10th International Scientific Conference
Technics, Informatics, and Education – TIE 2024
20-22 September 2024

Session: *Engineering Education and Practice*
Professional paper
DOI: 10.46793/TIE24.310M

Creating the Flipped Classroom in the Course Engineering Graphics

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Abstract: *With the advancement of technology, the possibilities of learning are changing and so are the approaches. There is a high demand in the market for engineers with an advanced level of knowledge in the field of 3D modeling. The students of vocational studies at the Faculty of Technical Sciences in Čačak have different prior knowledge in this field, and therefore the subject Engineering Graphics, in which 3D modeling is studied, is adapted to an intermediate level of knowledge. The paper shows the preparation of a new approach to teaching, the flipped classroom, because this strategy has proven to be successful in encouraging greater student activation and deeper knowledge.*

Keywords: *Technical drawing; 3D modeling; flipped classroom; Education in engineering*

1. INTRODUCTION

At European universities, students acquire basic knowledge of technical drawing and 3D modeling in the first year, as part of engineering curriculums. At the Faculty of Technical Sciences in Čačak, in the vocational studies of mechanical engineering, during the first semester, students have the subject Technical drawing. With the rapid development of computers and information technologies, there has been a revolution in the field of creating and using technical documentation. According to the mentioned changes, during the second semester, the subject Engineering Graphics has been introduced. During the 15-week Technical Drawing course, students acquire the knowledge and skills necessary for making technical drawings and reading already made technical drawings, while during the Engineering Graphics course, students learn the basics of modeling in the SolidWorks software package.

The lectures in Engineering Graphics were held in the amphitheater where the teacher presents the modeling process on the computer while the students can only follow the process on the screen via projection. Some students passively followed and some took notes during the lectures. After two hours of the lectures, it was noticed that some of the students who passively follow, stop following the class and start to get bored because of the large amount of information [1]. Also, a significant number of students attended classes without prior knowledge, which is why it took a long time to explain the basics of 3D modeling. Due to slow progress, students who had prior knowledge quickly lost interest in the subject.

In addition, the lectures lacked interaction because students could not work simultaneously on the computer to encounter possible problems in the modeling process. The observed problem was solved by providing a computer classroom for the lecture period. However, this solved only a part of the observed problem because, in addition to the students for whom it is a compulsory subject, students from the Graphics department and Information technologies for whom it is an optional subject, also follow the classes in the Engineering Graphics. The computer classrooms are mostly equipped with 20 computers, which is small considering that around 60 students attend classes during the lecture period. In this way, one third of the students actively followed the teaching and in parallel with the teacher on their computer applied, step by step, the modeling process. Two thirds of the students still passively followed the classes.

After several years of traditional teaching and observed problems, innovation in teaching is being considered in order to improve students' results. In addition to teaching materials in text format, e-education programs increasingly use multimedia materials. Different media have different informational attributes and make different demands on students regarding information processing. For example, our perception of a film whose action is based on a novel is different compared to the perception while reading the novel [2].

The rest of this paper is structured as follows: Section 'Related work' goes through some advantages faced by other researchers. Section 3 describes in details course outline. In Section 4, a conclusion and the future work are presented.

2. RELATED WORK

Following the literature in the field of engineering education, the inverted (or flipped) classroom approach emarges as a promising strategy. The flipped classroom is a new pedagogical method, which uses asynchronous video lectures and practice problems as homework, and active group activities for solving problems in the classroom [3, 4]. The Flipped Classroom consists of interactive group learning activities inside the classroom and direct one-on-one computer-based instruction outside the classroom.

Through the flipped classroom, not only knowledge can be well acquired, but also some other abilities can be developed, such as the ability to access information, a sense of teamwork, communicative abilities, and the ability to reason and (connect knowledge) summarize [5].

Research shows that students learn best when they are taught in accordance with their particular learning style, which can be dependent, collaborative, or independent [6]. The time when students really need a physically present professor is when they have a problem (get stuck) and need his individual help. The students do not need the presence of a professor while following the course content [7].

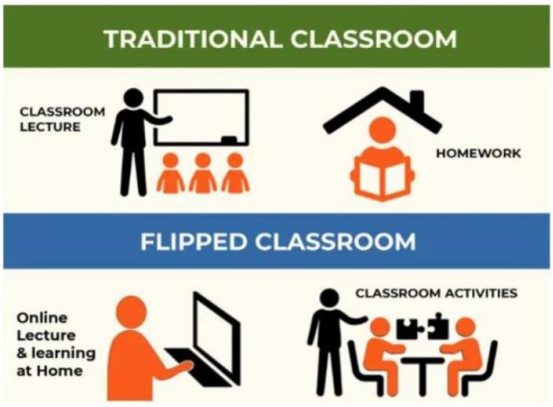

Figure 1. *Traditional Versus Flipped Classroom taken from [8].*

3. COURSE OUTLINE

After the decision to apply this method, video tutorials were recorded to accompany the course. The video tutorials are available for free on YouTube and could be found on the channel called "Engineering Graphics". In addition, teaching materials have been written in text format. The changes in the organization of the teaching process are planned in order to ensure the improvement of students' results.

Given that the course lasts 15 weeks, the idea is to divide the course into three parts. Each part lasts 4 weeks and at the end of each part the students take a test.

In the first part, it is planned to learn the modeling of prismatic and rotational parts, in the second part the generation of technical drawings, and in the third part the modeling of complex parts and assemblies.

The first part of the course should be the most intensive, because students will, at the same time, become familiar with working in the program, sketching procedures, basic modeling techniques of prismatic and rotational parts, and the most commonly used commands.

In the second part of the course, students are introduced to the basic techniques of generating technical drawings and the most commonly used commands. In order to successfully master this part of the course, students, in addition to knowing how to work in technical drawing software, must have a good knowledge of the principles of technical drawing.

In the third part of the course, students are introduced to the modeling techniques of complex parts and assemblies and the most commonly used commands used in this part of the course.

In order to motivate students to look at the teaching materials before coming to class, entrance tests will be prepared for each teaching week.

3.1 First part of the course

At the beginning of the course, it is necessary for students to familiarize themselves with opening a new document in SolidWorks, with the sketching environment as well as with document parameter settings. After that, through several prepared video examples, students will learn the basic commands for sketching the profile of model forms (Fig. 2).

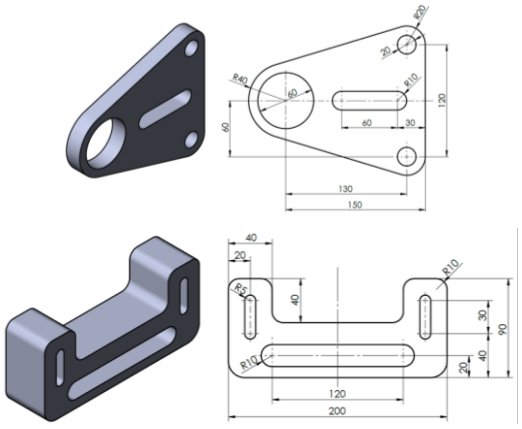

Figure 2. *Example of the profile of model forms*

Then, through several prepared video examples, students will master the basic commands for creating model forms of prismatic parts (Fig. 3). The commands needed for the first exercise are: Extruded Cut and Extruded Boss/Base.

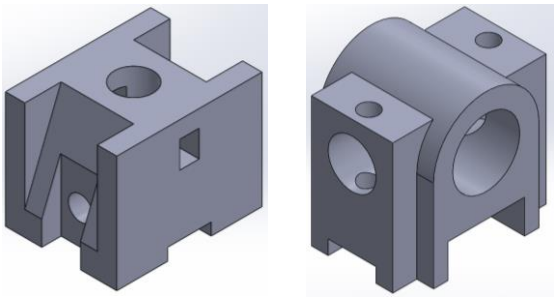

Figure 3. *Example of the prismatic form*

In the next step, students are expected to master the basic commands for creating model forms of rotational parts (Fig. 4). By creating these models students will learn the following commands: Revolved Boss/Base, Revolved Cut, Chamfer, Hole Wizard and Cosmetic thread.

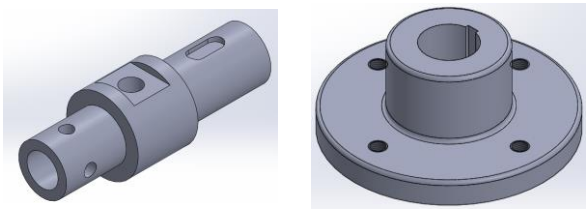

Figure 4. *Example of rotational parts*

Based on the knowledge they have acquired in the previous exercises, in the first test, students need to create appropriate model forms of prismatic or rotational parts based on the presented technical drawing of the 3D model in SolidWorks (Fig. 5).

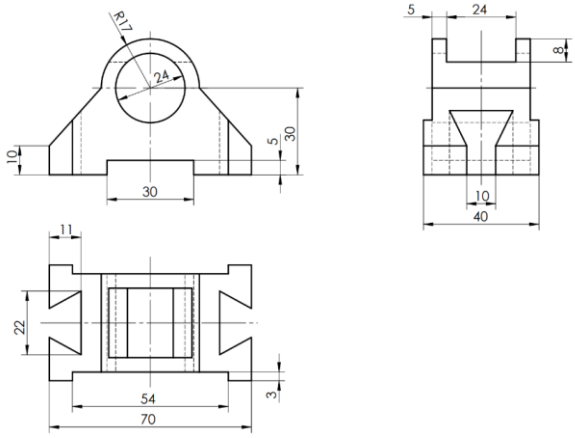

Figure 5. *Example of the first test: Based on the technical drawing create 3D model*

3.2 Second part of the course

In the second part of the course, students will first learn through prepared video examples that can be find in „Engineering Graphic" YouTube channel how to create orthogonal projections of 3D models in SolidWorks (Fig. 6).

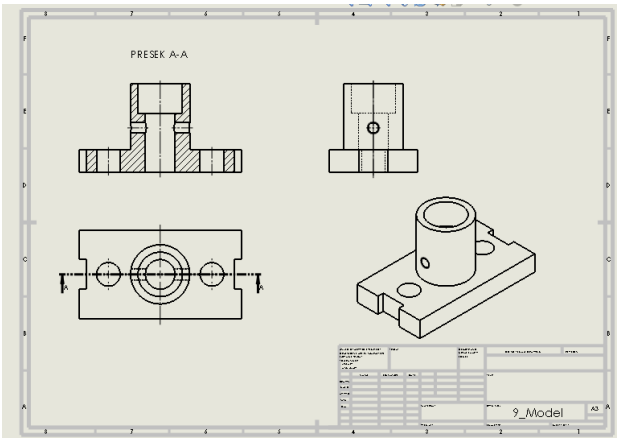

Figure 6. *Example of the orthogonal projections*

In order for the technical drawing to be complete, through several examples, the drawing must be dimensioned. Also the marking of surface roughness quality and tolerances is done in Solid Works (Fig. 7).

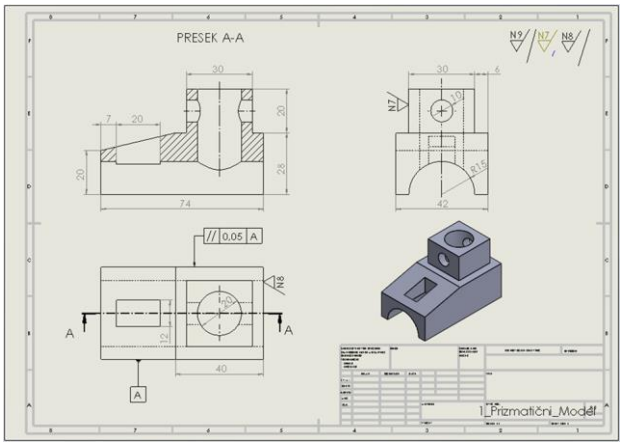

Figure 7. *Example of the finished technical drawing*

In the second test, based on the knowledge they have acquired in this part of the course, students are required to create a model and create a workshop drawing for the model shown in isometry. Figure 8 shows an example of the test task.

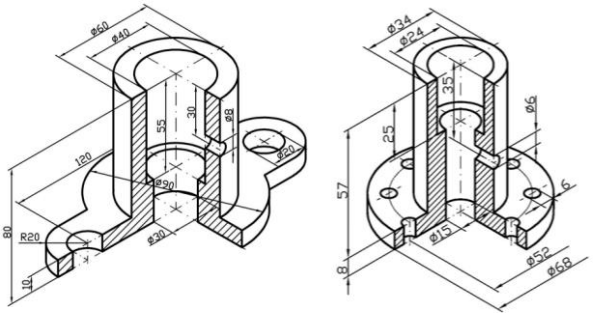

Figure 8. *Example of the second test: Based on isometric model create technical drawing*

3.3 Third part of the course

The third part of the course will be the most demanding for students, because in this part they need to learn how to model complex geometric

parts such as springs, bolts, nuts, gears, etc (Fig. 9).

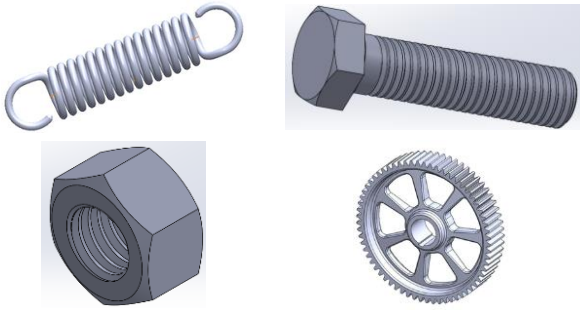

Figure 9. *Example of machine elements*

After that, students will learn, through appropriate examples from the above mentioned „Engineering graphics" youtube cannal, how to make assemblies (Fig. 10).

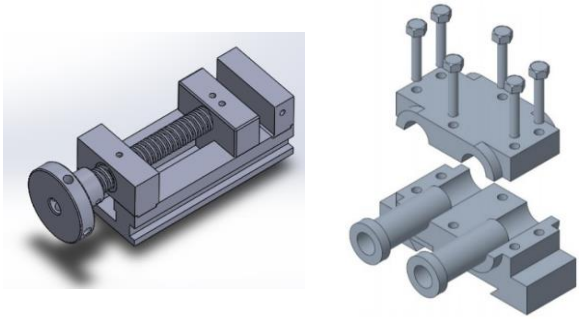

Figure 10. *Example of Assemblies adapted from [9]*

At the end of the third part of the course, students will take a last test. The test consists of two tasks. The first task is to model a suitable machine element, and the second task is to create a suitable assembly based on the given components of the assembly (Fig. 11).

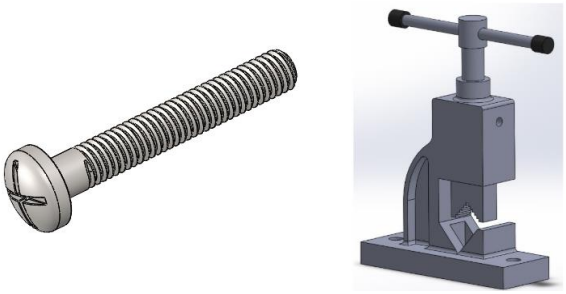

Figure 11. *Example of the third test: Task 1 – Create appropriate machine element; Task 2 – Create assembly based on the given components*

4. CONCLUSIONS

The changes are necessary in the teaching of engineering studies in the respective subjects in order to improve the results of students who need to respond to the increasing demands of the market. At the Faculty of Technical Sciences in Čačak, one of the very important subjects is the Engineering Graphics. It represents the universal language of communication of technical persons. According to conducted survey [10], which shows students' willingnes to upgrade their knowledge level, a new student-centered approach to teaching Engineering Graphics is planned.

The new approach to teaching through the flipped classroom will allow students to prepare before coming to class through video tutorials and teaching materials in text format that will cover all lectures and are made for absolute beginners with step-by-step explanations.

The future work will focus on the implementation of proposed flipped classroom. After implementation and, at the end of the course, the survey will be conducted in order to analyzed students attitude toward proposed method.

ACKNOWLEDGEMENT

This study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, and these results are parts of the Grant No. 451-03-66/ 2024-03/200132 with University of Kragujevac – Faculty of Technical Sciences Čačak.

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