ANALYSIS OF THE USE OF CAD-3D TO DEVELOP SPATIAL CAPABILITY

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Abstract

Comprehension and representation of elements, either in two or three dimensions, is presented as a main issue in Technical Drawing teaching since spatial capability is no developed in previous years to Higher Education. For this reason, ICT tools have been taken into account in the teaching method to help students in the design and generation of three-dimensional objects, which will also offer them extra background for any future subject.

The objective of this research is to find out whether the practice of teaching methods related with the use of 3D software will improve spatial capability of Technical Drawing students in Engineering. For this purpose, it has been developed a proposal to work spatial visualization through 3D-CAD.

Results affirm that the introduction of ICT software in the teaching and learning process can improve graphic expression skills and learning to learn capacity. It has contributed to a better understanding of concepts, by acquiring the capacity of relating theory with practice through active learning, and developing a holistic vision of the subject. These findings show ICT teaching method as an satisfactory strategy to integrate contents and educational experiences.

Keywords: Innovation, Architecture, Engineering, Spatial Capability, ITC.

1 INTRODUCTION

One of the great difficulties that the undergraduate students of Technical Drawing face is both the representation of elements/objects in 2D as in 3D. The challenge lies in the evident lack of spatial capacity development during the years prior to higher education. Furthermore, this is more evident when an isometric representation (3D perspective) is required from the orthographic projection (2D views) of an object [1].

So, it is essential to generate a solution for Engineering and Architecture Degrees, in order to make possible passing drawing and graphic subjects and because of the real need of knowledge and skill acquisition by students, whom must be focused to their professional future [2].

Nowadays there are different possibilities in terms of computer tools that help in this matter, such as presentations, among others. In which the resolution of various exercises conducive to the acquisition of these competences can be elaborated step by step. Nevertheless, and despite the great possibilities that these systems offer, it is necessary to propose a response to the present situation that will further accelerate the development of this capacity. The execution of computer practices where the student is the generator of knowledge and the one who faces the problem itself, by being able to make mistakes and learn from them is a more interesting process from the point of view of learning.

2 THE ACQUISITION OF SPATIAL COMPETENCE IN TECHNICAL DRAWING

In the Declaration of the Conference of Spanish-University Chancellors (CSUC) on the EHEA (2002) it was pointed out that the European convergence process provided an excellent opportunity to modernize the teaching, both in its organization and in its objectives, methods, contents and evaluation schemes of the learning effort (…) since a reform does not only affect the structure of the teaching, but also includes a broader set of actions, among which the proposal for a profound transformation in educational methods and perspectives stands out [3].

Therefore, these transformations include a renewal of methodologies, which directly influence teaching practices and focus on student learning. Passive teaching methods that define the traditional university must be modified to give prominence to the effort of the student in order not to give up the
effective role of active methodologies. In this sense, knowledge learning becomes one more element, and must be complemented with the acquisition of competences. Definitely, a teaching system in which theory and practice work together [4].

However, according to Fernández March [5], one wonders what is the best teaching method, but he concludes by saying that the results of research on this subject have not been able to prove the supremacy of any particular method. Therefore, it is the professor who must design a series of phases and strategies that must be justified. First of all, the didactic method has to be adequate to the situation of the student and that promotes a significant learning; therefore, it must also conform to the educational context formed by the teacher-student and pupil-student relationships. In this sense, the methodologies centred in the students are considered more formative, more generative of significant learning, and more adequate to foster memorization and transference of learning than teacher-centred methods.

For these reasons, and taking into account that student needs change over years, it would not be efficient a teaching model that only considers one approach. A flexible model will be required, that one able to reach several possibilities and tasks. Moreover, the methodological intervention of the professor must be oriented to obtain a feasible procedure to capture the attention of students which will maximize their learning abilities. Therefore, constructivism appears as a turning point in teaching-learning theories, in which the origin of the paradigm is that human learning is built on previous knowledge [6]. This approach is characterized by an active process that builds knowledge through interaction with the object of study and is understood by putting it in relation to various cognitive structures.

Regarding Technical Drawing, it is necessary to clarify that the way of teaching this discipline has traditionally been developed by two-dimensional methods: blackboard and paper. Nonetheless, in recent years, new technologies have greatly facilitated 3D modelling and visualization, so that it allows the combined 2D/3D design through computer support, whose possibilities have motivated a new teaching approach [7].

This subject is fully related to the degrees of engineering and architecture, as it allows the student's intellectual development in the field of three-dimensional space comprehension, which makes it essential in the training of undergraduate engineers and architects. For this reason it is curious to note that a considerable percentage of the students enrolled in the courses did not attend Technical Drawing in their Baccalaureate, which generates a great challenge with subjects related to the discipline, which are the last ones to be passed [8].

In addition, many educators are concerned about the way students are being taught in Technical Drawing in secondary school, which may will influence their future career [9]. And all this, despite the fact that the EHEA advised that efforts should be made to equip students with ‘spatial ability and knowledge of graphic representation skills’, since they are essential to train and improve them to their correct performance in the labour market [3].

The emergence of ICT was a new contribution to the academic world, a pedagogical tool through which learning is carried out by the interaction between the medium that provides knowledge, the environment and a mediator, by contributing to the achievement of the educational goals [10]. This evolution has allowed the transition from the concept of Technical Drawing to Multimedia Communication. They are useful both for theoretical and practical development, assuming a new methodological approach in the teaching and learning of technical drawing, since it provides important advantages over the blackboard system [7]. In this sense, ICT contribute to an improvement in teaching by providing creativity and innovation as they jump from a routine learning process to another charged with novelty and dynamism [11], which assumes a different approach when facing knowledge and a new approach to the professional practice in the industrial field [12].

In fact, the introduction of computer tools for assistance in the construction of pieces in three dimensions will provide a good basis for subsequent subjects, in addition to address the main objective, since it allows the development of the ability to graphically express themselves and the learning to learn competence.

Among the benefits of using an ICT tool, student is able to perform different possibilities of construction of the element or object by visualizing them on the screen instead of their brain, whereas it supports the spatial capability of the object to be drawn, which is necessary to perform this type of representation. The system consists of the opportunity of making numerous simulations of
construction of the element, as many as necessary, so that the student can arrive at the correct result of the proposed one.

The process of drawing in three dimensions in computer comes from the 2D representation, so it is only in the final result when you have to know how the conversion of the plane to the volumetry is done in order to check if the result is correct, which will allow the student at any time to know what he/she is not understanding and to modify it.

For this reason, ICT tools have been taken into account in the teaching method to help students in the design and generation of three-dimensional objects, which will also offer them extra background for any future subject [13, 14].

3 OBJECTIVE

The objective of this research is to find out whether the practice of teaching methods related with the use of 3D software will improve spatial capability of Technical Drawing students in Engineering. For this purpose, it has been developed a proposal to work spatial visualization through 3D-CAD.

4 METHOD

4.1 Sample

This experience was carried out in the academic year 2016/17, with 72 undergraduate students in the 1st course of Technical Drawing, within the Degree of Marine Engineering and Naval architecture at the University of Cadiz.

4.2 Procedure

Firstly, a test was passed to the students with questions aimed to find out whether they had taken the subject of Technical Drawing in the baccalaureate, whether they knew how to handle CAD software, and a diagnostic test of the knowledge and skills of the group, by evaluating the following items: Spatial Ability (SA); Geometric Basic Tracings (GBT); Construction of Figures and Geometric Polygons (CFG); Curves and Tangencies (CT) and sketching (S).

On the basis of the obtained results, a didactic proposal was designed based on the use of 3D software in which the activities were contextualized, diverse and significant. In a first phase a sketching of the object was done in Sketcher, where only 2D drawings are presented, and after, in the Part Design module, the object was built in three dimensions, in order to facilitate the 3D visualization.

The computer software of representation to be used was Catia from Dassault Systèmes. This platform offers several advantages: being one of the most used and advanced tools in the professional world of engineering, specifically for the drawing and representation of all kind of engineering objects. In addition, it is also used in several subjects of Engineering and Architecture Degrees.

Although this tool is logically oriented to the field of industrial, naval or aeronautical engineering, instead of Architecture or Civil Engineer, it is suitable to the goal of representing two-dimensional objects in three dimensions regardless the field of knowledge in which the student is.

Finally, a test was carried out after carrying out the didactic proposal to assess its academic impact.

5 RESULTS

Data analysis showed that only 46 per cent of the sample had taken Technical Drawing courses, either in 1st or 2nd year of the baccalaureate (Figure 1).
In addition, they were also asked if they had previous knowledge in CAD management. This question was answered positively by 16 students, of which 4 did not belong to the group that had not taken Technical Drawing in high school (Table 1).

| Table 1. Distribution of students who previously managed CAD program (expressed in %) |
|----------------------------------|---------------------------------|-----------------|
|                                   | CAD-background (16,7) | Non-CAD background (29,2) |
| Students within Technical Drawing background | 16,7 | 29,2 |
| Students without Technical Drawing background | 5,5 | 48,6 |

In the diagnostic test, the following items were evaluated: Spatial Ability (SA); Geometric Basic Tracings (GBT); Construction of Figures and Geometric Polygons (CFG); Curves and Tangencies (CT) and sketching (S). The results (table 2) indicate a large difference in all items among students who previously studied Technical Drawing in high school.

<table>
<thead>
<tr>
<th>Table 2. Average grade per group in the diagnostic test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students within Technical Drawing background</td>
</tr>
<tr>
<td>S.A.</td>
</tr>
<tr>
<td>3,8</td>
</tr>
<tr>
<td>Students without Technical Drawing background</td>
</tr>
<tr>
<td>0,2</td>
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</tbody>
</table>

Once the data was obtained, the above mentioned didactic proposal was put into practice, and as it was being done, the results of both groups were analyzed, obtaining the conclusion of the results from the direct observation of the researchers, and the evaluation allows to affirm that there is an improvement of the learning and the spatial capability, especially in the group of students who had taken Technical Drawing in high school (table 3).

<table>
<thead>
<tr>
<th>Table 3. Average grade per group after implementation of the didactic proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students within Technical Drawing background</td>
</tr>
<tr>
<td>S.A.</td>
</tr>
<tr>
<td>6,4</td>
</tr>
<tr>
<td>Students without Technical Drawing background</td>
</tr>
<tr>
<td>3,2</td>
</tr>
</tbody>
</table>
In short, the results of this research shows that the use of teaching methods related to the use of 3D software improves the spatial capability of students of Technical Drawing in Engineering, which influences in the overcoming of the subject (table 4).

Table 4. Students who improved the spatial capability and passed the subject (expressed in %)

<table>
<thead>
<tr>
<th>Students within Technical Drawing background</th>
<th>Passed</th>
<th>Failed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students without Technical Drawing background</td>
<td>30.5</td>
<td>15.3</td>
</tr>
<tr>
<td>Students without Technical Drawing background</td>
<td>7</td>
<td>47.2</td>
</tr>
</tbody>
</table>

6 CONCLUSIONS

First of all, it is necessary to point out the scarcity of existing researches regarding learning methods in the area of Technical Drawing. Although, short papers have appeared since 2000, they deal with personal experiences through IT software or any specific teaching method instead of generating a holistic method, which this research have tried to contribute.

Seeking for new techniques and work strategies is essential in order to achieve a closer approach to students, and they are closely related to the introduction of IT in the classroom [15]. Educators must feel the obligation to introduce the virtual world into the education and training of their students to adapt itself to new social and learning demands [16].

The results show that learning significantly improved through the use of new technologies, carrying out activities and living the learning as a progressive and formative experience [11], despite the fact it is essential that students have a background of the subject to effectively deal with it. In this sense, it would be essential for students who acceded to architecture or engineer degrees to have studied Technical Drawing in high school.

This research let affirm that the introduction of ICT software in the teaching and learning process can improve graphic expression skills and learning to learn capacity. It has contributed to a better understanding of concepts, by acquiring the capacity of relating theory with practice through active learning, and developing a holistic vision of the subject. Moreover, these findings show ICT teaching method as an satisfactory strategy to integrate contents and educational experiences.

REFERENCES


