Exploring the Impact of VR and AR Integration in Learning Management Systems: A Study on Enhancing Immersive Learning Experiences

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Abstract:
This paper presents a comparative analysis of four educational platforms that use virtual reality (VR) and augmented reality (AR) technologies: TinkerCad, Delightex, MolecularWebXR, and ENGAGE. We based our evaluation on three main pillars: platform classification (VR or AR), core functionalities and services it offers, and user experience (UX) based on our practical engagement. After sharing our experience, we have provided a modern comparative XR-Ed framework in which we have given more details to the performance factors. A review of the contemporary literature highlights the role of inclusive technologies in increasing motivation, improving knowledge retention, and fostering active participation in both STEM and higher education. The findings show that each platform meets different educational needs: TinkerCad supports early STEM education through 3D modeling and electronics. The Delightex platform offers interactive AR/3D environments that foster creativity and personalized learning. MolecularWebXR uses VR for scientific visualizations, allowing students to explore complex molecular structures. While ENGAGE enables collaborative virtual classrooms and conferences, emphasizing social presence and active interaction. While the study confirms the great educational potential of these platforms, it also identifies challenges such as limited access, infrastructure requirements, and the need for pedagogical adaptation.

Keywords:
VR/AR technologies, Tinkercad, Delightex, MolecularWebXR, ENGAGE

1. Introduction

Education, as one of the most important areas of a society, has undergone continuous transformations since ancient times until now. The end of the 20th century and the beginning of the 21st century, has marked a period of rapid technological progress. This development has had both direct and indirect effects on education. Many methods of explanation, assessment, entertainment through the Internet or the digitalization process have been developed. So, the teaching and learning process has had to keep up with technology by adapting methods according to the time. Now, one of the best experiences in education is undoubtedly the use of VR/AR technologies which offer 2D and 3D presentation of new lessons, which can be theoretical or practical. These technologies are always growing in terms of use and extension in the world's geographical space. They are quite profitable both in terms of abstract knowledge, or simulation of practical knowledge and recreation or entertainment. Each has its own weight and are key factors in professional advancement. These technologies are not without challenges, as for most of them the high cost of supply remains a problem and another part requires training for teachers so that they are ready to teach students. However, we have tried to provide an analysis of some of the main technologies with global impact by assessing their importance in our lives.

2. Related work

Recently, we have seen a great development of VR/AR technologies, offering new immersive environments in education. Their inclusion in education increases student engagement, increases motivation and is helping in practical learning. However, it can sometimes cause confusion, as students may not distinguish between real and virtual events [1]. Regarding the field of education, virtual classrooms, intelligent tutoring systems, and VR/AR platforms are commonly used. Also, expectations and hopes for the future are the integration of AI and ML in the growth and advancement of these technologies [2]. Typically, the technologies used for VR are headsets from various manufacturers, while for AR they are mobile phones, tablets, and platforms built on Unity3D [3]. The new developments are based on improving computer vision for AR/VR through a new system based on a lightweight auto-encoder for "in-sensor" processing [4]. One of the innovations in this technology is the development of a neural interface based on EMG sensors placed on the forearm to enable natural interactions with XR and more pleasant feeling of the operator. So, the goal is to decode the force of the hands and fingers in real time to experience a more realistic experience, but the challenge remains that almost no AR/VR technology has force inputs [5]. Similarly, another paper aims at a distributed sensor computing (DOSC) architecture with the aim of saving energy by up to 24% through semi-analytical methods and distributed neural networks (DetNet and KeyNet) for hand tracking in VR/AR devices [6]. Another goal is to use this technology in industry, mainly for staff training, increasing safety and professional preparation, although standardization of protocols and technological barriers remain a challenge [7]. In summary, we can say that the application of XR technologies in education is only expanding in language education, ICT, physics, astronomy, neurosurgery, history, special education, and mathematics [8].

3. Methodology

Regarding the methodology of this paper, it is built on a combined approach, which includes a systematic review of existing literature, personal experiences while using VR/AR platforms in the educational context, as well as a direct comparative analysis of them. Initially, we reviewed the most important studies and publications that address the impact of immersive technologies on the learning process, focusing on the main areas of user experience and educational potential. Then, our personal experiences while testing the platforms were integrated as a complementary source to highlight the practical challenges and opportunities that these tools offer. We developed the final analysis based on the XR-Ed Framework, which allows for a structured assessment according to six main dimensions: Learner Agency, Social Interactivity, Cognitive Challenge, Immersion, Embodiment and Authenticity. This approach aims to guarantee the most complete and objective perspective on the potential of VR/AR platforms in the field of education.

4. VR/AR platforms

In this chapter, four platforms that have direct use in practical and visual teaching have been analyzed. These technologies offer modeling, simulations, interactions and virtual experiments in real time. Through these platforms, a new pedagogical approach, level of student engagement and ease of use for beginners and advanced users have been enabled.

4.1 TinkerCad

The TinkerCad platform is used in an educational aspect by offering three main services for 3D, electronic modeling and coding, which is closer to AR technology. The platform provides a workspace in which users can create and simulate models for engineering, 3D design and electronic circuits. It has a very friendly GUI and offers a very simple approach for novice users.

A. TinkerCad - Scope of services

In the field of services offered by this platform through 3D modeling, users have the opportunity to create personalized objects through basic geometric shapes, which we can export and print on 3D printers. While regarding the electronics part, students or professors have the opportunity to build circuits with resistors, LEDs or sensors and test them through simulations. And finally, as a third and very important function, is the integration of the electronic project into Arduino, in which users can also write code to enable testing of the functionality of the circuits.

B. TinkerCad - Personal use and experience

TinkerCad has a simple look and feel and it is easy to use. It works directly from the browser, without the need for additional installations or devices, which makes it affordable for everyone. For first-time users, the entry is very intuitive. We can create the first 3D model with just a few clicks. The interface is quite structured and offers immediate visual feedback, which gives the user a sense of control. Personal experience with the platform clearly shows that TinkerCad is built to offer a feeling between playing and learning – making you feel like you are playing, while learning good design and electronics knowledge. A very good thing is the ability to experiment without fear, so any mistake can be reversed and each project is automatically saved in the cloud without any side effects.

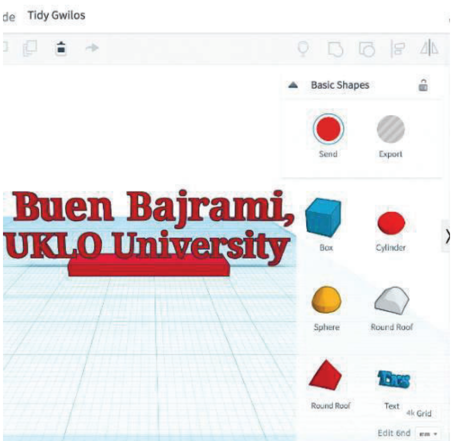

Figure 1: TinkerCad 3D objects

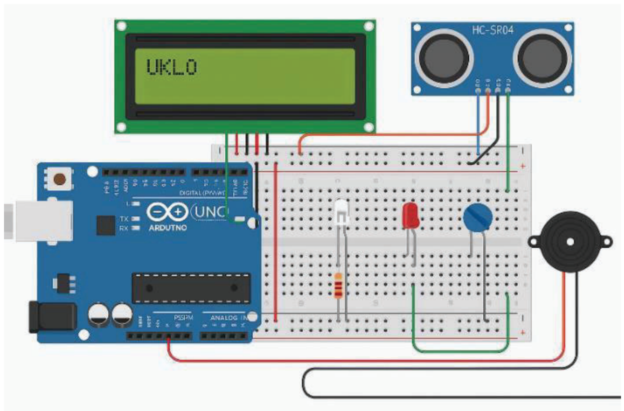

Figure 2: TinkerCad Arduino project

After a while of use, the feeling we have after a few days is that of progress: it starts with simple models and gradually moves on to more complex projects, which include programmable electronic circuits. Based on our experience, we can freely say that for educational and teaching purposes, the experience with TinkerCad is authentic, and quite motivating – a clear combination of practice with creativity.

4.2. Delightex

The Delightex platform is built on the foundation of augmented reality (AR) and 3D modeling, which focuses on creating educational content and personalized learning environments. The platform is intended for teachers, students and educators who want to enrich the learning process through visual and spatial interaction. Due to its nature, Delightex clearly falls into the category of AR/3D applications.

A. Delightex - Scope of services

Delightex offers a wide range of services that combine 3D modeling, interactive simulations and augmented reality. Users can build educational environments where a scientific, mathematical or technological concept is displayed through 3D objects integrated into real space. An important functionality is the ability to share these scenes with others, enabling collaborative work between students or live presentations for online learning. The platform also supports content customization, allowing educators to build activities according to the specific needs of the class or subject. The visual part is very strong: 3D objects can be rotated, zoomed and displayed in real context, making the learning process more lively and engaging.

B. Delightex - Personal use and experience

The process of creating content is similar to a game: 3D objects are selected, placed in space, linked to the learning scenario and then displayed through AR. Personal experience shows that the motivation to continue using it is directly related to the feeling of "augmented reality": when a theoretical concept, for example a molecular model or a geometric figure, is displayed on the table via a mobile phone or tablet, the lesson becomes tangible and more understandable

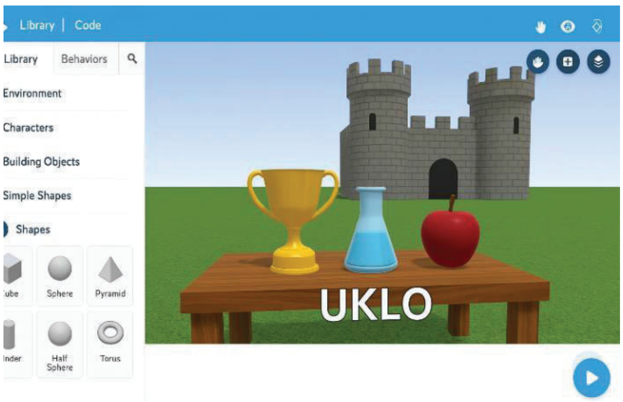

Figure 3. Delightex 3D objects

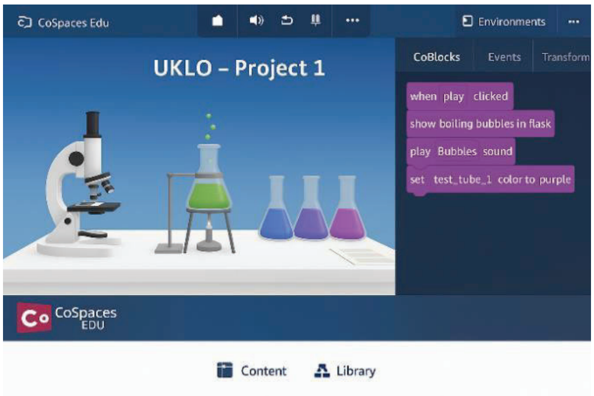

Figure 4. Delightex AR project

On the emotional side, Delightex offers a strong sense of involvement – students are not just spectators, but they become actors in the creativity. This interactivity makes us feel closer to the content and increases the level of engagement. Another important element is the financial aspect and the fact that the platform works well even without very expensive equipment: a regular phone or tablet is enough to experience AR. This makes the UX more accessible and lowers the cost barriers. However, in personal experience, sometimes technical limitations such as loading delays or the need for a good internet connection appear. These moments can bring frustration, but do not significantly diminish the overall value of the platform. For a new user, the experience is motivating and fresh; for an educator, it is a tool that opens up new pedagogical possibilities and facilitates teaching.

4.3. MolecularWebXR

MolecularWebXR is a virtual reality (VR) platform developed for exploring molecular structures and chemical concepts in a spatial environment. Built on WebXR technology, it runs directly from the browser, adapting to both VR devices and computer screens. Its goal is to transform ordinary 2D chemical models into immersive experiences, where the user can explore molecules and better understand their size, bonding, and structures.

A. MolecularWebXR - Scope of services

The platform offers 3D visualization of molecules, with the ability to rotate, zoom, and explore from any angle. It supports the use of VR devices for a strong sense of presence, making it seem as if the molecules are physically in front of students. Another important feature is the collaborative approach: teachers can explain structures directly in the classroom, while students follow the same model on their devices. This makes the platform valuable for interactive lectures, virtual labs, and more realistic demonstrations.

B. MolecularWebXR - Personal use and experience

Based on our personal experience, we can appreciate that the use of MolecularWebXR is unique, especially with VR equipment. Experiencing a complex structure like DNA in gigantic proportions and moving around it creates a deep conceptual understanding that cannot be achieved through flat images.

The platform is easy to use, as it does not require additional installations and works from the browser, offering easy access even for beginners. Immersiveness is the biggest advantage: the concepts seem real and tangible, making students more motivated and curious. However, the most complete experience requires quality VR equipment, otherwise it is reduced to a less immersive 3D visualization.

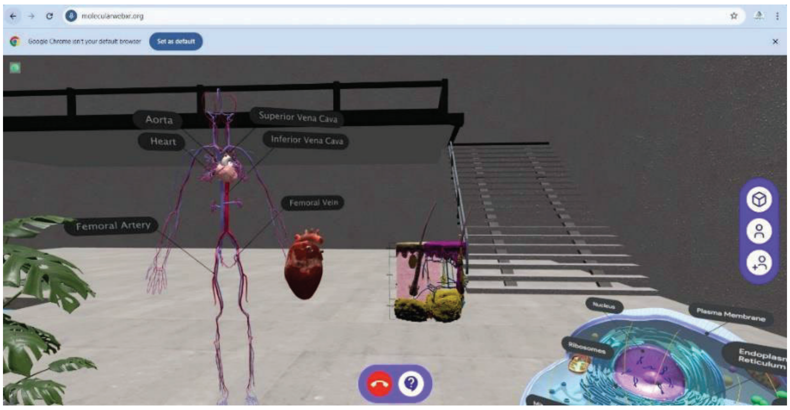

Figure 5. MolecularWebXR Biology project

Also, large models require powerful computers and fast internet. Despite its limitations, MolecularWebXR remains an inspiring tool that gives chemistry a new dimension, turning theoretical learning into a lively and meaningful experience.

4.4. ENGAGE

ENGAGE is an advanced virtual reality (VR) platform built for education and professional training. It creates a real-world environment where lectures, workshops, conferences and interactive training take place. Thanks to its widespread use in education, business and research, ENGAGE is one of the most popular platforms for contemporary communication and learning, clearly representing the category of educational VR.

A. ENGAGE - Scope of services

ENGAGE enables the creation of virtual classrooms with multimedia content such as videos, 3D models and presentations. A unique feature is the recording of sessions for full review in VR. The platform supports international meetings and conferences, where participants feel like they are in the same room. In addition, it offers personalized scenarios: scientific laboratories, historical spaces or business environments, built according to needs. It integrates real-time collaboration tools, enabling discussions, sharing of 3D objects and the use of virtual whiteboards.

B. ENGAGE - Personal use and experience

Using ENGAGE is like entering another world, where a sense of presence and inclusion in a special space is created. The user personalizes their content and actively participates in the class or conference. Real-time interaction – from raising their hand to working on projects, also increases the sense of community. The experience was engaging and the lectures became emotional and interactive events, far from traditional forms of online learning.

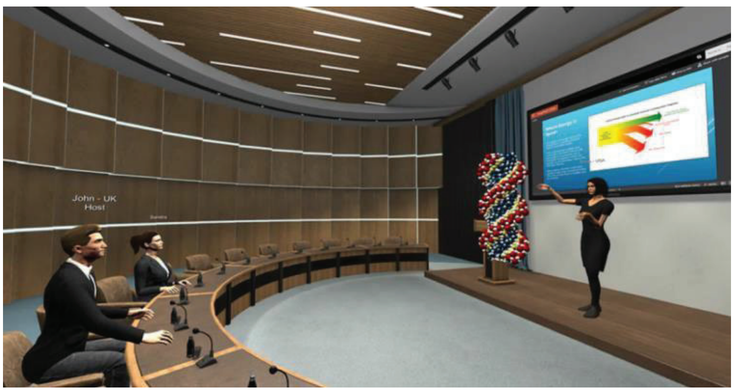

Figure 6. ENGAGE VR Meeting Room

One limitation remains the requirement for dedicated VR hardware to achieve maximum immersion, although the platform can also be used on lower-end computers. Despite this, ENGAGE manages to turn online learning from a passive process into an active experience by making the user a full participant in the learning process.

5. XR-Ed comparative framework

After evaluating personal experiences of the platforms, we have managed to form a comparative table based on the Extended Reality in Education framework, and its six comparative factors, which we have described as follows below.

1. Learner Agency – The degree to which a student has control over the learning experience (decision-making, personalization, etc.)
2. Social Interacitivty – The opportunities offered by a platform for collaboration and social interaction within the XR environment.
3. Cognitive Challenge – It represents the level of intellectual challenge, i.e. whether the XR platform forces the student to think critically or solve complex problems.
4. Immersion – It represents the level of psychological or perceptual immersion in a virtual environment. The higher the degree of virtual presence, the higher the immersion factor.
5. Embodiment – It represents the degree to which a user feels represented within an XR platform through their body movements, gestures, etc.
6. Authenticity – Represents the level of how well a platform simulates the real world or real situations.

Through this framework, we have tried to provide a clearer understanding by presenting the orientation and impact of these platforms in educational institutions, where each of them has occupied certain profiles and has provided XR services by increasing interactivity and interest of students to learn and understand lessons more easily. The assessment has been carried out through three levels, which are High, Moderate and Low in relation to the performance factors of the XR-Ed framework.

Table 1:

XR-Ed comparative framework of XR platforms

XR-Ed Factors	TinckerCad	Delightex	MolecularWebXR	ENGAGE
Learner Agency	High. Students create 3D Models and electronic circuits	High. Students build AR scenes and personalize the content	Moderate. Students can explore molecules but not to create new ones	High. Students participate in activities
Social Interactivity	Low. Individual work, no real time collaboration	High. Students allow to share scenes and presentations	Moderate. Teachers lead while students follow the same model	High. Multi user environment with full intercation
Cognitive Challenge	Very high. Requires problem solving and coding	Moderate. Stimulates creativity and personalization	Moderate. Supports understanding of complex structures	High. Advanced simulations and interactive discussions
Immersion	3D on screen. No VR.	AR via phone. No VR	Full VR. Deep experience through WebXR	Full VR. Complete immersive content

Embodiment	Low. No real embodiment. Only mouse/keypad interaction	Low. Basic embodiment. Only manipulation of objects in AR	Moderate. Movement and perspective in VR	High. Gestures and movements in VR
Authenticity	High. Simulates real labs	High. Content linked to curriculum	High. Realistic visualization of molecules	High. Realistic educational environments

The results of the table show that each of the platforms has its own distinct role in the learning process, meeting different needs in terms of pedagogical aspects. The combination of these technologies offers a richer learning model, increasing engagement but also understanding, especially for complex topics.

6. Conclusions

The research of VR and AR usage in educational fields, shows us that these platforms have passed the experimental phase and have now become indispensable in education. They are offering direct interaction of scientific concepts, a sense of physical presence even inside molecules that are offering a high-level representation by understanding these elements much better, from different dimensions. Our impression is that the integration of these platforms in education does not replace traditional methods, but simply empowers them by enriching knowledge and improving the form of explanation and understanding, specifically by adding practice and creativity. In addition to sharing personal experiences, we tried to present an analysis using the XR-Ed framework. Two of the selected platforms rely on AR technology, and the other two completely on VR. Only the Tinkercad platform does not offer real-time group work, unlike the other three platforms included in the paper. In terms of embodiment, only the ENGAGE platform offers an advanced level. The main challenge remains the cost of providing the necessary VR equipment, licenses, etc., which are currently still unaffordable for many institutions. But one thing is certain: the future holds great promise, offering a higher quality education based on practical and emotional experience.

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