Álvarez-Caldas, C. … et al. (2019). Educational Resources for Self-learning of Descriptive Geometry. In: García-Prada, J.C., Castejón, C. (eds.) *New Trends in Educational Activity in the Field of Mechanism and Machine Theory*, pp. 186-194 (Mechanisms and Machine Science, v. 64). Switzerland: Springer.

DOI: https://doi.org/10.1007/978-3-030-00108-7_21

Educational Resources for Self-learning of Descriptive Geometry

C. Álvarez-Caldas(✉), J. Meneses, S. Santos, A. M. Gómez, A. Díaz, J. A. Calvo, and A. Muñoz

Mechanical Engineering Department, Universidad Carlos III de Madrid, Avda. De la Universidad, nº30, 28911 Leganés, Spain
calvarez@ing.uc3m.es

Abstract. In this work, two educational resources for self-learning of Descriptive Geometry are presented: the "Zero Course" and the "Support Course". The creation of this e-learning material responds to the need that our students at University Carlos III de Madrid have to reach a minimum level at the beginning (Zero Course), and during (Support Course) the first course on technical drawing. First, the need is made out through results of surveys carried out in previous years. Then, some e-learning applications are exposed, among which the most appropriate to the need are chosen. Finally, the designed courses are described including all the technical resources. The results of the surveys carried out on the students of these courses, as well as some statistics of their qualifications, are also presented.

1 Introduction

Descriptive Geometry (DG) is the branch of Geometry that studies the representation of three-dimensional objects on a plane, using systems based on the concept of projecting the object on a plane in order to reduce the three spatial dimensions to the two dimensions of the plane. At present, the basic content of DG (as the basis of the Orthographic Projection) is taught in the last years of pre-university education and in practically all branches of Engineering; it is of vital importance in Design, Mechanical and Civil Engineering [1].

The main purpose of this subject is not only to provide students with theoretical knowledge of Geometry and Drawing, but also to enhance their spatial perception, one of the seven forms of intelligence and the most essential and vital one in the training of any engineer [1–3].

Although the necessity of having appropriate underpinning knowledge as well as skills and competences that can only be developed through laboratory and workshop practice is clear [4], present syllabuses allow students without this knowledge to arrive to technical degrees.

To establish the necessity of this work, a survey has been launched in a Spanish school of Engineering through a web platform used to communicate with the students to measure their previous preparation.

They were asked whether they had studied Technical Drawing at High School for two years (what is considered to be a proper preparation period of time), for only one

J. C. Garía-Prada and C. Castejón (Eds.): *New Trends in Educational Activity in the Field of Mechanism and Machine Theory*, MMS 64, pp. 1–9, 2019.
https://doi.org/10.1007/978-3-030-00108-7_21

year (what is considered an insufficient preparation) or if they had ever studied technical drawing before.

Surprisingly, it has been found that almost one in three Industrial Technologies students do not have the adequate preparation to face the subject with guarantees. This result is even worse in the Bachelor in Electrical Power Engineering and it becomes absolutely terrible for the Bachelor in Energy, where just four in ten students are prepared for the subject (Fig. 1).

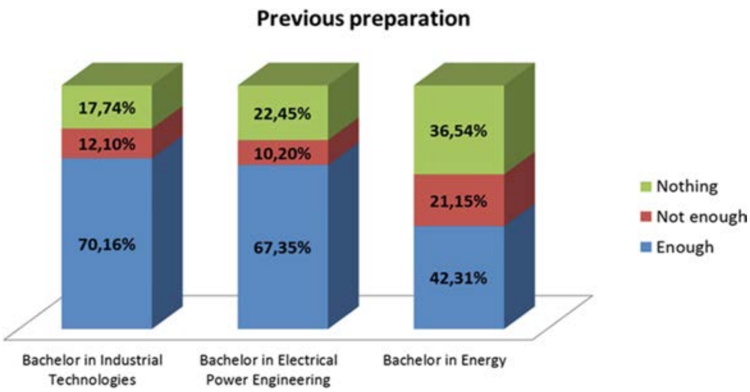

Fig. 1. Previous preparation of the Engineering Graphics students (data obtained by survey)

So the only possible solution is to help the unprepared students to reach the desired level by using e-learning. This is a solution that several teachers are currently using to solve other similar problems [5, 6].

To achieve this goal, a set of educational resources will be created. These resources will be intended for future students of the subject (trying to avoid the initial gap between them and students with a proper preparation) and to present students of the subject (trying to help them with those especially difficult contents).

Therefore, it will be necessary to find tools to develop those resources, making them attractive and fun, and easily accessible from everywhere. Also, it will be necessary to distinguish two levels, according to the two groups of students already explained.

2 E-learning

Educational innovations can improve learning outcomes and the quality of education. The effectiveness of the teaching method can be enhanced by the use of the ICTs (Information and communication technologies) [7]. From this emerges the concept of e-learning (electronic learning). The American Society for Training and Development (ASTD) defines e-learning as a broad set of applications and processes which include web-based learning, computer-based learning, virtual classrooms, and digital. Others authors delimit more the scope of e-learning, reducing only to the use of Internet [8].

But there is no doubt that it is one of the most used educational strategies at the present time not only in education, but also in professional and business context. Nevertheless, not all e-learning methodologies are completely virtual [9]. A significant proportion of university e-learning is based on blended learning (B-learning) [10–12]. In this case, virtual training is combined with face-to-face learning. Increasingly, more universities participate in such initiatives launching web portals with diversity of educational resources.

It is important not to confuse e-learning with OER (Open Educational Resources) [13]. Another thing is some online learning proposals can use different open resources. The OER are teaching, learning and research materials in any medium that reside in the public domain and have been released under an open license that permits access, use, repurposing, reuse and redistribution by others with no or limited restrictions. E-learning, as well as OER, are compatible and complementary with conventional on-site teaching and both can be used in order to improve learning aspects, such as reinforce some subjects or provide a strong academic base in some topics, inter alia.

Different types of OER or e-learning resources can be distinguished. For example, MOOCs (Massive Online Open Course) are a current educational trend in university teaching. Main characteristics of MOOC consist in they are free, massive, open, online and promote autonomous learning. MOOC also encourage the connection between users. A version of MOOC is NOOC (Nano-MOOC), ideal for segmented public who need specific training in an area. These courses have duration of up to 20 h. We may also find SPOOCs (self-Paced Open Online Course). In this case, the main difference is that the course has not time limit in order to finish it.

This paper is focused on the development of two e-learning courses in technical drawing in engineering. One of them is a payment B-learning course: a mixture between an online virtual training provided by edX platform (phase 1) combined with a face to face learning (phase 2). The other course is the result of a teacher innovation project, and would be considered as OER course, in which all the students enrolled in the subject can access for free to the whole course, but without the teacher's support.

3 Description of the Educational Resources

To meet the needs set out above, two online courses have been developed and presented in this article, covering two levels of learning: basic and intermediate.

The basic level course, referred to as "Zero Course", is designed for students who have an insufficient preparation, mostly due to not having attended any Technical Drawing course at High School. Actually, it is intended to be taught just before starting the first university course.

As regards the intermediate course, the so-called "Support Course", it is aimed at students who have difficulties in understanding specific orthographic projection topics, during the subject of Technical Drawing, taught in the first year of university.

In the following sections, the contents and methodology used in these courses are briefly presented.

3.1 Zero Course

In this course, the basics about technical drawing in engineering, emphasizing the fundamentals of the orthographic projection (or Monge's method of projection), are exposed in twelve videos in seven thematic blocks. Each thematic block consists of one or more videos and a self-evaluation test. In Fig. 2 below is the syllabus for this course (in parentheses the video number – V0 to V12 - and the duration of the video are indicated):

ZERO COURSE: TECHNICAL DRAWING IN ENGINEERING

- ❑ PRESENTATION (V0, 4'25'')
- ❑ USE OF TECHNICAL DRAWING MATERIAL (V1, 8'53'')
- ❑ REPRESENTATION SYSTEMS
  - Technical Drawing as a Language. The concept of projection (V2, 11'35'')
  - Types of Projections and Representation Systems (V3, 9'46'')
- ❑ FUNDAMENTALS OF THE ORTHOGRAPHIC PROJECTION (MONGE'S METHOD)
  - Elements of the Orthographic projection (V4, 7'51'')
  - Representation of points (V5, 15'44'')
  - Representation of straight lines and planes (V6, 8'10'')
- ❑ PARTICULAR POSITIONS OF STRAIGHT LINES AND PLANES (V7, 10'41'')
- ❑ RELATIONSHIPS OF PERTENENCE, PARALLELISM AND PERPENDICULARITY BETWEEN POINTS, STRAIGHT LINES AND PLANES (V8, 9'04'')
- ❑ INTERSECTIONS
  - straight line – straight line (V9, 2'49'')
  - Plane – Plane (V10, 4'51'')
  - straight line – Plane (V11, 5'19'')
- ❑ OBTAINING TRUE DISTANCES FROM PROJECTIONS (V12, 2'49'')

Fig. 2. Syllabus for the Zero Course (translated text from Spanish)

V1 was made with a zenith camera, so that the student can learn to use the different tools for technical drawing, and follow some examples, as if he were doing them by himself (see Fig. 3).

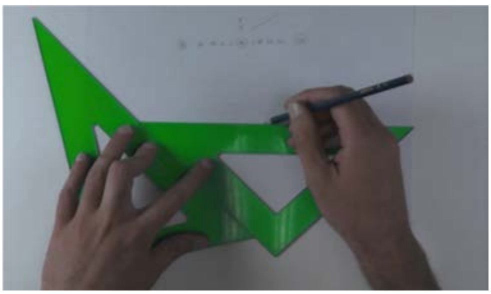

Fig. 3. Screenshot of the V1: "Use of the technical drawing material"

V2 and V3 were made with the software SmoothDraw 4 on a tablet in which one can write and draw with a special pencil as in a blackboard (see Fig. 4).

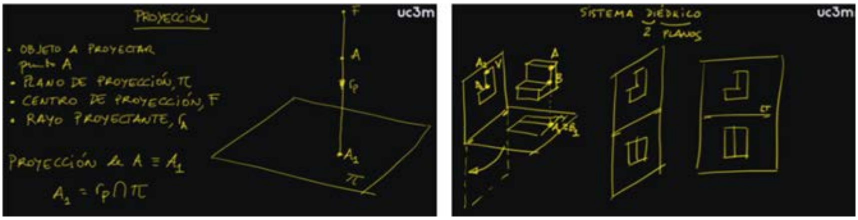

Fig. 4. Screenshot of the videos V2 and V3, belonging to the "Representation Systems" thematic block

V4 was made combining software PowerPoint and SolidEdge. The former allowed the geometrical elements to appear as the explanations were given, as well as the teacher to make annotations with the pointer; with the latter it was possible to make animations to facilitate the visualization of the projections from the object (see Fig. 5).

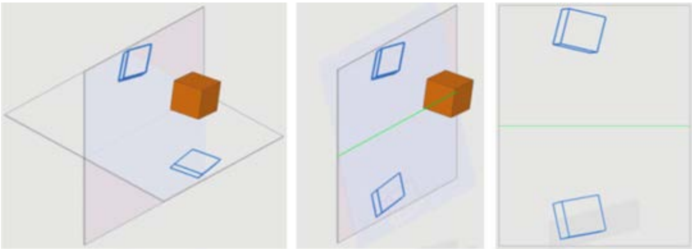

Fig. 5. Three successive screenshots from a SolidEdge animation in V4 about Orthographic Projection

The rest of the videos – V5 to V12 - were made using PowerPoint, allowing step by step explanations and annotations. Finally, all of the videos were edited with the software Camptasia.

3.2 Support Course

At this level, the educational resource has another approach: this is not a course that the student has to follow from beginning to end. It is rather a series of explanations through videos, on certain topics in which the student usually has difficulties. In this way, single videos can be viewed at any time without having seen the previous ones, even though references to other videos are indicated if necessary.

All the videos of this course were made with the software Power Point on a tablet to make annotations and drawings.

There are two types of video in the support course. The first type is composed of videos showing the main theoretical procedures of descriptive geometry, whereas the second type is made up of videos where a complex problem is proposed and solved step by step.

Both theoretical and exercise videos have three important aspects in common:

- The geometric elements and constructions involved are sequentially appearing as the theoretical topic (or complex problem) is being exposed (or solved).
- Two figures appear in the screen throughout the explanation, which makes it easier to understand: an axonometric perspective and the corresponding orthographic projections (see Fig. 6 left).

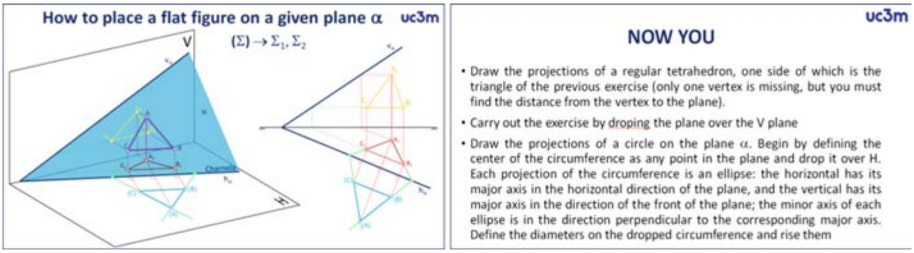

Fig. 6. Two screenshots of the video about "rotations of planes", left: Theoretical explanation with an axonometric view and the corresponding orthographic projections; right: "Now you" section. (translated text from Spanish)

- At the end of the video, in the section "Now you", the student is encouraged to deepen in aspects related to the theoretical topic just learned; or he is proposed to solve a problem based in the previous one, but of a higher level of complexity (the guidelines are given, see Fig. 6 right).

4 Students Self Evaluation Process (Zero Course Only)

A self-evaluation process has been implemented in order to measure the student knowledge acquired during the course. Main advantages of this system are:

- students with different initial preparation can learn at different paces
- it's less distracting than a group-study learning
- makes the learning deeper because the student needs to face the problem alone and he does not have the opportunity to quit thinking that the problem will be resolved by the group

A five exercises collection is associated to each theoretical chapter. These five exercises have been carefully prepared to assure that the student fully understand the subject. Once it's completed and passed the exercises collection the chapter is closed and the student is fully qualified on that matter.

Test exercises have some of the following structure:

- Objective test that have clear right or wrong answers. Multiple-choice tests fall into this group. Students have to select a pre-determined correct answer from three or four possibilities.
- Short questions that require the student to provide a definition, or a concept identification.

5 Results Analysis

At the moment, only feedback from the zero course students is available, since the Support course will be tested during this academic year that has just begun.

According to an anonymous survey, the contents of the course have been well selected. An 85% of the students, think that the level is accurate. A 12% of the think that the level is excessive (Fig. 7, left).

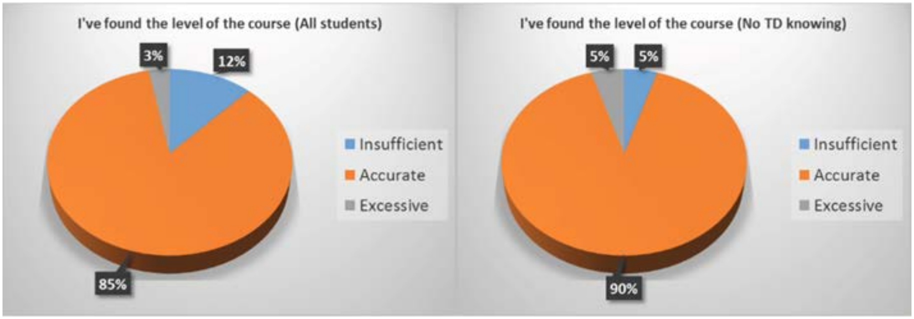

Fig. 7. Answers of the students to the question "I've found the level of the course…"

To analyze this results properly, it is necessary to know that some students who have technical drawing knowledge have applied to the course, even when it is designed for students with no technical drawing knowledge.

Separating students with technical drawing knowledge and without it, it can be concluded that 90% of the students with no knowledge find the level accurate (Fig. 7, right).

Paying attention to the created on-line material, 76% of the students think that it is also accurate (Fig. 8, left).

Restricting the response to students without technical drawing knowledge, only 67% of them find the material accurate. Almost one in four students with no knowledge, would like to have more on-line material, while 9% of them find the material excessive (Fig. 8, right). According to the opinions written by them in the survey, they have not enough time to see it all. In the other hand, 92% of the students with technical drawing knowledge find the material accurate, and no one of them thinks that it is excessive.

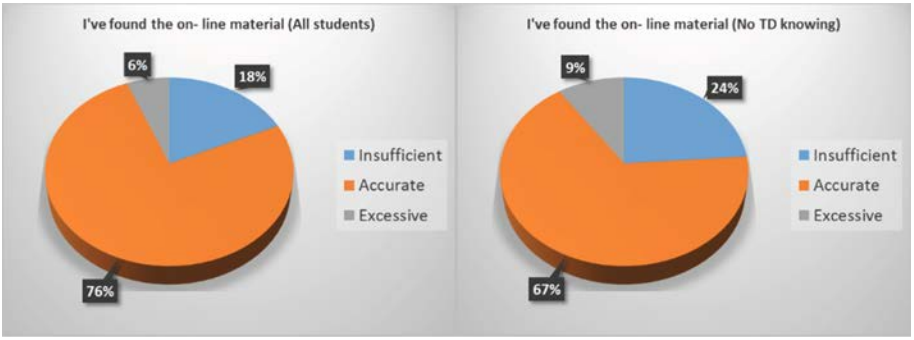

Fig. 8. Answers of the students to the question "I've found the on-line material…"

6 Conclusion and Future Work

According to students opinions, the created material is very useful for them to learn technical drawing concepts.

They think that the level of the material is accurate, but also that the amount of the subject covered by the on-line material must be extended.

Therefore, it can be concluded that the result of the work is satisfactory but there is still a lot to do in order to cover more concepts.

It is easy to propose the first future work: to extend the concepts covered by the on-line material.

Other possibility is to translate the material into English for students of the bilinguals groups.

It is also important to analyze the results of the students who have follow the zero course after their first university year. It would be very interesting to see if they have better academic results than those students that have not followed the course.

References

1. Rubio García, R., et al.: Interactive multimedia animation with macromedia flash in descriptive geometry teaching. Comput. Educ. **49**(3), 615–639 (2007)
2. Contero, M., et al.: Learning support tools for developing spatial abilities in engineering design. Int. J. Eng. Educ. **22**(3), 470–477 (2006)
3. Kaufmann, H., Schmalstieg, D., Wagner, M.: Construct3D: a virtual reality application for mathematics and geometry education. Educ. Inf. Technol. **5**(4), 263–276 (2000)
4. Tornincasa, S., Chirone, E.: The Leonardo WEBD project: an example of the WEB3D technology applications for distance training and learning. In: XIV Congreso Nacional de Ingeniería Gráfica, Santander, Spain (2002)
5. Jones, B.W.: Teaching computer graphics in the online environment. In: 59th Annual Midyear Conference of the Engineering Design Graphics Division of the American Society for Engineering Education, Williamsburg, USA (2004)
6. Rojas Sola, J.I.: Internet: La nueva puerta del siglo XXI aplicada a la enseñanza de la geometría descriptiva. Revista Mágina **10**, 197–203 (2002)

7. OECD: Innovating Education and Educating for Innovation. OECD Publishing, Paris (2016)
8. Rosenberg, M.J.: E-Learning: Strategies for Delivering Knowledge in the Digital Age. McGraw-Hill, New York (2001)
9. Garcia Marcos, C.J., Cabero Almenara, J.: Evolución y estado actual del e-learning en la Formación Profesional española. RIED. Rev. Iberoam. Educ. a Distancia **19**(2), 167 (2016)
10. Marsh, G.E.I., McFadden, A.C., Price, B.J.: Blended instruction: adapting conventional instruction for large classes. Online J. Distance Learn. Adm. **6**(4) (2003) AQ1
11. Pina, A.B.: Blended learning. Conceptos básicos. Píxel-Bit Rev. Medios y Educ. **0**(23), 7–20 (2004)
12. Dukes, M., Waring, L., Koorland, S.: The blended course delivery method: the not-so-distant education. J. Comput. Teach. Educ. **22**(4), 153–158 (2006)
13. UNESCO: Guidelines for open educational resources (OER) in higher education; 2011; 2015. (2015)