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Editorial

Virtual/Augmented Reality Applications in Education & Life Long Learning

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1. Introduction to the Educational Use of Virtual/Augmented Reality

Recent advancements in educational technology highlight the significance of disruptive technologies in enhancing Learning Experiences (LX) in a more targeted, personalized, and engaging context. Specifically, Virtual Reality (VR) and Augmented Reality (AR) applications have the potential to enhance learning by offering students, regardless of age, memorable experiences within explorative digital environments that would otherwise be impractical to recreate or, at the very least, prohibitively expensive.

Furthermore, the proliferation of mobile computing enables individuals to utilize their personal devices in both informal and non-formal learning settings, such as museums, libraries, and workplaces. Voluntary and self-motivated learning (i.e., life-long learning), whether pursued for personal or professional reasons, can be facilitated remotely through learners' personal devices and infrastructure [1].

The challenges associated with implementing Virtual and/or Augmented reality technologies in education and Life-Long Learning are multifaceted, and span various aspects. These include, but are not limited to, the establishment of suitable instructional approaches [2], the exploration of innovative toolsets that can be effectively utilized across a diverse range of educational settings [3], mitigating learner indifference as well as enhancing student engagement in Special Education [4], and optimizing student retention in all levels of education.

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2. The Present Issue

This Special Issue aims to present Virtual and Augmented Reality technologies as a game-changing approach and as core elements of effective teaching and learning environments. These solutions, when used in a wide range of educational contexts, either inside or outside of classrooms, offer memorable immersive and Mixed Reality learning experiences to learners. The scope of this issue includes AR/VR reference architectures tested under diverse educational conditions (e.g., K-12 education, higher education, vocational training, life-long learning, and STEM education), literature reviews on various educational applications of AR and VR, and approaches for vocational training purposes that integrate Mixed Reality applications into industrial processes.

The current Special Issue attracted the interest of many researches worldwide, and eventually seven high-quality papers were selected for publication after a double-blind review process. The selected papers explore essential themes within the realm of AR/VR solutions for educational applications. The following paragraphs very briefly describe how those seven original works contributed to the objectives of this Special Issue.

In the first paper, da Silva et al. (Contribution 1) presents and evaluates a reference architecture for Extended Remote Laboratories (XRLs) used in high school students to enhance the accessibility and quality of science education, thus overcoming physical laboratory limitations. Study participants were engaged in immersive learning experiences using the proposed solution, and reported positive results according to a learner experience questionnaire that covered aspects of usability, immersion, and utility. Adaptation of VR gadgets and validation of the students' learning outcomes are included in future plans.

Within the Digi-Orch project, Kaimaris et al. (Contribution 2) created an AR application to extend and enrich an analogue leaflet/flyer/poster through a mobile application to provide an enhanced audience experience to classical music lovers (e.g., a 360° VR tour of the event). The proposed architecture contains a Content Management System (CMS), 3-D model databases, an AR content management interface, and an AR dynamic projection subsystem, in order to combine traditional (printed) physical materials with digital content. The proposed prototype was evaluated under real-life conditions in music concerts, as well as in educational context. The educational version helps young students to understand the instruments of the orchestra (through their sounds and 3D models) by means of the AR technology.

Villarroel et al. (Contribution 3) proposed a system for virtualization and monitoring of industrial processes using an enhanced SCADA system. This reference architecture allows for low-profile processes of an industrial plant—such as a bottle sealing process—to transmit information to the business level. Using a typical VR development tool like Unity 3D, the developers achieved communication between the PLCs and other industrial equipment and the operators who monitor key-process variables. Moreover, they proposed this virtualized environment as a teaching tool, since it allows for industrial automation engineering students to manipulate industrial processes in a controlled environment by eliminating the risk of accidents and by also protecting expensive equipment from misuse or damage. Having an eye on Industry 4.0 requirements, the proposed enhanced visualization SCADA system integrates several disruptive technologies like Big Data, Internet-of-Things, and Virtual Reality.

A paper which is targeted to Vocational Education and Training (VET), and performs a comparison of current software/hardware Mixed Reality tools, comes from Ortega-Gras et al. (Contribution 4). Specifically, the authors researched successful examples of Mixed Reality tools—such as VR, 360° 30 videos and MR–applied to the Woodworking and Furniture field's (W&F) training actions. After an analysis of the opinions of students, teachers, and training organizations regarding the development of immersive XR training contents and the use of XR in education, this work concluded that there is an unclear workflow for educational content development and a lack of uniform technical and legal standards. While authors will continue working towards the digital and green transformation of VET in the W&F sector, their plans include monitoring the efficiency of the teaching–learning process through Mixed Reality educational interventions.

Although the use of AR and VR technologies has been proposed and tested mostly in engineering educational topics, their impact on language learning is rarely found. Belda-Medina et al. (Contribution 5) have investigated the effectiveness of AR in vocabulary development in English language among students of secondary education. This study applied both quantitative and qualitative approaches to measure three main parameters: the impact of AR technology on student motivation, the effect of their use on vocabulary development, and the attitudes of secondary education school students toward AR technology. The results indicated that although vocabulary learning performance was not affected by the AR educational interventions, students maintained a positive attitude and a strong interest in AR technology for language learning.

Despite many empirical studies having reported the benefits of Extended Reality (XR) technologies—such as AR and VR—in K-12 and higher education, their integration in education is being delayed. Through Meccawy's systematic review (Contribution 6), the lack of a single path to follow for developing immersive learning environments using XR technologies is highlighted.

Contribution 7 performs a literature review of educational applications of AR and VR in diverse educational contexts, such as K-12 education, higher education, lifelong learning, STEM, and vocational training. Specifically, this research underscores the notable influence of AR/VR on education. The authors emphasized the impact of AR/VR on student's motivation, the achieved learning outcomes, engagement, and overall learning experience. The suggestions emphasize the importance of a pedagogically sound design, educator training, and considerations for accessibility to guarantee fair access for every learner. By comprehending the strengths, limitations, and challenges, it enables informed decisions on the effective utilization of these technologies to craft engaging and impactful learning experiences and, thus, in turn, fosters a generation of learners who are both technologically proficient and driven by knowledge.

3. Summary of the Included Research Works

Although the concept of AR/VR technologies in education is not new, the interest of researchers in this topic focused on the development of reference architectures that will deliver media-enhanced educational services to learners. This can be taken as an indicator that AR/VR technologies are still under development, and there is no one solution for everything. On the other hand, some content development tools, such as Unity, have become popular among content developers with diverse technical backgrounds.

Regarding the scholar or scientific fields in which Virtual and Augmented Reality technologies are being applied, we witness an expansion in subjects other than those of engineering and physics. Researchers nowadays experiment with language and music learning, in addition to STEM topics. This trend can be confirmed by other studies as well, since it is easy today to find applications in topics like eHealth/telemedicine [5], art and art education [6] and more.

Overall, the findings include the positive attitudes and opinions of students and teachers regarding the educational uses of AR/VR technologies, but there is still a long way to go. Possible barriers appear to be the lack of a common educational standard, training of educators/teachers, and the high price of the required equipment. Especially for AR, this cost can be reduced thanks to the bring-your-own-device (BYOT) principle.

4. Conclusions

AR and VR technologies provide unique advantages, especially for scientific data visualization and providing memorable student experiences. There are limitations to be taken into account when designing educational interventions using AR/VR tools, and the lack of a common educational framework. Although usability, technology acceptance, and learners' experiences are evaluated quite often, evaluation methods based on objective learning results are rarely found. Moreover, the social dynamics of a classroom may not have been investigated enough, as most educational applications or AR/VR/XR are still single-user apps.

AR/VR technologies have reached a level of maturity suitable for standardization in educational applications, and the audience appears prepared to embrace these enhanced learning experiences, aiming to optimize both user satisfaction and educational outcomes [7]. However, recent findings indicate that, apart from the readiness of the audience, content developers have to support inexperienced and less-frequent users to manipulate the virtual environment and to stay focused on the main objectives of the learning environment [8]. It seems that users without a strong gaming background or long experience in AR/VR applications are the critical slice of end-users who may face difficulties and show resistance to the digital transformation of education using disruptive technologies.

Overall, it is possible that we are witnessing the beginnings of the creation of a new or renewed learning theory that comes to better interpret the phenomena related to the use of disruptive technologies within socializing environments [9]. Other future research could be focused on 3D media-enhanced socializing environments, the evaluation of group student work, and work towards the development of standards to allow interoperability between AR/VR educational applications.

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