Experiment My Shape. E-learning in 3D Virtual Environments for Design and Architecture

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Abstract: *The period of the Covid pandemic has posed a significant challenge to education in visual arts, such as interior design or architecture, where subjects such as "spatial organisation" and the shape of objects are not well suited for online discussions. The solution that the present multidisciplinary team found during its research work was to immerse teachers and students under the form of digital avatars in a 3D virtual environment, designed according to a research theme, e.g. Early Modernism Design. Within the virtual space a lesson can be taught about the 3D real shape of the historical objects, like the Bauhaus furniture. The Virtual Learning Environment (VLE) was implemented on the Mozilla Hubs 3D online platform and was named "Experiment my shape!". The 3D models of the pieces of furniture were imported from Sketchfab, one of the most used online libraries of 3D models. After experimenting with this virtual environment for online teaching at the Interior Design MA level of the National University of Arts Bucharest, teachers and students recognized its pedagogical efficiency and recommended it as an effective e-learning tool for students in Design and Architecture.*

Keywords: Virtual Learning Environment (VLE), interior design, 3D models, visual perception, Mozilla Hubs.

1. Introduction

The period of the pandemic and associated restrictions led the authors to seek alternative ways of teaching and learning for the interior design and history of design at the National University of Arts (UNA Bucharest), some of the difficult subjects to be discussed online being those of the real shape of the objects. Online

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3D virtual environments were considered as a viable alternative, considering the previous experience of the authors (Stefan, 2012; Gheorghiu & Stefan, 2018; Gheorghiu & Stefan, 2019; Motaianu, 2021; Stefan & Motaianu, 2022) as well as the specifics of design classes that require visualisation and analysis in 3D space.

In addition, in the post-pandemic period, distance learning is no longer an exception, but a reality that must be taken into account. Therefore, online solutions must be developed even in non-pandemic conditions to benefit from technological advancements in the field of online 3D platforms and "metaverses" ("universe of universes") (Dionisio et al., 2013; Park & Kim, 2022). These platforms present an essential feature to be used in multi-user distant learning, namely the simultaneous presence of a large number of participants without a decrease in performance. On the other hand, several authoring tools and online repositories of 3D objects, available free or under the Creative Commons licence, are currently available. In recent decades, Virtual Learning Environments (VLEs) have been used extensively in distance learning. Several research works have discussed the affordances of VLEs (de Freitas, 2008; Annetta et al., 2010).

The online 2D environments, such as Google Meet (2022), are still viable and used within the hybrid learning/teaching model but have proven to be limited in their capacity to support visual arts education.

For the “Objects-Spaces-Cultures” class regarding design objects/pieces and decorative art, in which access is difficult, or even impossible, to the objects that must be studied, the present multidisciplinary team proposed an innovative solution using Mozilla Hubs (2022), a free, web-based 3D platform, to create a Virtual Learning Environment (VLE) for teaching and learning purposes.

The VLE (named "Experiment my shape!") is one within which a lesson can be taught about the shape of virtual objects that copy authentic ones, and also a personal study can be performed by students by experiencing in 3D the real shape of the historical objects, such as the Bauhaus furniture.

For the first experimental stage, the multidisciplinary team proposed a virtual space to be used both as a meeting place for the teachers and students, and as a space for displaying the pedagogical material, by placing historical furniture objects, in this case, objects created within the Bauhaus School, as well as explanatory materials, such as texts and posters. This virtual space was taken from the collection of predefined 3D scenes, offered by Mozilla Hubs, and edited with the help of the Mozilla Spoke editor, so as to create an architectural space that respects the architectural principles specific to the Modern period of the third decade of the 20th century.

The expected benefits were firstly the observation and analysis in 3D of the objects that are the subject of teaching/learning, and secondly, the interactivity and communication facilities, through which students could ask questions or formulate a personal opinion.

The paper sections will present the following:

- The authors' description of the research work in relation to similar work and domain status;
- An analysis of the learning affordances that can be leveraged using Mozilla Hubs;
- The detailed implementation of the "Experiment my shape!" VLE;
- The presentation of the results of a demonstration and survey conducted with students.

The paper will conclude with lessons learned and future research.

2. Research Background

2.1. Current Online 3D Platforms

Current online 3D platforms that can be used to develop immersive virtual worlds can be categorised as legacy platforms (González et al., 2013), such as SecondLife and OpenSimulator, as game engines such as Unity3D, and modern platforms, such as Mozilla Hubs.

OpenSimulator (2022) is an open-source, free, 3D multi-user platform, which allows easy content creation and user communication, and is recommended for building online virtual worlds and communities. Despite the numerous virtual worlds hosted, including virtual universities (González et al., 2013), in terms of usability and ease of access, OpenSimulator has several limitations, such as the requirement to be accessed using a client application.

Unity3D (2022) supports advanced 3D capabilities, such as 3D simulations, Virtual Reality (VR), Augmented Reality (AR) or Mixed Reality (MR) scenarios, animations and cinematics. Unity3D requires programming skills, which recommends it for the development of games and complex educational projects.

Mozilla Hubs is a multi-user, open-source platform (2022) which benefits from increased performance due to the inclusion of modern technologies, such as WebVR and WebXR, directly in the web browser. It does not require the installation of any additional software and it is optimised for the Firefox browser. Mozilla Hubs is customisable for different purposes, and at the current stage of development, it is offered for usage at no-cost. The Mozilla Hubs platform can be accessed from different devices, including VR headsets.

For specific purposes, it is worth mentioning platforms such as Artsteps (2022) or Kunstmatrix (2022), which offer hosting for virtual exhibition-type projects.

State-of-the-art level of current technologies, including Artificial Intelligence (AI), are the "digital twins" which can be defined as virtual representations of the real environments, with the purpose of supporting high-qualified activities, training or virtual simulations (Park & Kim, 2022; Microsoft Mesh, 2022).

2.2. Virtual Learning Environments

Virtual worlds are “crafted places inside computers that are designed to accommodate large numbers of people” (Castronova, 2005). A 3D virtual world is “a synchronous, persistent network of people, represented. as avatars, facilitated by networked computers” (Bell, 2008). A 3D virtual world (3DVW) is defined as “a computer-simulated electronic 3D virtual environment that users can explore, inhabit, communicate, and interact with via avatars, which are graphical representations of the users” (Ghanbarzadeh et al., 2014).

A 3D Virtual Learning Environment (VLE) is a virtual world designed for educational purposes (Loureiro & Bettencourt, 2014). In Dalgarno & Mark (2008) affordances of the VLEs such as experiential learning, contextualization, collaborative learning, intrinsic motivation and user engagement, are discussed.

Specific benefits that are expected from teaching and learning within the designed VLEs are the provision of an active and authentic learning process (González et al., 2013), to support the “development of imagination and spatial analysis” (Gheorghiu & Stefan, 2015), “opportunities to explore, create, imagine, collaborate, role play, interact, socialise, learn, and experience events in a safe and vivid manner, and they can also be linked to the real world and other Web resources and services in a variety of scenarios” (Ghanbarzadeh et al., 2014).

The experience of architecture students studying in VLE are discussed in Vecchia et al. (2009) and Myung et al. (2022).

2.3. VLE on Mozilla Hubs Platform

Virtual worlds for educational purposes need to satisfy both technical and environmental design requirements, as well as the creation of pedagogical content.

In the case of the current research, it was necessary that all these requirements be fulfilled through the effort of the research team, i.e. so as not to require IT operations or financial support from the University. In order to achieve the desired objective, databases with 3D design objects, such as Sketchfab (2022), were explored. These databases currently contain a limited number of authentic objects, but new digital objects can be added following a 3D scanning. One such object, for example, a Guéridon table, was scanned by a doctoral student from UNA, and uploaded to Sketchfab for the theory class mentioned above.

Mozilla Hubs offers satisfactory performance for wide use, but also possibilities to customise the content or the way to use the platform, such as "kits to create […] custom spaces, powerful avatar and identity options, integrations with existing communications tools" (MozillaLab, 2022). In this sense, Mozilla Hubs provides "VR chatrooms" within its virtual spatial "hub", that can be accessed individually via a link and can also be interconnected within the hub, via links, to facilitate the navigation. Furthermore, for optimal performances, a cloud-based version of Mozilla Hubs using Amazon Web Services (AWS) is also provided.

Social affordances are also important assets provided by Mozilla Hubs, such as communication, sharing content and collaborative work.

3. Implementation of the "Experiment my shape!" VLE

Mozilla Hubs is a platform for hosting predefined or customised 3D spaces and to support communication in mixed reality (MozillaLab, 2022). Users can select a 3D scene from a set of predefined spaces, that usually need a customization that can be performed in the Mozilla free web-based graphic editor, Spoke (2022). In addition to the Elements Kit, Spoke has a built-in 3D digital object database from Sketchfab platform, one of the most used online libraries of 3D models (Sketchfab, 2022). The 3D scenes need to be uploaded into Mozilla Hubs to create a corresponding "chatroom".

3.1. The Virtual Space

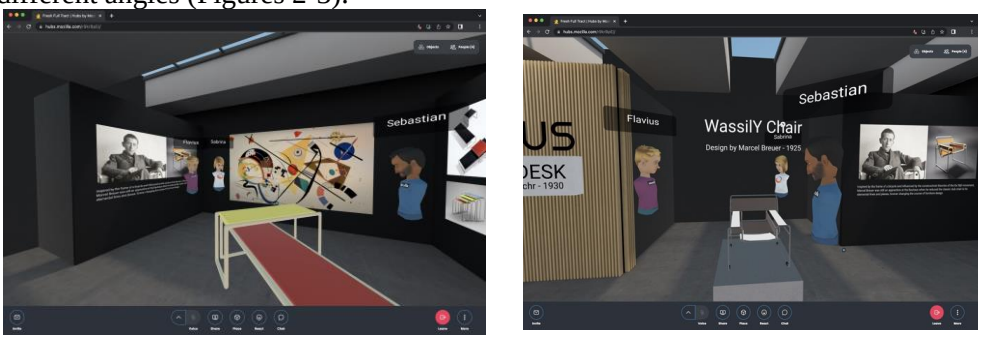
In the case of the "Experiment my shape!" VLE, a predefined virtual space was selected and customised using Mozilla Spoke editor. The customization consisted in the preparation of the virtual space to be suitable for the design class, respectively to accommodate the placement in the virtual space of some objects specific to Bauhaus design along with documentation and design posters made during the 1920s.

For the space dedicated to Bauhaus design, four design objects were selected, including three pieces of furniture: the Wassily Chair and the Laccio Tables designed by Marcel Breuer in the 1920s, a Bauhaus Desk, designed by Petr Vichr in the 1930s and a chess set designed by Josef Hartwig in 1924 (MOMA Museum, 2022). All the 3D models of those objects were imported in Spoke from the Sketchfab database.

The resulting virtual space was uploaded to Mozilla Hubs, which generated a URL address (UNA "Experiment My Shape!", 2022) (Figure 1).

Figure 1. The Entrance into UNA "Experiment My Shape!" Virtual Space

The objects were positioned on pedestals and the placement in space was done such that it allows the avatars to move around them and view the objects from different angles (Figures 2-3).



Figures 2-3. Students Moving Around the Object

3.2. The Learning Objectives

The perception of forms (Arnheim, 1964) is a mental process that was put to the test in the case of distance visual education.

Even before the pandemic, the prints of design objects, as well as the exhibition in art and design museums around the world, did not allow an integral experience of the shapes of the objects, these being presented in 2D or exhibited in a manner that did not allow a holistic, integral experience of the shapes. Therefore, the ability to experiment the shapes of things in three dimensions would allow students from the first years from the design or architecture institutes, a clear understanding of the volumes of objects and of the construction method, and consequently would allow the rapid development of good volumetric perceptions of the objects in the built space.

From the Mozilla Spoke editor's collection of predefined virtual spaces, a simple and empty space was selected and customised in order to observe the architectural principles specific to the Modern period of the third decade of the 20th century.

The virtual space for the presentation of the objects was designed as a space for experimenting with the shape of objects, but also to be able to provide documentation and information to help a better understanding of the culture that generated the design objects.

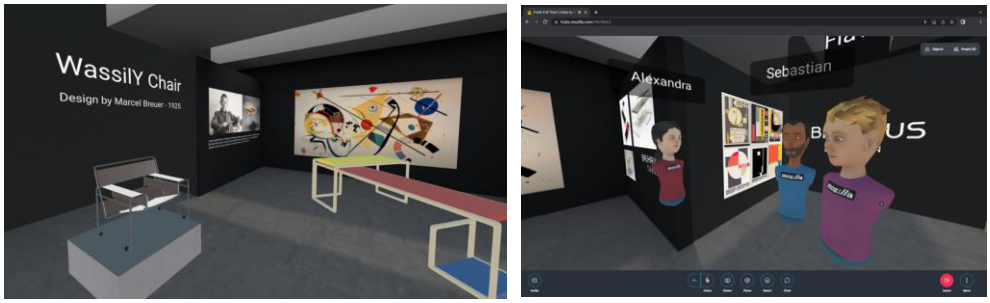
Teachers and students, in the form of avatars, can access this space, where they can interact with digital objects. Not being able to experience in the real world the original design objects from the Bauhaus movement, the students can thus experience in the virtual environment the shape of objects in a much easier way than in reality and thus understand the complexity of their forms.

4. Experimentation of the "Experiment my shape!" VLE

An online seminar was organised within the "Experiment my shape!" VLE with a group of students. Two of the authors described the history and functions of the objects, while the students experimented with these objects in space, from different personal perspectives, and studied the teaching class support content, digitally exhibited on the walls.

4.1. The Online Design Class

During the class, the students entered the virtual environment where they had the opportunity to move around the objects, in order to perceive their size and their shapes (Figures 4-5).



Figures 4-5. Students Analysing Objects and Communicating Opinions

4.2. The Research Survey

For the VLE evaluation "Experiment My Shape!" five students responded to a questionnaire with answers based on a 5-point Likert scale:

Evaluate the VLE "utility": a) to what extent did the VLE help you achieve the learning objectives for the "Objects-Spaces-Cultures" seminar? (5- Extremely; 4-Very much; 3- Moderately; 2-Slightly; 1-Not at all). The results: 20%-Extremely; 73%-Very much; 7%- Moderately; 0%-Slightly; 0%-Not at all.

Evaluate the VLE "usability": to what extent was the VLE easy to use? (5-Extremely; 4-Very much; 3- Moderately; 2-Slightly; 1-Not at all); If not: c) what problems did you encounter? The results: 55%- Extremely; 35%-Very much; 10%-Moderately; 0%-Slightly; 0%-Not at all. Students reported some technical problems regarding the lags of the environment.

Rate the VLE design quality by giving a general assessment as follows: 5 – Excellent; 4- Above Average; 3-Average; 2-Below Average; 1-Very Poor. The results: 80% – Excellent; 8% - Above Average; 2%-Average; 0%-Below Average; 0%-Very Poor.

5. Conclusions and Next Research

The results of the survey showed that the experience with the three-dimensional objects in the virtual space allowed a correct perception of the shapes, the students being able to remember the proportions and details of the experienced objects. The interaction between teachers, students and the 3D objects, as well as the information displayed on the walls of the virtual architectural space, created a learning environment whose effectiveness was verified on the occasion of the semester examination.

The process of presenting objects continues to have some limitations, due to the current level of Mozilla Hubs technology. Although the Spoke editor allows the placement of certain 3D objects from the Sketchfab platform, in most instances it does not place them with the textures that generate their volume, nor does it apply the ambient light from the space. Because objects that have complex shapes (containing a large number of polygons) are most often imported without textures, they are viewed schematically. Also importing multiple objects into the Spoke editor makes it difficult to export the space to Mozilla Hubs. Importing complex 3D objects directly into the Hubs space currently presents the same limitations as in the Spoke editor. It is expected that the platform will be improved in the future.

Future research intends to expand the 3D database with many decorative objects from different historical periods, which will be scanned or imported as 3D models and transferred into different virtual spaces necessary for future classes. The focus will also be on creating more complex virtual spaces, in which the spatial organisation of objects in different historical periods can be studied, allowing the students to experience them together with their coordinators.

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