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Mobile Augmented Reality: A pedagogical strategy in the university environment

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Abstract

Mobile augmented reality (m-AR) in addition to being a booming computer technology is an innovative tool that can support the pedagogical process in university classrooms, which is why this research aims to show a methodological proposal for its implementation, with the purpose of facilitating the learning of the spatial reasoning of the students, through the visualization and manipulation of three-dimensional virtual objects, promoting the motivation of learning the knowledge and topics typical of the course of industrial design and technical drawing for the career of industrial engineering. A collection of geometric figures have been developed with the help of technological tools such as 2D and 3D modeling software, computer-aided design program and augmented reality application software.An updated methodology is proposed, available to any teacher, aimed at stimulating the mental processes related to the spatial reasoning of the students, which integrates technological tools in the teaching of the dihedral system and the different graphic projections.

Keywords: pedagogical innovation; technical drawing; augmented reality mobile; university education.

Realidad Aumentada Móvil: Una estrategia pedagógica en el ámbito universitario

Resumen

La realidad aumentada móvil (RA-m) además de ser una tecnología informática en auge es una herramienta innovadora que puede apoyar el proceso pedagógico en las aulas de clases universitarias, es por eso que la presente investigación tiene por finalidad mostrar una propuesta metodológica para su implementación, con la finalidad de facilitar el aprendizaje del razonamiento espacial de los alumnos, a través de la visualización y manipulación de objetos virtuales tridimensionales, fomentando la motivación del aprendizaje de los conocimientos y tópicos propios del curso de diseño industrial y dibujo técnico para la carrera de ingeniería industrial. Se han elaborado una colección de figuras geométricas con ayuda de herramientas tecnológicas como software de modelamiento 2D y 3D, programa de diseño asistido por computadora y softwares de aplicación de realidad aumentada. Se propone una metodología actualizada, al alcance de cualquier docente, orientada al estímulo delos procesos mentales relacionados al razonamiento espacial de los alumnos, que integra herramientas tecnológicas en la didáctica de sistema diédrico y las distintas proyecciones gráficas.

Palabras clave: innovación pedagógica;dibujo técnico; realidad aumentada móvil; educación universitaria.

Introduction

The constant search for new tools that serve to facilitate and enhance the capture of the capture of knowledge in diverse areas of understanding, is an activity that will always be a part of the evolution of information and communication technologies (ICT), especially those that are commonly used in human everyday life. It is there, where smart mobile devices or Smartphone stand out from the rest due to their increasing massification and due to its undeniable in university classrooms, this opens the window of opportunities for the implementation of new teaching strategies.

According to Paredes [1], cell phones in the classroom are mainly used for searching for information in internet, communication, sharing files, taking notes, information storage, website platforms use, applications use (app), currently being mobile devices in association with other technologies the most used aspect, since it transforms these mobile devices into power teaching tools, a fact that is being recognized by educators worldwide. Among those associated technologies, AR has outdone the rest, first by being highly innovative and next for having unlimited potential in application fields.

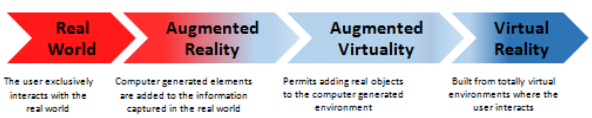


Figure 1. Taxonomy of Mixed Reality [2].

Font [2] defines AR as a technology that permits adding digital content or virtual information to elements of the real world, that is to say, a mixed reality is created, which comes into contact with the real environment and the virtual environment simultaneously, as showed in Figure 1. The architecture of this technology includes three fundamental elements: the display devices, these are the peripheral hardware in charge of capturing images of the real world, such as web cameras, tablets or smart phones. AR when using this last type of device takes on the name m-AR. Another essential elements are the software used, which are divided into integration, display and modeling, all these can work in isolation or integrated and are responsible for generating virtual objects and combining all the element of the scene, both real and virtual, showing them on the screen to the user. Finally, triggers are those that prompt the appearance of virtual information, which can be QR codes, objects, geolocation or markers and determine the exact position and orientation of real and virtual objects in the real world.

The mixtures of realities that AR presents, makes the perception of the environment a more enriching experience, which provides current teachers an innovative tool that can be used to improve the learning process of any topic where it is implemented. In addition to the previously mentioned, the undeniable universalization of mobile devices is presented, which allows the interaction between the realities captured by the students to be complemented with superimposed digital data in a simple way without detracting from the main theme where it is implemented, this makes for a more attractive educational content [4]. In the first AR experiences as a support tool in the teaching/learning process in university education, Moreno and Pérez [5] indicate that they have been implemented in strategies such as educational games with AR, object modeling with AR, books with AR, teach materials with AR, all primarily intended for the development of students' professional skills.

This has led to the study of the impact of strategies on said pedagogical process, in areas such as biology, physics, grammar, languages, mathematics, religion, arts, etc. [6]. For their part, in the area of the industrial design and technical drawing, the following investigations stand out: In 2017, Ayala, Blázquez and Montes-Tubío [7] showed the good response from students in a university course of engineering graphic expression to the introduction of 3D augmented reality models, this was through an experimental study based on the ARCS method. Then in 2018, Cerquiera, Clero, Moura and Sylla [8] measured the university students' level of enjoyment, using a pilot application of virtual reality visualization, construction, deconstruction and manipulation of polyhedra or 3D solids with or without animation. Recently in 2019, Garzón and Acevedo [9] performed a meta-analysis of 64 quantitative investigations present in the main scientific databases (Web of Science, Scopus and Google Scholar) conducted between 2010-2018 to analyze the impact of augmented reality on student learning. All these pedagogical investigations reinforced what Herpich, Martins, Fratin & Rockenbach [10] affirm, that the implementation of innovative strategies is highly relevant for students' cognitive development, and even more if these activities are supported by tools that help to develop spatial reasoning through the demonstration of abstract concepts in interaction with multimedia resources. This is combined with the need for universities to adapt and update themselves in the use of new tools and technologies in the educational field, offering a promising present and future as a line of applied research associated with disruptive pedagogical innovation [11]. The aforementioned expresses the importance of the successful use of these innovative technologies in the classroom, which according to Ferguson [12], not only has a positive impact on students achieving cognitive change, but also affective and behavioral changes in them, thus becoming more confident, motivated and realistic.

The implementation of a technology such as AR in the academic environment has no future viability if it is not framed in an educational approach adapted to the particular curriculum, which in turn will depend on the characteristics and context of the instance where applicable. Bower, Howe, McCredie, Robinson and Grover [6] indicate that the AR can be associated with different pedagogical approaches, leading to infer that the optimal solution may not reside in a specific educational paradigm but rather a combination of pedagogical approaches.

In this work, an alternative pedagogical proposal is presented, where AR is used in a less complex way, as a didactic support resource in the teaching process implemented in university classrooms, exposing its most relevant advantages and limitations. This described methodology is supported by constructive pedagogy, since it involves the use of various active strategies focused on achieving an education based on the construction, by the student, of their own learning, and taking into account that selecting activities that motivate student participation and reaction is a crucial aspect in the pedagogical process, since the degree of commitment and openness to internalize the concepts, ideas and topics that are facilitated within the classroom will depend on this, that is why the implementation of well-selected activities can lead the student to deep reflections and perceptions [13].

Experimental

The present work is an applied investigation performed under the Action-Research approach [14], since it allowed the educational innovation from planning, action, observation and reflection, thus promoting improvements in the educational process in order to improve teaching practices and the pedagogical process with the support of ICT [15]. The design of this educational proposal has as context the chair of Industrial Design and Technical Drawing from the School of Industrial Engineering in the Department of Engineering Sciences from the Universidad Católica del Maule, which was held by the author of this work. The total number of participants were 82 students (68.3% men and 31.7% women) with ages between 19-25 years old. This course is of particular importance due to its link with the development of spatial reasoning in students and its close relationship with the internalization of abstract concepts in engineering drawing such as cross sections, auxiliary views, intersections, interpretations of engineering drawings, and where its lack of development may be the cause of the students' poor performance in the course [16]. These last authors define reasoning or spatial ability as a component of intelligence, which is linked to the capacity to form a mental representation of the world, but what is generally known as spatial ability, is in reality a part of the spatial capacity. The three main components that define spatial capacity, two of them: dexterity and capability, which are genetic origin and cannot be trained, while the last, spatial ability, can be educated through the development of a study methodology, pedagogical tools and independent study.

That is why, this work is based on the interest of the aforementioned teachers from the school of industrial engineering, in facilitating the teaching and learning processes in students of the Industrial design and technical drawing course, especially to help them develop mental processes related to spatial reasoning. It is a constant concern for the department's academics that one of the consequences of the constant updating of the university curricula is the reduction in courses related to graphic expression in engineering, a phenomenon that has already happened in other universities [16], which in turn generates the constant need from the academics to ensure strategies that are sufficiently effective for their completion in the 16-week time frame of the course, which is perhaps the solution to this problem, a change in the didactic strategies used.

For the design of the proposed pedagogical strategy, the basic principles proposed by Cuendet, Bonnard, Do-Lehn & Dillenbourg [17] were followed, these principles required that the AR systems were flexible enough that the professor could adapt it to the student's needs, that the content could be taken from the curriculum and delivered in short periods like the rest of the lessons and that the application of the AR systems should take into account the restrictions of the context.

The methodology developed in this investigation is focused on the expected learning results in the curricular activity, in which it was implemented, which requires students to apply the ISO and NCh standards to the display of a geometric object using new technologies for the elaboration of industrial design productions. To achieve this objective, the aim is that, with support from AR, students no only understand the dihedral system but also the different graphic projections not as a scientific abstract, but as the representation of objects in the environment [18], as well as its relation with the industrial design. A framework of 32 sessions are detailed in the course syllabus, where evaluation, criteria and indicator techniques are established to measure the learning results. These work sessions are divided into theoretical and laboratory classes.

- Theoretical classes. They were held in a classical classroom for 90 people, with projector, white-board and desks.

- Laboratory classes. Room equipped with a computer with Aumentaty® community software, such as Creator® 2019 (integrator software) and AutoCAD® 2019 (modeling software) that were installed, all of their free or academic versions. Additionally, for these classes, students must have a mobile phone with the Aumentaty Scope® application installed (Display Software).

The development of the pedagogical proposal described in this report seeks to update the procedures used in the implementation of innovative tools in university teaching, in order to contribute to the retention, appropriation and understanding of highly abstract technical content and the promotion of spatial cognitive skills in students [19].

Results and Discussion

The purposed methodology is described below in a sequence of weekly activities distributed throughout the professor's work sessions that can be summarized in Table 1.

Week 1: In this instance, the general course content was presented, the methodology, planning, evaluations and bibliography handed out. The general framework of technical drawing and their application in engineering was discussed, trying to unify the previous knowledge of this group of alumni.

Week 2: The different projection systems (Orthogonal, conical, axonometric), the different projection plans (Vertical, horizontal, profile) and the different views that were generated from a drawing was briefly explained, all through the support of the lectures and the application of AR installed in mobile telephones, which was proposed by Sánchez [20].

The students were given, in printed format, an AR workbook called AR-Book UCM, shown in Figure 2, which included a series of exercises aimed at putting into practice the students' spatial reasoning and abstraction level, in these exercises they had to complete the isometric view of each of the figures, must have side, profile and plan views. These figure drawings served as markers (Figure 2a), with which the students, using their phones, could visualize them through Aumentaty Scope® display application. This session was intended to familiarize students with the application and how to visualize solids in 3D and the relationship with their representation in 2D, as can be seen in Figure 2b.

Week 3: The general characteristics of the plans, types (set, manufacture, assembly, etc.), standardized sizes and dimensions, labeling, line types, data box and technical standards by discipline were explained.

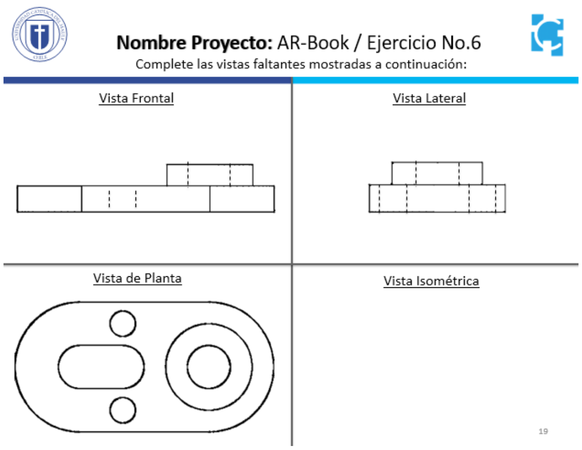
Table 1. Industrial Design and Technical Drawing course syllabus

Week	Description of the activities	Resources	Evaluating instrument
1	Presentation of the course. Definition, uses and applications in Engineering.	Syllabus, Master class, Lectures Lectures, Telephone or mobile device, AutoCAD 2019, Augment Creator 2019, Augment Scope 2019	Written test, guideline, rubric, Workshops, Cumulative Test, PBL
2	Theory of projections and views		
3	Standardization of drawings, formats		
4	Scales, dimensioning and folding of drawings		
5	CAD Control No.1		
6	ISO and NCh Standards		
7	Aerial and Isometric Perspectives		
8	CAD Control No.2		
9	Drawing Lecture in Engineering		
10	Industrial Drawing Designs		
11	Cuts and Sections		
12	Final Project Development 1		
13	CAD Control No.3		
14	Final Project Development 2		
15	CAD Practical Exam		
16	Final Project Presentation		

Week 4: In this class, the information of different types of scales was provided, dimensioning and their standards, as well as how to fold flat according to NCh 2370 regulations.

Week 5: The introduction to graphical environment of the AutoCAD® 2019 software was explained, covering the basic instructions for the two-dimensional drawing, work tools, drawing edition, help commands, formats configuration, layers and lines. The learning of the basic drawing commands (line, circle, copy, move, erase, rotate, symmetry, etc.) were evaluated.

Week 6: In the work sessions of this week, the ISO procedures and Chilean drawing standards were detailed, their comparison with DIN, UNE, ANSI standard, as well as their implementation in engineering projects.



a)

b)

Figure 2. a) Workbook marker b) Display of marker through Scope® app.

Week 7: The topics covered were the dihedral system, the aerial and isometric perspective, teaching the procedure to make freehand drawings in both perspective with the help of set squares.

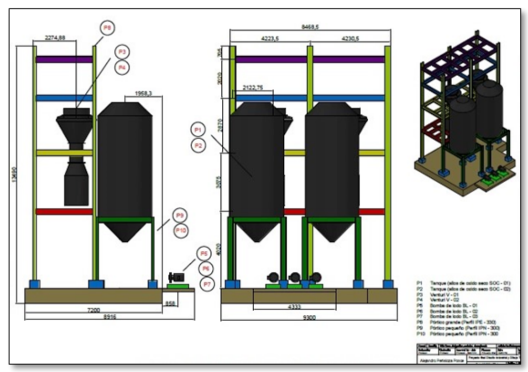
Week 8: Students were introduced to additional editing commands in AutoCAD® 2019 software. Their learning of basic editing commands (rotate, scale, symmetry, offset, fillet, chamfer, extend) was evaluated.

Week 9: The reading and interpretation of engineering plans was discussed. Basic distributions of the work area of a drawing, as well as the different symbols used in the main disciplines according to the drawing.

Week 10: The concept of industrial drawing design and its integration with current CAD software was introduced. The environment of drawing solids in AutoCAD® 2019, the display commands and generation of solids in 3D is explained.

Week 11: The topics covered were the main types of cuts and solid sections, cutting planes, planes for cutting projections (views). Criteria and regulations taken into account when cutting a 3D object. Parallel flat cuts. The concept of Boolean operation in AutoCAD® 2019 as a tool for creating complex 3D solids was explained.

Week 12: The characteristics of the final project were explained, which was of an individual nature, both the evaluation rubric and the project guidelines were provided, which consisted of modeling a 3D set of industrial elements, then translating those into an engineering plan that has a frontal, lateral and isometry view, all replicating the physical plans provided by the professor (metallic structure assembling drawing). Later, this plane drawn by students served as a marker for integration with the 3D model in AR, as can be seen in Figure 3.



a)

b)

Figure 3. a) Mechanical structure drawing that serves as a marker. b) AR display through the Scope® app.

The Aumentaty® community was formally introduced to the students, the basic procedure for AR integration with two-dimensional markers was explained using the software, through the procedure described in Figure 4.

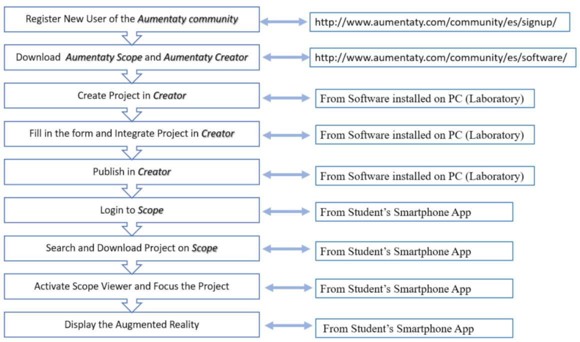


Figure 4. Procedure to display virtual objects through AR [21].

Week 13: The editing tools for 3D solids, dimensioning and dimension styles were explained in AutoCAD® 2019.

Week 14: Test integration practices were performed with basic 3D models generated in AutoCAD® 2019 (DWG Format), exporting them in graphical lithography application formats (STL format), and importing them later into an integration software with AR Aumentaty Creator®. The markers used were the two-dimensional drawings generated (without texture) of 3D models previously made by students. The idea is that the students can view these 2D markers in the Aumentaty Scope® software installed on their cellphones and have the ability to view the 3D object created using AR with the same device. Difficulties to generated content were found in the Aumentaty Creator®, as well as in importing and exporting content. The display of the contents was uneven in a percentage of students due to the difference in performance between the phones available.

Week 15: An integrator exam was performed (50% theoretical – 50% practical) designed to measure the learning of the contents covered throughout the course.

Week 16: The final project presentation and delivery was carried out in a public exhibition.

With the development of this methodology implemented for the pedagogy of technical drawing and industrial design concepts, they were able to create virtual learning objects that use the advantage provided by AR technology to capture the students' attention, stimulating their motivation, therefore positively impacting the learning process [22], through the implementation of innovative educational strategies, which, has already been demonstrated, promoting transversal skills learning, such as leadership, teamwork and communication [23].

Conclusion

A procedure has been performed for the teaching of the dihedral system and the different graphic projections by including AR technology in the development of educational content, which was oriented to the stimulation of mental processes related to the students' spatial reasoning, where the creation and integration of virtual models moved away from great procedural complexities and the need for deep knowledge in the computing area, supported by the increase of mobile smart phones presence in university classrooms, own by the student population. The development of this investigation allowed to know the existence of free software that serves as pedagogical tools for easy and fast learning on how to use this technology, such as Aumentaty Creator® 2019 and Aumentaty Scope® 2019, which seeks to serve as a guide for the university community in the adoption and implementation of this type of technology as a pedagogical strategy, as well as its strengthening as research line due to its high potential as a didactic tool, ample implementation field and the positive performance stimulation and disposition towards learning by students [24].

The developed methodology shows to be a valid strategy to improve the pedagogical process in the technical drawing area, due to the impact on motivation in students for the use of innovative technology, thus giving students the possibility for an immersive experience in the industrial environment, without needing to leave the classroom or expose themselves to physical risks [25], however, difficulties were encountered in its implementation due to the characteristics of hardware (poor performance by older mobile phones) and software (the Aumentaty Creator® platform slowness due to its dependence on a high-bandwidth internet connection).

It was determined that, in order to perform and effective design of AR based pedagogical activities, it was necessary to form multi-disciplinary teams that included the IT, pedagogical and industrial areas. The quantification of stimulated motivation with the implementation of the present methodology is proposed for future work.

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