METAVERSO ETSIE

METAVERSE ETSIE

José M. Gandía-Romero*[1], Fernando Cos-Gayón López[1], Josep R. LLiso-Ferrando[1], Ana Martínez-Ibernón[1], Adrián Llorca Sanchis[2], Jalal Saadi[2], Milagro Iborra Lucas[1]

[1] Universitat Politècnica de València, Depto. de Construcciones Arquitectónicas
[2] Imhotep Studio
*corresponding author: joganro@csa.upv.es

RESUMEN

El METAVERSO_ETSIE es una innovadora iniciativa educativa desarrollada por la Escuela Técnica Superior de Ingeniería de Edificación (ETSIE) de la Universitat Politècnica de València (UPV). Se trata de un entorno de aprendizaje basado en el metaverso, diseñado para mejorar las competencias de los estudiantes mediante experiencias inmersivas e interactivas. Su objetivo es proporcionar una herramienta educativa coordinada que se ajuste a las demandas actuales del sector, impulsando la transformación digital en el ámbito de la ingeniería de edificación. A través de entornos virtuales, ofrece a los estudiantes una plataforma para desarrollar habilidades prácticas en un contexto simulado pero realista, preparándolos para afrontar los desafíos cambiantes del sector de la construcción. Tiene como objetivos motivar a los alumnos, fomentar el autoaprendizaje, reforzar la adquisición de conocimientos previos, favorecer la adquisición de "visión espacial" y dinamizar el proceso de enseñanza-aprendizaje a partir del uso de las últimas tecnologías que permitan trabajar de forma inmersiva e interactiva. El proyecto se enmarca dentro de un Proyecto Institucional de Innovación y Mejora Educativa (PIME) de la Convocatoria Aprendizaje + Docencia 2024 de la UPV. En el artículo se describen las tareas y se muestran los resultados correspondientes a las acciones desarrolladas durante el primer año del proyecto relacionadas con el diseño, el modelado 3d y las simulaciones con las actividades que posibilitarán que el segundo año se hagan las implementaciones en grupos con alumnos y se habilite el acceso a través de una plataforma online.

Palabras clave: *Realidad Virtual, Metaverso, Construcción, Ingeniería de Edificación.*

ABSTRACT

The METAVERSO_ETSIE is an innovative educational initiative developed by the Escuela Técnica Superior de Ingeniería de Edificación (ETSIE) at the Universitat Politècnica de València (UPV). It serves as a metaverse-based learning environment designed to enhance students' competencies through immersive and interactive experiences. It aims to provide a coordinated educational tool that aligns with current industry demands, fostering digital transformation within the field of building engineering. By leveraging virtual environments, it offers students a platform to develop practical skills in a simulated yet realistic context, preparing them for the evolving challenges of the construction sector. The project aims to motivate students, promote self-learning, reinforce the acquisition of prior knowledge, enhance the development of "spatial vision" and energize the teaching-learning process by encouraging the use of the latest technologies that enable immersive and interactive work. The project is part of an Institutional Project for Innovation and Educational Improvement (PIME) under the 2024 Learning + Teaching Call of the UPV. This article describes the tasks and presents the results corresponding to the actions carried out during the first year of the project, related to design, 3D modeling, and simulations with activities that will enable, in the second year, implementations with student groups and access through an online platform.

Keywords: Virtual Reality, Metaverse, Construction, Building Engineering.

1. INTRODUCTION

The digitalization of the university environment has marked a turning point in teaching and learning methods in higher education. This technological transformation has prompted a rethinking of how content is delivered to ensure that students acquire the necessary competencies for their future professional degrees. In this context, a call for Educational Innovation: "Learning + Teaching" (L+T), was promoted by five Vice-Rectorates: "Faculty and Academic Planning," "Planning, Academic Offer and Digital Transformation," "Organization, Studies, Quality, Accreditation and Languages," "Students and Entrepreneurship," and the Vice-Rectorate for "Internationalization and Communication." As part of the competitive L+T calls, the "Call for Educational Innovation and Improvement Projects" (PIME) was launched. The School of Building Engineering (ETSIE) at the Universitat Politècnica de València (UPV) has promoted one institutional project on Educational Innovation and Improvement (PIME 2024–2026) called METAVERSO_ETSIE. This project focuses on the development of an educational metaverse as a methodological tool to enhance the teaching-learning process. This paper presents the progress made during the first year of the project.

In recent years, the metaverse has become a consolidated digital paradigm that merges physical and virtual environments, primarily through technologies such as virtual reality (VR) and augmented reality (AR). The use of the metaverse represents a radical transformation in the way individuals interact, learn, and create within shared three-dimensional digital spaces (Mystakidis, 2022). In the educational field, the incorporation of the metaverse as a training tool has grown significantly, especially after the COVID-19 pandemic, which accelerated the digitalization of higher education (Cai, 2024).

Recent studies have shown that immersive environments enhance motivation, engagement, and the acquisition of practical skills, particularly in technical disciplines such as engineering, design, and architecture (Abdullah et al., 2025; Mustafa, 2022). These tools enable the simulation of construction contexts, management of collaborative projects, and visualization of realistic 3D models with which users can interact (Lee et al., 2024). However, certain limitations are also acknowledged, including technological challenges, implementation costs, and the need for specific teacher training (Kye et al., 2021).

From the academic perspective of architectural technology, the metaverse offers an opportunity to rethink educational spaces by integrating active methodologies into hybrid, dynamic, and participatory learning environments. In this context, ETSIE joins this trend by developing a metaverse focused on teaching, reinforcing the role of both students and teachers as active participants in an interconnected digital environment. This metaverse aims to become an innovative pedagogical platform where teachers and students can interact in simulated spaces, developing technical and transversal skills within a safe, engaging, and technologically advanced environment. This paper outlines the progress achieved during the project's first year, which focused on the design, modeling, and prototyping of the initial three-dimensional scenarios that will form part of ETSIE's educational metaverse.

2. OBJECTIVES

The overall purpose of the METAVERSO-ETSIE project is to implement an immersive environment that serves as a cross-disciplinary learning space for students in the Bachelor's Degree in Building Engineering. The aim is not only to foster students' spatial awareness, but also to stimulate motivation, promote self-directed learning, and facilitate content assimilation. Additionally, the project seeks to boost academic performance, prevent dropout, and contribute to educational excellence.

Within the framework of this general objective, the specific goals for the first year of the project were as follows: to identify international experiences and best practices in the use of virtual environments applied to teaching in architecture, engineering, and related disciplines; to analyze the specific needs of the teaching staff involved—organizational, technical, and pedagogical—in order to ensure the pedagogical coherence of the environment to be developed; to define the priority virtual spaces to be modeled; and to develop the three-dimensional modeling of the defined scenarios, with special emphasis on construction elements linked to the "Construction" courses within the degree program.

3. METODOLOGY

The methodology employed during the first year of the project was structured around two tasks: a review of the state of the art regarding the use of virtual environments and immersive reality in higher education, and the initial development of the three-dimensional model that will make up the ETSIE metaverse. Both lines were approached from a collaborative and interdisciplinary perspective, involving faculty members from various courses within the Bachelor's Degree in Building Engineering, as well as experts in 3D modeling and interactive environment development.

A bibliographic and documentary review was carried out to identify projects, success cases, and best practices related to the application of immersive technologies in university teaching. Academic databases, university repositories, and institutional documents related to educational innovation were consulted. Special attention was given to experiences from leading institutions such as Stanford University, Harvard University, the Massachusetts Institute of Technology (MIT), University College London (UCL), and Helsinki University, among others.

In parallel, working sessions were held with participating faculty to collaboratively define the pedagogical requirements of the virtual environment to be developed. This process was essential to ensure that the modeled spaces addressed actual teaching needs. Tools such as semi-structured interviews, group meetings, and internal questionnaires were used to gather information on:

- Common difficulties identified among students (particularly in technical subjects)
- Course content that could benefit from 3D or immersive representation,
- Current limitations in physical learning resources (labs, site visits, models, etc.)
- Proposals for scenarios, construction elements, and real-life construction situations to be represented in the metaverse.

Once the needs framework was defined, the team moved on to the conceptual design and modeling of the first 3D environments of the metaverse. Two priority contexts were selected: the ETSIE institutional space, and construction scenarios serving as pilot environments simulating works in progress and model exhibitions. Both settings were modeled with a high degree of realism and construction detail, including actual areas of the building and structural-phase construction sites designed for cross-disciplinary learning activities. Software tools such as Autodesk Revit and Archicad were used to generate 3D geometry, apply textures, set up lighting, and perform basic rendering.

The models were created in editable formats and exported as executable files (.exe) for offline viewing, allowing for progressive validation by the teaching team. Future scalability of the project and its integration into additional courses were also considered. During the validation phase, pilot review sessions were conducted in which participating faculty members identified improvements and made proposals for expansion to be implemented in the next project phase.

4. RESULTS

The study conducted through the bibliographic analysis concluded that the metaverse is a highly promising resource in higher education, particularly in fields such as engineering and architecture. As an immersive tool, it enhances spatial awareness, supports three-dimensional interactivity, and enables users to experiment with virtual environments. These areas of knowledge demand strong visual and spatial resources, and the metaverse not only allows for the representation of projects and constructions, but also provides an enriched cognitive experience in which students can navigate, manipulate, and collaborate within digital environments featuring precisely modeled materials, components, and construction systems or execution processes. Another key aspect highlighted in numerous studies is the integration of complementary technologies such as augmented reality (AR), virtual reality (VR), and Building Information Modeling (BIM), especially in hands-on practice and self-directed learning activities. Additionally, the metaverse supports greater equity in access to complex educational experiences, particularly in contexts where site visits, in-person workshops, or physical laboratories are not feasible.

The word cloud in Fig. 1 visually represents the most relevant concepts identified from the analysis of conclusions found in the reviewed literature on the use of the metaverse in higher education. The term “spatial awareness” stands out, reflecting its key role in the development of essential cognitive skills for interpreting three-dimensional models, construction plans, and simulated environments. Following this, concepts such as immersion, learning, and virtual reality occupy prominent positions, highlighting the importance of immersive educational experiences that go beyond traditional expository methods. Terms such as interactivity, simulation, collaboration, and innovation also appear frequently, indicating a shift toward active methodologies, student engagement, and cooperative work in virtual environments. Finally, terms like AR, BIM, prototypes, instructor, avatar, and virtual laboratories illustrate the wide range of technological resources and methodological approaches that converge within this environment.

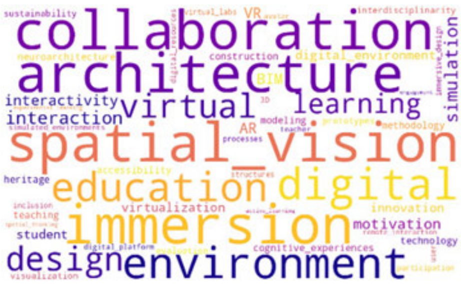

Figure 1. Nube de palabras obtenida a partir de las conclusiones de los trabajos bibliográficos analizados

A SWOT analysis is also included below as a summary of the conclusions drawn from the bibliographic review (Table 1).

Table 1. SWOT analisys

Strengths	**Weaknesses**
Immersion and realistic simulation of architectural environments	Need for technological infrastructure (hardware and connectivity)
Student motivation and active participation	Training for teaching staff
RA, RV and BIM Integration	Lack of specific pedagogical standards
Cost and risk reduction in specific practical activities	Available places for specific activities (first-person visits using VR headsets)
Opportunities	**Threats**
Interdisciplinarity and global collaboration	Rapid obsolescence of platforms and devices
Inclusion of students in simulated environments without geographical barriers	Digital divide and exclusion due to lack of access
Promotion of active and innovative methodologies	Dependence on private and/or commercial platforms
Boost of the teaching role as a guide in virtual environments	Need to train teachers in the use of these technologies

Based on the analysis of various websites and studies related to experiences gathered from internationally renowned universities (such as Stanford, Harvard, ETH Zürich, TU Delft, UCL, among others), the potential of immersive virtual environments as high-impact pedagogical tools can be highlighted. In this context, the following table summarizes a set of learning activities that can be developed within an academic metaverse, aligned with the professional competencies required in architecture and engineering (see Table 2).

Furthermore, the metaverse not only represents an innovation in technical teaching, but also a valuable extension of academic and administrative services within the university environment. Several pioneering universities in the adoption of virtual environments—such as Arizona State University, the University of British Columbia, the National University of Singapore, and UCLA—have begun to integrate immersive spaces that replicate key functions of their physical campuses. Virtual libraries, digital information offices, guided tours for new students, or personalized tutoring rooms in VR are just a few examples of how the metaverse can facilitate access to information, enhance the student experience, and improve the efficiency of university services.

The following section summarizes a series of activities and resources focused on institutional management, academic orientation, personal support, and social interaction, which can be integrated into an educational metaverse. These proposals aim to create comprehensive environments in which learning, consulting, interacting, and growing—both personally and professionally—are part of the same immersive experience (see Table 3).

Table 2. Most relevant learning activities identified for the project

Learning Activity	Description
Exploration of virtual spaces	Spatial understanding
Virtual construction processes	Simulation of phases/processes, error identification
Construction	Visualization of construction systems and technical details
Heritage/rehabilitation	Historical reconstruction in VR for study and dissemination
Health and safety	Training in risk scenarios without real danger
Collaborative design in VR/AR	BIM modeling, multidisciplinary teamwork
Structural simulations	Visualization of loads, stress and collapses
Digital twins	Real-time monitoring with IoT for predictive maintenance
Construction materials and quality	Quality control and material selection
Immersive teaching	Interactive classes and technical simulations in real time
Virtual laboratories	Access to materials and didactic resources (e.g., scale models)
Installations visualization	Visualization of elements and layout of building systems
Energy efficiency analysis	Simulations related to energy performance

Table 3. Most relevant information and/or service activities identified in the project

Information / Service Activity	Description
Virtual library	Access to books, journals, and digital collections
Concierge and services	Consultation of schedules, classrooms, and procedures in immersive mode
Campus tours	Guided visits and orientation for new students
Tutoring and academic support	Personalized meetings in virtual offices
Academic office	Virtual academic procedures and student services
Social spaces	Cafés, clubs, and gathering areas
Exhibition spaces	Immersive tours and exhibitions

On the first year of the project, several aspects considered relevant by the teaching staff for the implementation of the METAVERSE proposal were identified. It was essential that the initiative be both pedagogically meaningful and technically viable. As a result of this initial phase, a comprehensive 3D model of the ETSIE building was developed, incorporating its most representative spaces (classrooms, corridors, lobbies, and technical rooms), as well as virtual classrooms for "construction sites" and "model exhibitions." Additionally, spaces defined in the master plan—such as the BIM classrooms scheduled for renovation—were included. The model was designed to be both modifiable and scalable, allowing for future updates based on evolving needs.

The virtual environment was developed with a high level of architectural and construction detail. The final model was compiled into an executable (.exe) file format, allowing it to run on standard computers without the need for an internet connection. This approach was selected to facilitate validation by teaching staff and to ensure future usability in settings with limited technological resources.

During the review process, faculty members responded positively, particularly highlighting the realism of the environment and the clarity of navigation. Among the most common comments were:

- The usefulness of visualizing construction details within a three-dimensional context.
- The potential to incorporate educational resources and interactive sequences into specific environments.
- The need to expand the variety of scenarios in future phases.

In addition, graphic materials and technical diagrams were developed to document the modeling process, the adopted visual standards, and potential improvements to be implemented in the programming phase. These resources will be included in the project's shared repository and will serve as a foundation for integrating the metaverse into other undergraduate courses.

The creation and modeling of the ETSIE metaverse was carried out in four key stages. First, a graphic representation of the building and its surroundings was produced using DWG-format plans (AutoCAD). Based on this foundation, a detailed 3D model was generated using software such as Revit, Archicad, or SketchUp, incorporating construction elements and custom equipment. The third phase focused on optimizing this model in Unreal Engine 5, where textures, movable components, and the ability to explore the environment in first- or third-person view were added—resulting in a highly immersive and realistic experience.

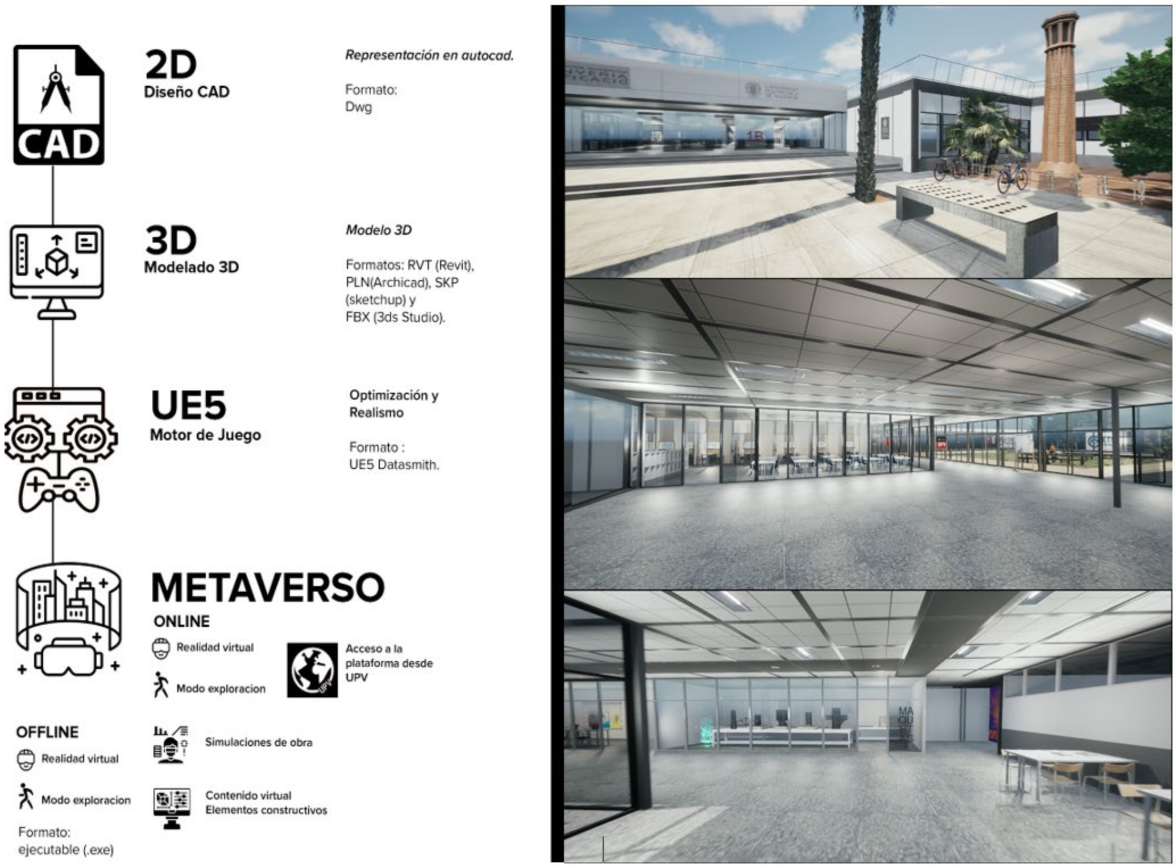

Figure 2. Creation and modeling stages of the ETSIE metaverse (left). model images (right)

The images in Figure 2 (right) reflect the high level of fidelity with which the physical environment of the ETSIE building has been recreated, including exterior areas, common spaces, and access to various facilities. Figure 3 (left) shows a virtual reproduction of the model room, which allows for the interactive visualization and manipulation of three-dimensional models (Figure 3, right). In Figure 4, a top-down view of the virtual “shallow foundations” construction site is displayed, along with an image showing a user (via VR headset) interacting with the environment and accessing technical information in real time.

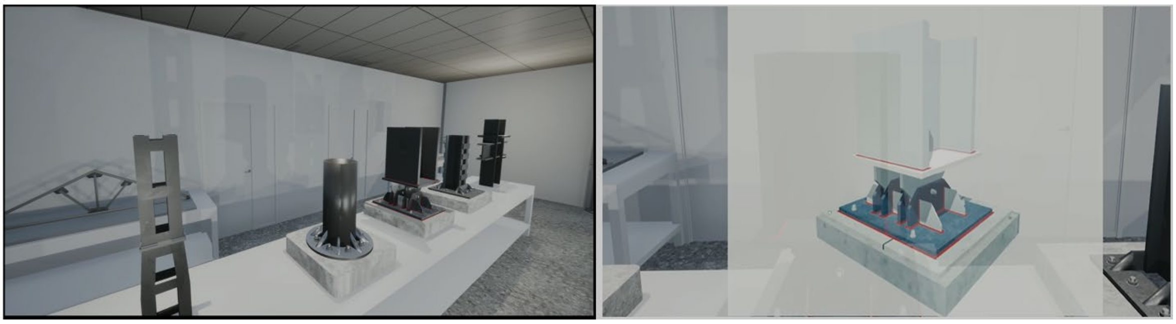

Figure 3. Images of the model exhibition room (left) and three-dimensional visualization of one of the displayed models

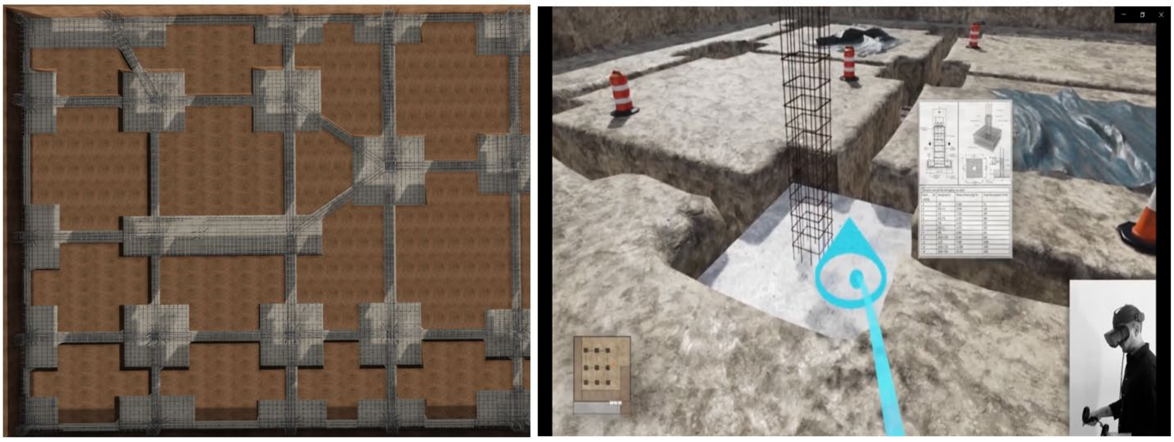

Figure 4. Image of the .bimx file generated from the virtual foundations project and screenshot of first-person navigation through one of the construction phases

5. CONCLUSIONS

The progress achieved during the first year of the METAVERSO ETSIE project highlights the transformative potential of immersive technologies applied to university teaching. Virtual reality, when combined with active methodologies, enables the overcoming of traditional limitations associated with two-dimensional learning resources, facilitating spatial understanding, construction analysis, and the connection between theory and practice. Through interaction with three-dimensional models, students can simulate construction processes, identify errors, anticipate technical decisions, and take an active role in their own learning.

The collaborative work among instructors from different subjects has enabled the project to be developed in a cross-disciplinary manner, promoting content integration, methodological coherence, and future scalability of the generated environments. This approach has also supported alignment with the educational objectives of the Technical Architecture degree, contributing to the development of both specific and transversal competencies such as analytical thinking, decision-making, autonomy, creativity, and technical visual communication. The direct involvement of faculty in defining virtual scenarios and continuously evaluating the 3D design has validated not only the technical feasibility of the project but also its pedagogical relevance. This has been essential to ensure that the developed environments respond to real classroom needs and can be used as support tools across different courses in the curriculum.

During this first year, key learning activities and institutional services have been identified, a detailed model of the ETSIE building has been created, and virtual environments such as construction sites, exhibition halls, and interactive tours have been incorporated. This has established the foundation for the second year of the project, which will focus on functional development and integration with teaching platforms. Planned advancements include programming interactive menus, avatar-based navigation, incorporating gamified dynamics, enabling online access, and launching pilot experiences with students from several courses.

REFERENCES

Abdullah, N. H. I., Nincarean Eh Phon, D., Zulkifli, N. S. A., Sahadun, N. A., Mohd Zin, N. A., Mohamad, A. & Andek Jelantek, A. N. H. (2025). The impact of virtual reality on student engagement and learning outcomes in technological learning environment – A SWOT analysis. *International Journal of Advanced Science, Engineering and Information Technology, 15*(3), 708-717. https://doi.org/10.18517/ijaseit.15.3.12654.

Cai, C. (2024). Research on the effectiveness of metaverse-based learning in business courses: A systematic review. *Journal of Education and Educational Research, 7*(2), 251-257. https://doi.org/10.54097/mnanpn41

Chen, J., Fu, Z., Liu, H. & Wang, J. (2024). Effectiveness of virtual reality on learning engagement. *International Journal of Web-Based Learning and Teaching Technologies, 19*, 1-14. https://doi.org/10.4018/IJWLTT.334849.

Kye, B., Han, N., Kim, E., Park, Y. & Jo, S. (2021). Educational applications of metaverse: Possibilities and limitations. *Journal of Educational Evaluation for Health Professions, 18*, 32. https://doi.org/10.3352/jeehp.2021.18.32.

Lee, L. H., Braud, T., Zhou, P. Y., Wang, L., Xu, D., Lin, Z., Kumar, A., Bermejo, C. & Hui, P. (2024). All one needs to know about metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda. *Foundations and Trends in Human-Computer Interaction, 18*(2-3), 100-337. https://doi.org/10.48550/arXiv.2110.05352.

Mustafa, B. (2022). Analyzing education based on metaverse technology. *Technium Social Sciences Journal, 32*, 278-295. https://doi.org/10.47577/tssj.v32i1.6742.

Mystakidis,S. (2022). Metaverse. *Encyclopedia,2*(1), 486-497. https://doi.org/10.3390/encyclopedia2010031

AKNOWLEDGES

Universitat Politècnica de València, “Convocatoria aprendizaje + docencia (A+D) 2024”: **PIME/24-25/414**