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Spatial design education with digital technologies in the period of pandemic contingency.

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Abstract

Space education has always been in constant evolution and new teaching systems are beginning to emerge in the face of technological advances. In the area of spatial representation in period of pandemic contingency, it has faced new challenges. Such is the case in the Tecnologico de Monterrey Campus Monterrey, in the course Formal Representation of Space. This article presents a new method for the student to build a shelter that was previously in physical form at real scale, now presents it with digital tools such as non-immersive virtual reality and augmented reality. The purpose of the use of these techniques is to learn how to visualize any object to represent its proposals in real space.

Keywords: Hybrid Representation, Augmented Reality, Spatial Projection, Interactive Education.

1. Introduction.

Today's students are interconnected and collaborate with their peers in the classroom using different types of technologies. Video projection is a tool for creating interactive learning spaces and environments that can be continuously updated according to students' needs (Quintero et al., 2019).

Today, in this period of pandemic, education begins to be more flexible and to generate other roles. During this period of uncertainty, students begin to experience new emotions with their families, economic and social concerns. Therefore, education, besides working on instruction, also takes the attitude of optimism and hope for all that is to come. This leads the teacher to perform methods different from the conventional ones that involve more work in front of the monitors or screens.

Blevins (2018) states that preparing students to interact critically with these communication technologies poses the challenge of allowing students to work with technological devices as they exist now, but also in their certainly changing future forms.

Therefore, this article presents a different methodology for students to develop spatial skills using digital techniques such as non-immersive virtual reality and augmented reality. At first, students expressed curiosity and enthusiasm about this learning system, and their satisfaction increased when they saw their final work materialized with digital tools. In addition, more creative results were observed in their final presentations. The interactions between teachers and students were more direct because the professors saw it through the Zoom platform, the group was divided into teams to advise them better.

The course is a five-week block where drawing, descriptive geometry and design theory are studied, and culminates with a final work called Sensorial Cabin, which consists of designing and building a full-scale 2x2x2 m cabin. To do this, the student studies Munari's book (2016) How are objects born? In this book the author defines Sensorial Cabin as a structure where the student can isolate himself, study, meditate, write, listen to his music, read, sleep, and talk with his friends. This structure should solve the problem on a structural, aesthetic, personal and economic level.

2. State of the art

It is said that the human mind tends to interpret reality which leads us to the perception of the surrounding space. Understanding the spatial sense allows us to develop the sensory perceptions to express any idea or proposal in a visual way. To carry out this project it is necessary to learn the basics of design, drawing, geometry and digital technologies.

Scaravetti and Doroszewski (2019) establish that virtual representations are widely used in teaching to visualize a design model or a simulation. However, many students have difficulty understanding mechanical systems from a 2D design drawing or 3D CAD definition. So, when students lack technological knowledge, augmented reality can provide an answer to the difficulty of establishing the link between a representation and the real system. But to get to implement the digital tools first it is important to understand the theoretical aspects that allow the construction of the design and construction of the Sensorial Cabin.

2.1. Modular Shelter

Munari (2016) defines sensorial cabin as a plastic-coated steel structure reduced to the essentials. It is a structural module with its corresponding sub-modules, which allows formal coherence and maximum combination according to functions. For the author, the sensorial cabin is a delimited space and at the same time open to be inhabited by one or two people. It is a habitable module that contains personal things, a place to meditate and at the same time, a place to listen to one's favorite music, a place to read and study. It is a light and transparent cave, or also closed, a hidden space in the middle of the people, a space of its own. The author summarizes it as the space that can be adapted to the personality of the inhabitant, transformable at every moment. Its dimensions mean that it must be easy to transport, so it must be dismountable or foldable.

So that the student could get more information, the term "shelter" was used. The current shelters are structures to be used temporarily and with a certain function. Some types of shelters are designed for artists where they can write, paint, or compose music. They are also intended as hotel rooms with panoramic views to appreciate nature. Other alternatives are emergency shelters, designed to help people affected by disaster. These are usually lightweight structures that are easy to transport and quick to assemble/disassemble.
Yu et al. (2018) tell us that a modular shelter requires prefabricated volumetric units the size of a room, which are normally factory produced and installed on site, and therefore have a high construction efficiency and have received considerable attention in recent years. Azefi and Ahangar (2012) determine that there are two main types of shelters in terms of material, use and construction technology. These are: 1) Shelter with transformable elements, uses both rigid and flexible materials and 2) Shelter with non-transformable elements. uses rigid materials.

The construction of a shelter starts with a custom design, which can be thought of as a series production with prefabricated parts. And with an instruction manual, anyone can assemble it without any problem. To do this, it is necessary to use modules to make their assembly effective.

Table 1. Compersion of shelter types

Rigid Forms	Flexible Form
• Large Volume	• Flexibility in form
• Security	• Foldability
• Can Use recyclable materials	• Ease of transportation
• Energy efficiency in roduction and use	• Users aesthetic preferences
• Ease of assembly but takes time	• Using recyclable material
• Less evironmental pollution	• Visual communication
• Esae of manufacturing	• Ease assembly
• Expandably	• Difficult to be expand
• Less flexibility	• Light weight
• Heavy	

Source is from Asefi, M., Sirus, A. (2012)

2.2. Modular Organization

When a design is made up of identical and similar figures, it can be said to be made up of modules. Wong (2001) emphasizes that the presence of modules tends to unify the design. Modules can be easily discovered in almost all designs if we look for them. A design can contain more than one set of modules. Modules should be simple. Those that are too complicated tend to stand out as individual forms, so the effect of unity can be nullified. The easiest way to organize the modules is through a structure or grid.

Nevertheless, Ching (2015) defines that a grid establishes a regular pattern of points at their intersections. Projected in the third dimension, the pattern of a grid is transformed into a set of modular and repetitive units in space. A grid is most often established in architecture by a skeletal structural system of columns and beams. Since a three-dimensional grid can organize space. The concept of modular organization is used in various designs, including modular construction. Ching ends by saying that the power of a grid organization allows for a design pattern, which defines a space.

Yu et al. (2018) explain that modular construction provides a new way of building, it is done with units made in a factory and assembled in a specific site to create functional buildings. Having many constructive advantages, such as high productivity and rapid construction, this structural style shows significant potential in changing conventional building methods and has received considerable attention since the early 20th century.

In addition, scale refers to the size of something compared to the size of something else, proportion also has an influence because it refers to the proper or harmonious relationship of each of the parts to the whole.

2.3. Digital visual representation systems

In recent years, with the development of computer-aided design and building technology, free-form structures have become one of the most striking trends in contemporary architecture. Numerous free-form structures have been built with innovative designs and attractive shapes (Wanga et al, 2018).

Deshpande and Kim (2018) establish that the ability of Augmented Reality (AR) technology to track and visualize the relationships of objects in space has been used in various industry applications to support the complex engineering of object assembly tasks. Therefore, the technical principles of augmented reality are also determined in the field of perception.

According to Jeřábek et al. (2014) RA can be characterized as a technology, or a technological-perceptual concept, which implies a technological, perceptual and information aspect, which adds visual, sound and other virtual elements to perceived reality, i.e. it uses the combination of the real environment with intentionally introduced information, thus creating a new form of reality, which is richer in information than the original primary environment. This principle is realized through various forms, various technical devices and by its nature can work through all perceptual channels simultaneously or individually.

For Jeřábek et al. (2014) the parameters that define the nature of information according to the type of perceptual channel with which the system works are the following:

1. Type of graphic data. Difficulty in processing the information that the user must present.
2. Dynamism. Visual information from the perspective of perception.
3. Spatiality. Perceiving spatial depth is a complicated process and is affected by a series of stimuli.
4. Color information. RA can process the images in 1 bit or in 2-8 bits.

In spite of augmented reality (AR) and virtual reality (VR) are technologies of great importance for the architecture, engineering and construction (AEC) sectors, since the built environment is intrinsically associated with three-dimensional (3D) space and AEC professionals depend to a great extent on images for communication (Davila et al. 2020). For this reason, the use of augmented reality in this course allows the student to: a) learn to visualize in a spatial way the objects that students designs, b) be able to represent their designs more accurately and c) learn a technological tool that allows them to locate their designs in a real environment.

3. Materials and Methods

The design of complex architectural components, such as kinetic architectural elements, poses a challenge due to the multiple technological branches involved (Jayathissa et al, 2018). In this study, the use of augmented reality in the teaching of spatial representation was implemented as part of the challenge to be carried out in the block of Formal Representation of Space, which was aimed at students of Architecture, Industrial Design, Digital Art and Humanities. In this block, the student will develop the language and spatial technology to apply it to design in the professional field of architecture, digital art and industrial design.

The block is divided into four modules of five stages: The first introduces the student to the understanding of form and space from the physical and virtual point of view, while the remaining three explore the design process and its techniques for representing spatial solutions in the sensory habitat. The modules consist of:

1. Graphic Representation
2. Form and Space
3. Materialization
4. Technologies in Art

The challenge involves designing, representing, and building a cabin, remembering that it is a small physical space to be occupied, in this case, by two people. This cabin must have a specific use or function and can be inspired by an artistic vision. In the habitat project, the results in terms of design, dimension and materialization were presented in various forms. For its construction there was no restriction of materials, but there was a tendency for economical and recyclable materials.

The course was divided into two parts:

1. Theory and development of representative skills.

2. The process of development of the sensorial cabin.

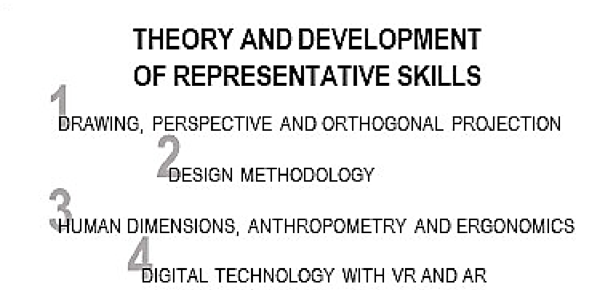


Figure 1. Theory and development of representative skills

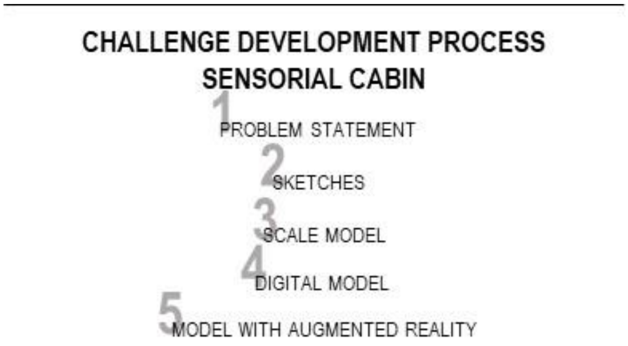


Figure 2. The process of development of the sensorial cabin.

The course was programed by the following steps see the figure 3:

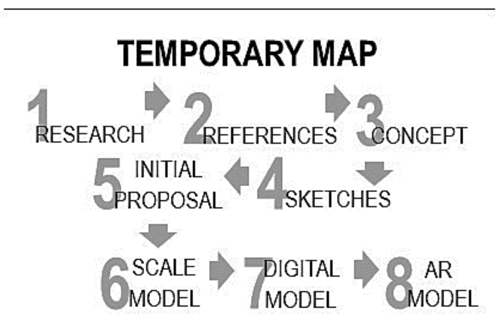
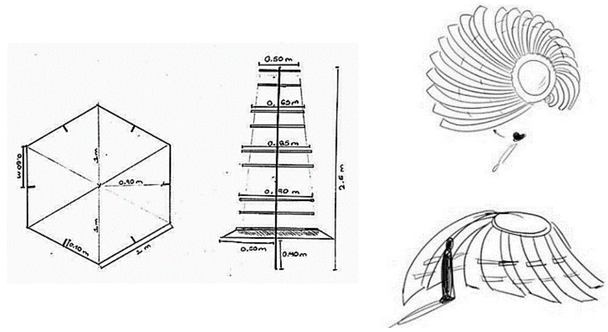


Figure 3. Time map of the design process.

3.1. Project implementation process.

1. Research: Learn the design methodology of the author Bruno Munari
2. References: Analyze a specific pavilion under Bruno Munari's specifications so that the student can generate his own design.
3. Concept: Develop proposals for the creation and realization of the design.
4. Sketches: Generate the first sketches for the sensorial cabin, applying what has been learned about drawing, perspective and orthogonal projection.

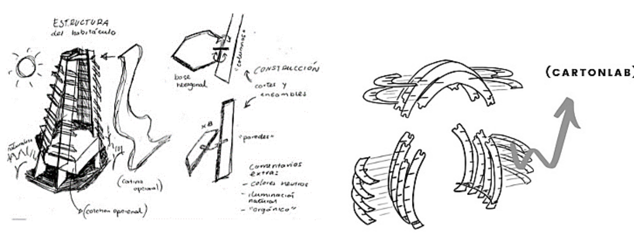


a) Viviana Teresa Quevedo Orgaz b) Camila Ramos Hernández

Figures 3. Examples of sketches made by students.

5. Work on the chosen proposal based on the following points:

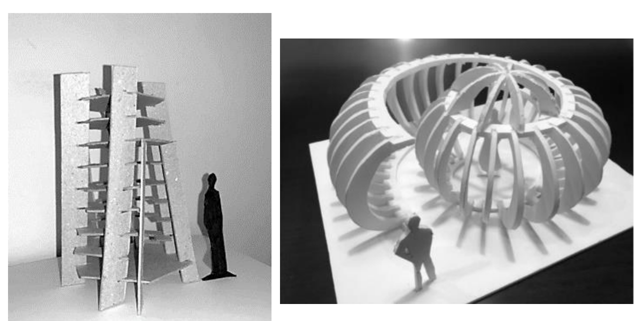
   a. Formal analysis.
   b. Materials.
   c. Joints, Assembly and Assembly.
   d. Circulation.



a) Viviana Teresa Quevedo Orgaz b) Camila Ramos Hernández

Figures 4. Examples of student sketches

6. Build a model in scale 1:20.



a. Viviana Teresa Quevedo Orgaz b. Camila Ramos Hernández

Figures 5. Examples of student sketches

7. Make the model in SketchUp.

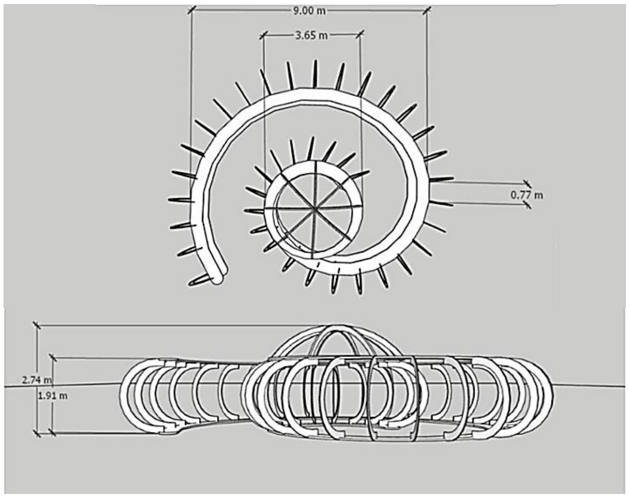
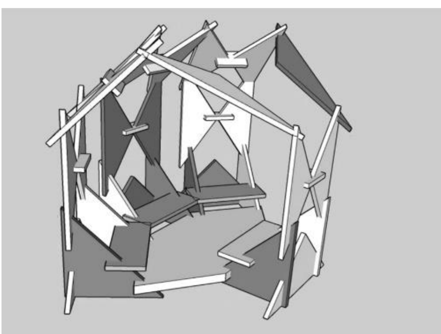
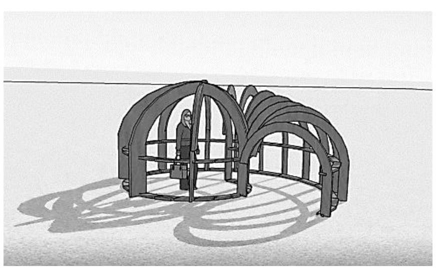


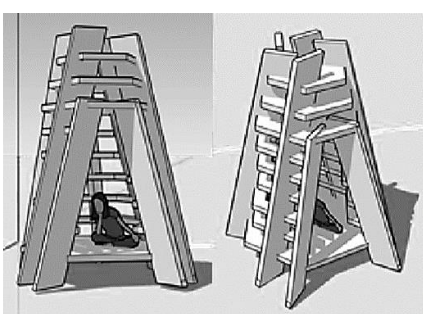
Figure 6. Study of the dimensions of the Shelter in SketchUp. Camila Ramos Hernández



a) Edgar Manuel de León



b) Camila Ramos Hernández



c) Viviana Teresa Quevedo Orgaz

Figures 7. Models made in SketchUp

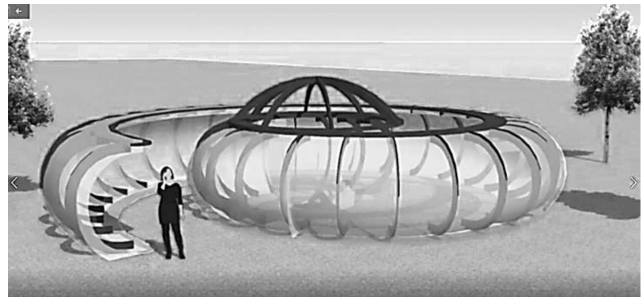


Figure 8. Proposal for the non-immersed VR sensorial cabin. Camila Ramos Hernández

8. Final presentation in RA in a real environment with human scale to check its dimension.

a) Edgar Manuel de León

c) Viviana Teresa Quevedo Orgaz

b) Camila Ramos Hernández

Figures 9. Projects presented in AR.

In these examples, students demonstrate the stages that led to their designs. These works are based on design theory, foreshortening, perspective, anthropometry and ergonomics. The latter by adding a person as a full scale in the presentation of RA.

4. Results and Discussion

Given the experience of designing a virtual course focused on the visual representation of space, both teachers and students had to adapt to the new teaching system. The integration of non-immersive VR and AR in the course, was able to exceed the expectations established in the Tec21 model. Conducting a virtual course in a pandemic contingency period was not an easy task. In addition to preparing the course, the emotional state of the student under pressure due to the pandemic had to be considered.

However, by using digital tools the student was able to develop more creative proposals and learned to better visualize objects in space. To work with non-immersive VR, SketchUp was used because it is a very learning-friendly program, one advantage being that the student can learn to work in three dimensions with the three coordinates of x, y, z (lake, width and height). In addition, the student can also give the animation of the object designed to appreciate each of its sides. Another advantage is its compatibility with the Augment program to produce AR, its particularity is that it can work with the mobile phone and find free versions. Teenagers are always with their mobile units and it is easy for them to want to adopt it as a working tool. Consequently, they apply what they have learned with drawing and perspective by inserting the image in a real place at the right angle. In the same way, it was possible to apply what was learned in Bruno Munari's methodology, as well as other design theories that were seen throughout the course. Therefore, when the student presents his AR work on video, he exposes a change in his language and thinking since the course began.

Finally, the introduction of VR and RA without immersion in the block of Formal State Representation has allowed the course to be followed. With the introduction of the AR, the design proposals became more real.

5. Conclusions

In recent years, the use of digital tools has increased considerably in education. Due to the pandemic contingency period, students are unable to leave their homes, so the educational program changes its strategy from analog to digital. Originally in the block of Formal Representation of Space the final challenge was to design and build a full-scale room with dimensions of 2x2x2 meters, but with the beginning of the pandemic contingency the program had to change to the construction of a digital room with application of AR in a real environment. The course involves drawing, descriptive geometry, and design fundamentals. Therefore, the aim of the article is to present a methodology to develop spatial skills with the digital techniques of non-immersion VR and AR transmitted in virtual form.

This project involved students from architecture, industrial design, digital art and humanities whose objective is to learn how to visually represent and develop spatial skills. The program surpassed the established expectations and the students were amazed at the quality of the work they were able to accomplish. Among the observations made were the following:

- During the pandemic period, the students were asked to work individually, despite the good results they preferred to work in teams to feel supported in the project.
- Extra sessions were required by Zoom to clarify the doubts of each student.
- Teaching to draw and project required the use of shots from different angles so that the student could understand better.
- Learning the use of SketchUp and Augment, extra sessions were used. On the other hand, the students helped each other through the WhatsApp.
- Both SketchUp and Augment can visualize foreshortening, proportion, views, planes, scale, measurements, etc.
- VR and AR opened opportunities to present feasible and saleable design proposals.
- Because the course is not customized, the teacher gave feedback and warnings to the students through Remind or Canvas.
- To run the course, it is important that the digital tools must be compatible.
- A spatial skills development course is recommended to provide extra advice through various means such as Zoom, WhatsApp, Remind, Canvas, etc. The aim is not to delay the progress of the course and avoid the feeling of frustration in the student.
- VR and AR can make high quality presentations in any space design project.
- Recently, construction and manufacturing companies are interested in investing in virtual reality technologies.
- The student can work with AR through the mobile device and place his design on a given terrain.
- Through AR, the progress of a project can be seen in real time.
- AR can visualize virtual furniture in a real room.

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