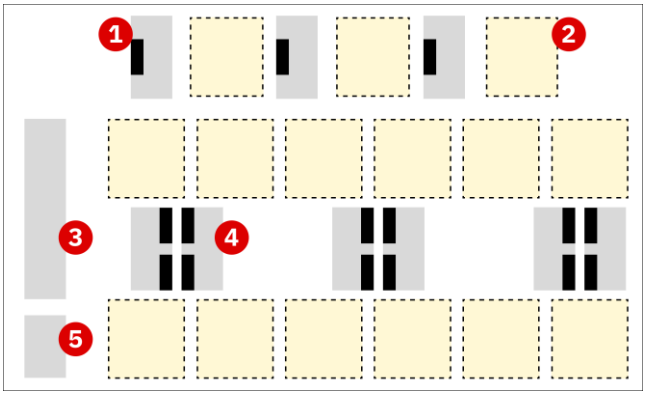

Figure 1. General layout of the VR Laboratories: 1) Working station 2) Boundaries taped area 3) Desk 4) Double working station 5) Headsets wardrobe

2.2. Research on digital and virtual applications/platforms

Once the Laboratories were organized and structured at the hardware level, actions were taken in terms of both desk research and empirical research on the software side. Various applications (both standalone applications and online platforms) potentially relevant for educational use of virtual reality technology in the classroom were studied. This research aimed to provide an initial categorization of different software application case studies, serving both internally at METID Learning Innovation as a university Task Force for lesson design support and in discussions with professors to guide them in making appropriate software choices. A dedicated resource conducted research on various VR applications, including those from Meta Quest 2, Steam VR, and internally developed ones using Unity or Unreal Engine. Cataloging these applications involved taking notes on direct usage experiences and recording technical/educational features of interest of the applications and platforms. When needed, temporary licenses were purchased, developers or platform distributors were contacted, and educational insights were developed.

3. Displacement of the lessons in VR Labs

This chapter outlines recommended procedures developed by the department's Task Force, informed by empirical experiences. Two guides, including the 'VR Vademecum' and a 'Video Tutorial' on YouTube, are tailored for faculty and students. These resources aim to familiarize students with equipment and Lab functioning before entry, and to suggest the instructors with the best procedures collected from other courses in managing the lessons into the Labs.

3.1. Procedures for the students

The educational journey in Virtual Reality requires a careful and conscious approach from students (Slavova & Mu, 2018), both for the innovative methods of lesson delivery in the classroom and to avoid purely entertaining activities that may detract from the educational objective. Guidelines provided by METID Learning Innovation are taken from the VR Vademecum priorly cited documentand from the introductory Video Tutorial for entry into the Labs. Next paragraphs introduce these tools.

3.1.1. VR Vademecum

The Vademecum's first section defines VR theoretically, introducing key concepts for lesson delivery. It then familiarizes students with the VR equipment, explaining feedback mechanisms and controls. Information on the organization of the VR Labs at Politecnico is provided, detailing layouts, capacities, and operating procedures. Instructions for approaching and using the devices, including controller functionalities and Oculus interfaces, are outlined. Lastly, VR sickness management and the importance of following instructor guidelines are emphasized.

3.1.2. Video Tutorial

An online Video Tutorial is provided to students before the lessons commence. This tutorial guides students through key steps in navigating the VR Labs, offering detailed demonstrations of how the devices function and explaining the layout of the workstations. (Fig. 2) The video is available on YouTube under a Creative Commons Non-Commercial 4.0 International License.

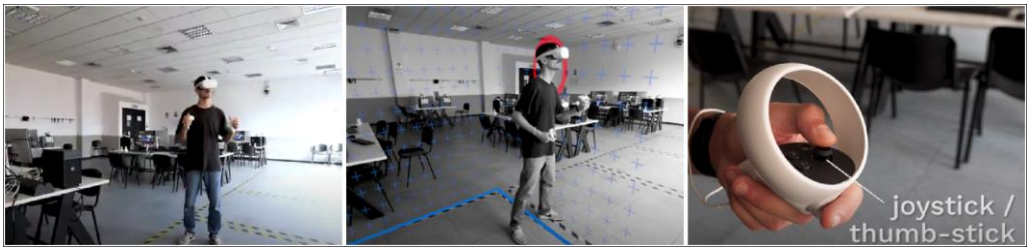

Figure 2. Screenshots from the online video reporting the first steps on how to approach the Labs.

3.2. Best practices for the instructors

Designing and executing VR lessons requires a systematic approach by educators. The following guidelines are based on observations from lessons conducted over time in VR Labs.

3.2.1. Defining suitable content for use in VR

Understanding technology advantages and disadvantages, limits and benefits, instructors identify how to set the VR possibilities to their lesson content. This lead to the identification of the suitable application or platform for the educational objectives, and they have to inquire about

licensing procedures, considering the required duration and number of students. It is needed to test the application priorly to the displacement of the lessons in order to ensure its quality and ease of use, and to prepare the different roles in approaching the content.

3.2.2. Definition of lesson structure and organization of the VR Labs

After testing the application, the next step involves integrating it into the lesson structure. This includes organizing both theoretical and practical aspects, typically done by the instructor. It's crucial to inform students beforehand about the lecture content, the new VR-based learning approach, and the lesson structure. Basic preparation rules for the Labs include ensuring equipment is charged and functioning, uploading each application onto PCs/VR headsets, pre-organizing student work, arranging group formations, providing adequate tutors for assistance, ensuring proper ventilation, and informing students about technical details.

3.2.3. Conducting the lesson and collecting feedbacks

Before the lesson, instructors ensure app and device functionality, share preparatory material, and prepare the classroom. During the lesson, they both deliver content and moderate technology use. Afterwards, discussions with students about the new experiences foster mutual interest. Students can share thoughts or doubts about the technology, while instructors explain perspectives and future plans.

4. Impact of VR Labs on the students

The recommended procedure for instructors highlights the significance of collecting feedback from students to evaluate their engagement and satisfaction with this unconventional method of lesson delivery. The department has devised an online questionnaire using the Microsoft Forms application, intended for professors to gather feedback.

4.1. Post-lesson questionnaire general structure

The description of each individual question will not be detailed as the document provided is customized by individual instructors for their lessons. The initial questions posed to students are optional and aim to assess the prevalence of VR technology and VR devices among students (e.g., 'Have you ever used VR systems?'). Responses to these questions are multiple choice. Subsequently, questions are asked regarding the experience of the lesson itself, any difficulties encountered, and the content of the lesson. Students are then asked to indicate, on a scale from 1 (negative) to 5 (positive), with 3 being neutral, their level of satisfaction with certain aspects related to the new lesson displacement method. The list of characteristics on which students are asked to express their views varies depending on the content of the lesson and the mode of VR use. A subsequent section asks questions about the mode of lesson consumption, whether in groups or individually, and the corresponding level of satisfaction with the mode and its

characteristics. The next question is an open-ended one, inquiring about aspects that the respondent particularly enjoyed. This is followed by another open-ended question, asking if there are any suggestions the student wishes to offer to the instructor for the lesson. The final question asks whether the student would like such a consumption system to be applied to other courses of study, and if the response is negative, the student is asked to specify why.

4.2. Discussion on first indicative results

Since the questionnaires are customized by instructors on a case-by-case basis, the responses cannot be considered representative of the overall functionality of the VR. This could be considered as material for further study on the topic. Results are reported only from the last question posed to students: 'Would you like a similar activity to be repeated in this course or in any other courses?' From the questionnaire results collected across eight courses held in the VR Labs, involving a total of 394 students from various departments and courses, during the academic years 2021/2022 and 2022/2023, 97.4% of respondents (384 students) indicated they would like a similar activity to be repeated. Although not methodologically conclusive due to questionnaire limitations and the sample size, this provides a qualitative initial indication of the positive impact of introducing VR as a learning tool in classrooms.

5. Conclusions

An increasing number of educational institutions are exploring the integration of emerging technologies, such as VR into their lecture formats. (Bogusevschi et al., 2020; Jiang & Fryer, 2024; Philippe et al., 2020) VR is among the advanced technologies, including Augmented Reality, Artificial Intelligence and others, being experimented with in educational settings. Initial implementations of VR in lesson delivery have shown positive impacts on student learning, leading to increased engagement and attention. (Akman & Çakır, 2023; AlGerafi et al., 2023; Marougkas et al., 2023; Yoon et al., 2024) This paper provides guidelines for the systematic establishment of VR-equipped classrooms, based on empirical insights gained from the research group's experience in implementing VR-based lessons. Since their inception in 2021, the two VR Labs at Politecnico di Milano have been utilized by various departments for a range of activities with a total of 30 activities including courses, lectures, workshops, and exams; students, from a very first indicative survey, seems to give positive feedbacks on the activities conducted into the VR Labs.

References

Ardiny, H., & Khanmirza, E. (2018, October). The role of AR and VR technologies in education developments: Opportunities and challenges. In 2018, 6th RSI International Conference on Robotics and Mechatronics (IcRoM). IEEE. https://ieeexplore.ieee.org/document/8657615

Akman, E., & Çakır, R. (2023). The effect of educational virtual reality game on primary school students' achievement and engagement in mathematics. *Interactive Learning Environments*, *31*(3), 1467–1484. https://doi.org/10.1080/10494820.2020.1841800

AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education. *Electronics*, *12*(18), Articolo 18. https://doi.org/10.3390/electronics12183953

Bogusevschi, D., Muntean, C., & Muntean, G.-M. (2020). Teaching and Learning Physics using 3D Virtual Learning Environment: A Case Study of Combined Virtual Reality and Virtual Laboratory in Secondary School. *Journal of Computers in Mathematics and Science Teaching*, *39*(1), 5–18.

Bozkurt, A. (2020). *Educational Technology Research Patterns in the Realm of the Digital Knowledge Age* (1). *2020*(1), Articolo 1. https://doi.org/10.5334/jime.570

Dale, E. (1969). Audio-Visual Methods in Teaching (3rd ed., p. 108). Holt, Rinehart & Winston, New York: Dryden Press. https://www.researchgate.net/figure/283011989_fig1_Figure-2-Edgar-Dale-Audio-Visual-Methods-in-Teaching-3rd-Edition-Holt-Rinehart-and

Jiang, J., & Fryer, L. K. (2024). The effect of virtual reality learning on students' motivation: A scoping review. *Journal of Computer Assisted Learning*, *40*(1), 360–373. https://doi.org/10.1111/jcal.12885

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A systematic review of Virtual Reality in education. *Themes in Science and Technology Education*, *10*(2), 85–119.

Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade. *Electronics*, *12*(13), Articolo 13. https://doi.org/10.3390/electronics12132832

Philippe, S., Souchet, A. D., Lameras, P., Petridis, P., Caporal, J., Coldeboeuf, G., & Duzan, H. (2020). Multimodal teaching, learning and training in virtual reality: A review and case study. *Virtual Reality & Intelligent Hardware*, *2*(5), 421–442. https://doi.org/10.1016/j.vrih.2020.07.008

Slavova, Y., & Mu, M. (2018). A Comparative Study of the Learning Outcomes and Experience of VR in Education. *2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 685–686. https://doi.org/10.1109/VR.2018.8446486

Yoon, M., Choi, K., Yoon, S., & Jo, I.-H. (2024). Task type matters: The impact of virtual reality training on training performance. *Journal of Computer Assisted Learning*, *40*(1), 205–218. https://doi.org/10.1111/jcal.12874