Virtual and Augmented Reality: Enhancing the learning experience in higher education in the U.A.E. Current standing & research directions

Dimitrios Xanthidis,
Computer and Information Science,
Higher Colleges of Technology,
Dubai, U.A.E.,
dxanthidis@hct.ac.ae,
https://orcid.org/0000-0002-1349-5749

Christos Manolas,
Music and Sound Design for Media
Ravensbourne University,
London, U.K.
xmanolas@gmail.com,
https://orcid.org/0000-0003-0057-8374

Sujni Paul,
Computer and Information Science,
Higher Colleges of Technology,
Dubai, U.A.E.,
spaul@hct.ac.ae,
http://orcid.org/0000-0002-4863-1333

Ourania Koutzampasopoulou Xanthidou,
Computer Science and Information Technology,
University of Malaya,
Kuala Lumpur, Malaysia
xarania@gmail.com,
https://orcid.org/0000-0002-2659-7138

Abstract**—*In addition to the established and widespread technological tools and trends of the past decades, such as the surge of mobile computing, high-speed networks and social media, new technologies utilizing the increased power and capabilities of modern computers is developing rapidly. Perhaps, no better example of this can be found than the rapid developments in Virtual and Augmented Reality (VR/AR), that have recently made the step from the laboratories and specialized, bespoke training applications of the past, to the mainstream. Advances in VR/AR have opened the floodgates to digital internships, virtual labs, and novel collaborative and experiential learning. The magnitude and impact of these emerging technologies is also evident on the significant interest in their application and use in various commercial, professional, and industrial contexts. Examples of these include, but are not limited to, the entertainment industries, specialized training, corporate demonstrations and conferencing, and prototyping and modelling in the technical and engineering areas. Since universities play a vital role in moulding tomorrow's talents, integrating such technologies can help them not only by supporting teaching and learning, but also by contributing to related research and enhancing the learning technology frameworks in their entirety. The aim of this research paper is to briefly discuss the position of these emerging technologies in the educational sector in general, and explore what their role, impact, and structure may be in the educational systems of the future with a focus on higher education in the U.A.E. Eventually, it will contribute by suggesting areas of interest for its future use in higher education in the U.A.E.*

Keywords**—*Higher Education, Augmented Reality, Virtual Reality, Learning Object, U.A.E.*

I. Introduction

Virtual Reality (VR) enables the user to be engaged in a computer-generated, interactive audio-visual environment through diverse visual and auditory interfaces and devices. The created environment is also frequently supported by other sensory cues, such as tactile and olfactory [23], aiming to make the experience as immersive and enveloping as possible. The ultimate goal of VR is to present the user with a multisensory experience that disconnects them from the physical world and transfers them in an alternative reality.

Augmented Reality (AR) is not hugely dissimilar to VR from a technological or conceptual viewpoint, but its main goal is to integrate artificially generated multisensory cues and other digital information into the real-world. In this augmented real environment everything is processed and produced in real time and a lot of research has been conducted to go deep into the AR characteristics [25]. As such, the two platforms share a common base, but also have unique characteristics that make them suitable for different applications (Table 1).

Table 1: Comparison of Augmented and Virtual Reality

Comparison	*VR*	*AR*
Meaning	*VR presents something which isn't actually present with the help of computers.*	*AR utilises your current environment and overlays with the digital information on it.*
Experience	*To experience VR, headsets are mandatorily required to connect with a computer or gaming console.*	*AR experience can be gained by downloading AR apps on your smartphones as the camera will capture the real environment and automatically lay virtual objects on it.*
Interaction	*With VR headset you get completely separated from Real-World.*	*AR allows users to be real-world and superimposes virtual elements.*
Examples	*Creation of illusion with the help of VR headsets*	*Snapchat lenses and the game Pokemon Go*
Tools	*HTC Vive, Oculus Rift or Google Cardboard*	*Smartphones, AR apps*

In the context of higher education, Virtual and Augmented reality (VR/AR) can be viewed both as the subject of research and innovation [3] and as the means for Learning Objects (LO) and the satisfaction of typical user requirements [22]. As a research and innovation tool, the technologies can enable both the educators and the learners to engage in cutting-edge research that is in line with current practices and future trends on a global scale. In their most basic form, their use as LOs enable the visual transfer of knowledge, which can be combined with the teacheR's explanations and guidance concerning the content displayed thus allowing integrating several human senses, i.e., sight, hearing, touch, and (experimentally) even smell and taste in the whole experience [23].

In addition to providing teachers with advanced teaching and learning tools, one of the most important features of VR/AR in the educational context is that it can assist learners in developing problem-solving skills and investigating new notions, concepts and areas of interest [2]. It is, thus, unsurprising that the use of VR/AR for educational purposes ranks quite high in the list of the sectors where the application of the technology is most useful (fig. 1).

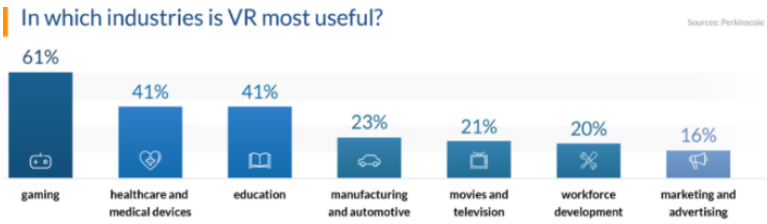

Fig. 1: Industries using VR [32]

In line with global trends and developments, higher education institutions in the U.A.E. have also expressed an interest in exploring new immersive technologies in various contexts. Notable examples include the work in the areas of immersive and 3D technologies currently carried out at the Dubai Women's College (DWC), Zayed University and the United Arab Emirates University (UAEU). Although such work may not fit strictly into the VR/AR context in a narrow sense, it expresses an undeniable interest in immersive and 3D technologies, something that is crucial for the analysis and considerations regarding the future use and impact of VR/AR in the regional higher education sector.

Incorporating VR/AR in higher education in the U.A.E. can be valuable both to learners, who will be the main stakeholders in this process, and to faculty members, who will update their skills and knowledge in the process of integrating these innovations into their teaching methodology. Last but not least, such developments will be of value to the institutions themselves, which will have to conceive and implement these new models of educational innovation.

The first part of this paper briefly outlines the role and position of VR/AR in the educational context, both in terms of research and innovation and as a teaching and learning tool. Next, the focus shifts to examples of current practice utilizing immersive and 3D technologies in higher education in the U.A.E. Finally, the paper discusses possible functions and areas of interest regarding the use of VR/AR in the educational context in the U.A.E., with the aim of laying the foundation for further work and developments in this area.

II. VR and AR in the Educational Context

Universities and colleges have always been at the cutting edge of new technologies, driving development and creating the next generation of scientists, developers and entrepreneurs. As such, it should not come as a surprise that VR/AR technologies had been the subject of academic interest and experimentation for many decades prior to their popularization and widespread adoption. For instance, significant work focusing on the principles behind VR/AR systems, such as visualisation, simulation and construction of virtual worlds was carried out as early as the 1990s [5]. It is also well known that VR/AR systems developed in collaboration with academic establishments and research teams have been used for years for specialised and laboratory tasks, such as flight and medical simulations [12, 16], as well as in various fields of engineering [27]. For instance, teachers are enabled to share knowledge with students using images superimposed on reality of their classrooms. Through the model of a digital human body shown in the three dimensions of space, the teacher can access any type of information about its elements, separate each of its parts to show details, or even have students interacting with the model at will to develop any type of activity. Moving this initiative to engineering, teachers would have a digital model of an engine, printed circuits, or even an architectural structure. The current challenge will be to identify which technology is most applicable for each subject area. This is a developing process that is also essential in order to expose empirical results that support different proposals [27].

On a broader scope, the past and future uses of VR/AR systems for educational purposes extend beyond the narrow boundaries of simulation training and covers, among others, areas like the development of tailored teaching environments, improvement of the learner's spatial perception, development of the learner's emotional intelligence by being more empathetic and practical and the overall improvement of effectiveness and motivation in teaching and learning [10, 18]. Detailed information regarding VR/AR in the educational context can be found in the work of researchers like Garzon *et al.* [5], who have worked on a systematic review and meta-analysis of augmented reality in educational settings, and Beck's [16] work on augmented and virtual reality in education. In addition, the use of technological aids as tools for specifically assisting learners with disabilities has been the subject of numerous studies, and a large body of literature relating to this subject is available [19, 20].

A brief look at this background reveals that VR/AR have been always closely related to the educational sector, both in terms of research and innovation, and as teaching and learning tools. This is a crucial observation, as it highlights the long-lasting interest and the direct relevance of these technologies to the educational sector in general.

According to a report from Goldman Sachs [30], with the reduction in the cost of VR gadgets and tools, the number of educational utilization of VR gadgets is estimated to expand drastically to up to 15 million by 2025. Several colleges and universities have already signed up for this technology and using it to improve the level of higher education. This stream has been benefiting educational institutions in multiple ways, such as:

a) Visual Learning

b) Training to Future Teachers

c) Designing Futures

d) Campus Visit & Enrolments

In addition, specific methodologies focusing on how such technologies can be incorporated in the higher education context in a structured way have also been developed. For instance, Manuel [24] developed a six-step process for adoption of VR/AR in higher education (fig. 2). The six steps are summarized below:

- *Phase 1:* Concerned with the training of teachers on new technologies.
- *Phase 2:* Related to the development of the conceptual prototype of the experience that the teacher wants to use in a course.
- *Phase 3:* Joint work of the subject-matter-expert team: a teacher, a technical programming expert, and an educational architect.
- *Phase 4:* Focus is on the production.
- *Phase 5:* Related to the complete, systematic faculty training on the identified areas of interest.
- *Phase 6:* Teachers can create customized courses based on active methodologies that make use of latest new technologies.

Fig. 2: Steps to adopt AR/ VR in education. [24]

Given the above, it would be interesting to further study the extend to which the local academic institutions' management executives are aware of these developments and, if so, if they are making steps towards utilizing these new technologies into their curriculae. It would, also, be worth exploring the possible challenges, shortcoming, best practices from their whatever, if any, previous experience and their level of satisfaction as a result of that.

III. AR/VR IN THE U.A.E. UNIVERSITIES

Dubai Women's College (DWC) is the first educational institute in the United Arab Emirates to open a new campus in Second Life. DWC's island in Second Life includes several features including an Abra with Abra station, a welcome video screen, a Majlis area serving coffee and a second TV screen for welcoming the user, scale model of DWC's First Life campus with link to the DWC homepage, a UAE flag, and a mosque. In addition, the island has several private features which are open only to DWC staff, students, and invited guests, including a Palm Island development, a Library, five classrooms, Abayas for sale, and a Museum that is currently under construction. DWC's Second Life campus aligns with the DWC's graduate learning outcomes, including encouraging critical and creative thinking skills, global awareness and citizenship, technological literacy, self-management and independent learning, teamwork and leadership, vocational competencies, and mathematical literacy [31]. At DWC, Second Life is planned to be used for several learning activities, including training in the hospitality Industry, X-ray department simulations, hospital and nursing simulations, dentistry simulations, jewellery design and manufacturing, international student exchanges between universities and colleges, cultural exchanges, and Internet commerce-sales of student-created items. Higher Diploma IT students from the Dubai Women's College participated in a virtual exchange program with students from Korea Advanced Institute of Science and Technology (KAIST). Second Life was used with the aim of enhancing cultural awareness and improving the students' English and IT skills.

Zayed University in Dubai, realizing the benefits of using a virtual environment for teaching, introduced nearly 55 students from graphics and networking classes to the concepts of creating 3D objects and the principles of server building within a virtual world. The project utilized OpenSim, the open source server platform [31]. Students create 3D objects within the virtual environment and are able to control their own Avatars and come up with unique presentations.

The Department of Architecture at the United Arab Emirates University (UAEU) designed and constructed an immersive CAVE at VR-LAB. This was in support of the envisioning of 3D spaces and structures based on 2D renderings, an essential skill for students of architecture. The fundamental idea behind the 3D immersive environment is to present the student with a perspective image that changes while navigating through the proposed design [31]. Reportedly, navigating through the CAVE can have significant benefits for the students, such as:

1. *Spatial thinking*: 3D presentation enhances understanding and spatial thinking and allows the students to visualize concepts. Students can use VR to explore perspective and spatial relationships. For example, a virtual walk through a building which is still in the design stage, provides feedback about the architectural applications.
2. *Increased interest level*: The environment strongly motivates learning by simulating fantasy, challenge and curiosity. The experience of move inside the model of a building one has designed can be thrilling.
3. *Increased level of technological expertise*: The students' level of technological expertise and abilities increase with exposure to the immersive environment settings. Learners feel connected and involved in the technology.
4. *Constructive learning*: Learning combines cognitive, affective and psychomotor skills, and provides opportunities to students to develop new ideas and perspectives. The environment allows students to construct knowledge outside their own experiences.
5. *Realism in learning*: High degree of apparent realism while minimizing actual risk. 3D design tools are used in the design studio for testing and exploring architectural concepts. CAVE exposure offers a new way to approach 3D model courses, and new instructional concepts.

The above are some examples of current uses of immersive and 3D technologies in higher education institutions in the U.A.E. The reason they are important for the current study is that they highlight an expressed and clear interest in utilizing tools and technologies (i.e. immersive and 3D) closely related to VR/AR, for educational purposes. As such, it can be claimed that the adoption of VR/AR related technologies by higher education institutions in the U.A.E. has already started, and it is not so much a question of whether VR/AR systems will become educational tools in the future rather than what are the best and most structured ways to integrating them into the existing systems.

One of the areas for further research work in this direction is to systematically investigate the current state of VR/AR technologies in the U.A.E. in general, and, subsequently, explore how this relates to their use in the higher education context in particular. This can be done by means of qualitative and quantitative research designed to explore the context in which immersive and 3D technologies are being used in the U.A.E., and the extent of their use. Ultimately, this is expected to assist the researchers in making informed and relevant observations regarding the optimal future uses of the technologies, in line with regulatory guidelines and recommendations, commercial and professional demand, and cultural and social trends.

IV. VR/AR TOOLS, BENEFITS AND OBSTACLES

A number of VR/AR tools are currently available on a commercial level. Indicative advantages and limitations of some of the most popular of these tools are presented in Table 2 below [34]:

Table 2: Advantages and Limitations of AR/VR tools

AR/VR TOOL	Advantages	Limitations
Oculus	High Performance, Headset Positional Tracking, Immersive Experience	PC required to operate, Primarily a gaming Device, Expensive, No curriculum content, no classroom controls
HTC VIVE	Top quality experience, Active Developer community, Wide range of hardware peripherals	High price, limited educational content, requires high-end PC, complex setup & management, external sensors needed, no classroom management
SONY Playstation	Lower cost relative to PC-based headsets, simple setup & Configuration, high quality games available	No educational content, tethered by wire to a required PlayStation console, requires monitor or TV for setup, closed ecosystem & content, no classroom management
Google Expeditions	Low equipment cost, tether-free operation, centralized content delivery for expeditions	Requires mobile device, physical setup takes time, overheating devices cause lesson disruption, no device management
Atlantis ClassVR	Low cost standalone system, classroom device & content management, curriculum aligned resources, ability to create own content, supports VR & AR	No positional tracking

The benefits from utilizing VR/AR in everyday tasks can be numerous. A recent survey revealed some of these as follows [32]:

- Real time information (49%)
- Training by real-time experience mirroring (49%)
- Enhance creativity due to reduced costs and risks (48%)
- Real time collaboration of remote workforce (47%)
- Live another person's life experience (41%)
- Capture live user behavior (25%)

However, as with every new technological development, the adoption of such technologies has its own set of drawbacks and obstacles that challenge the idea of the technology being a panacea. Some of the barriers related to this are the following [32]:

- User experience problems due to technical issues: 26%
- Not enough quality content available: 24%
- Hesitating consumers and businesses: 14%
- Legal risks and lack of regulatory framework: 13%
- Difficulties in financing and investment: 12%
- High costs: 10%

Nevertheless, the prospects of VR/AR are promising enough to cause the businesses to start preparing the necessary models for the adoption and integration of this future trend. Such models include, but are not limited to, the use of VR/AR in hardware sales, advertisements, eCommerce sales, mobile network data, enterprise/B2B, subscriptions, premium apps, mobile network voice, etc. [33].

From a market share and financial perspective, Facebook is the largest single investor in VR/AR after buying Oculus for $2 billion and investing at least $500 million more [11]. The decision of the company to split Oculus into PC and mobile divisions and showcasing two different VR social platforms may be viewed as an indication of what might come next. Oculus' PC VR division looks set to stay focused on the VR "Specialist" and "Enthusiast" markets mainly due to pricing, and, thus, it does not currently looking like a Facebook-sized (i.e. hundreds of millions or billions of users) asset. Facebook could keep the Oculus PC VR division as a high-end test bed to support mobile VR/AR efforts, spin it out (like Niantic from Google), merge it (potentially consolidating the high-end PC VR market), or sell it outright [33].

In light of such developments, it would be interesting to investigate the plans and timeline for investment in VR/AR from the local industry and higher education institutes. Such a study would also serve the need from the part of the local academia to, possibly, modify their academic programs in an effort to prepare the new generation of local workforce.

V. Discussion/Conclusion

While examining VR/AR technologies in the context of higher education, one of the most obvious considerations is to question how they could be utilised in order to support learners within their disciplines and areas of specialisation. Typical examples of this include the ability to study and work on 3D representations of architectural structures facilitating access to all the layers that compose the structure (wiring, conduits, and any type of existing material), complex engineering structures like aircraft and automobile engines, or magnified computer circuits.

In the U.A.E. in particular, such training will be highly relevant to the local economic and professional environment, as modelling and simulation-based training could enable students to build hands-on, practical experience on subjects like engineering, architecture and mass media productions.

Another area VR/AR may be of significant value is in the representation of abstract concepts [29], such as complex mathematical functions in space, or difficult to communicate ideas prior to implementation, like painting, music, or sculpting. To this, one could also add those subjects that are difficult or impossible for one to get hands-on experience at, such as microbiology, chemistry, nanotechnology, geology or medical professions. VR/AR could provide researchers, educators and learners in such areas with a ground-breaking new tool for learning and exploring the various topics, and an environment where teaching and learning is freed from concerns relating to the feasibility and scale of an idea, the scale of risks and costs involved in a real-life exploration of such complex matters, practical limitations, or health, safety and ethical constraints [26]. For instance, VR/AR may enable the user to scrutinize the human body, magnify dangerous microorganisms or delve into the depths of a volcano, all in the comfort of the classroom. Such applications of the new technologies are relevant globally, but in the context of the U.A.E. higher education in particular, they could assist in the development and supply of cutting edge teaching and research that could both enhance the existing programs and open pave the way for an improved educational offering in such subjects on a global scale.

Outside the strict limits of discipline-specific training, VR/AR tools could be also used to improve teaching and learning irrespectively of the nature and strict boundaries of the academic discipline. VR/AR platforms can be used to enhance the learning experience in the classroom, to test ideas and skills in the form of simulated tasks, or provide a more exciting and intuitive environment through which students and staff access their portals and online accounts. One of the long-term goals of this research project is to explore such possibilities in detail, and map how VR/AR could be incorporated in the teaching and learning process, while taking into account the structure of the higher education system and the unique characteristics and requirements of the industrial and professional environment in the U.A.E.

Utilizing such structured methodologies can help U.A.E. higher education institutions to develop unified, efficient, and easy to validate and quantify workflows, which fit into the regulatory and administrative requirements. Such frameworks will make the work of the various different bodies involved in curriculum and content development (i.e. administrative, regulatory, educational) more consistent, structured, and easier to manage.

Taking into account observations made during this initial study, and the general trends on a global level, in terms of possible future uses of VR/AR in the higher education context in the U.A.E., 5 main areas of interest are highlighted:

1. *VR/AR as an Educational Aid for Teaching and Learning Purposes:* This may include virtual classroom environments and 3D modelling incorporating elements suggested by the subjects and topics within the various different disciplines, or portals and interfaces already used by the university and the students that may be partially or entirely transferred to a VR/AR setting.
2. *VR/AR as an Assistance Tool for Learners with Disabilities:* VR/AR systems designed to address specific disabilities can be incorporated to teaching and learning in order to provide support and establish equal opportunities provisions.
3. *VR/AR as a Creative Tool in Applied Media and Performance Arts:* Applied Media and Performance Arts are arguably some of the subject areas that are at the centre of the ongoing VR/AR revolution [1, 4, 8]. VR/AR not only can fit into the existing portfolio of media studies, but also create a whole new direction for media education in the U.A.E.
4. *VR/AR as a Computer Science Pathway:* This pathway will focus on the technical or technological aspects of VR/AR production, as opposed to its creative potential, and may include software or hardware development, such as scripting, logic and behavior programming, or integrating specific pieces of hardware to the VR/AR experience to create novel experiences and platforms.
5. *VR/AR as a Research Tool:* In addition to the teaching and learning value of VR/AR, educators, learners and researchers could benefit from the integration of the technologies into the academic institutions, both by using them as research tools and studying them as subjects for further development and exploration.

Further work in this direction may include the compilation of a detailed list of the most beneficial and relevant uses of VR/AR technologies for higher education purposes in the U.A.E., as well as the undertaking of a thorough review of existing methodologies and recommendations on a global scope, relating to how the integration of VR/AR should be carried out in the higher education context in the U.A.E.

VI. Conclusion

This paper briefly discussed some concepts related to the position of VR/AR in the educational sector, both on a global scale and in the higher education context within the U.A.E. in particular. Subsequently, it explored and identified possible areas of interest for such technologies for future developments within the higher education sector in the U.A.E. Such future research questions could be:

1. How much aware are the academic institutions' executives of the VR/AR developments related to higher education?
2. Are they making any steps towards utilizing these new technologies into their curriculae?
3. What is the penetration of VR/AR technologies in the higher education in the country?
4. What are the plans, if any, of investing in VR/AR in the academia locally?

The main focus should be to help the Higher Education Institutions in the U.A.E. explore and understand the possibilities offered, and the challenges posed by integrating VR/AR into teaching and learning, and academic research.

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