

## THE INCLUSION OF THE STUDY OF 3-DIMENSIONAL MODELING IN THE COURSE OF ENGINEERING GRAPHICS AT TUM

**Abstract:** 3D models are becoming increasingly important as design documents. The ability to create them becomes a necessary skill for the future specialist. In this context, we proposed to develop a methodology for learning the basics of 3D modelling without substantially changing the Engineering Graphics Curriculum.

**Key words:** 3D models, methodology for learning

### 1. CASE DESCRIPTION

Modern businesses cannot imagine themselves without 3D digital models. 3D digital models have become an important type of design documentation, used directly in production.

Moreover, traditional plan drawings can easily be created on the basis of a 3D model. The type of design documents and the technologies for creating them are changing radically. The modern world is on the verge of the emergence of digital enterprises based on artificial intelligence, robots, additive manufacturing technologies, etc. The core of these enterprises is the 3D model.

Fundamental changes have also taken place in standardization. Standards have emerged or been updated, focusing on the three-dimensional format of design documents.

Technologies for creating and types of design documents have changed, which means that the system for training specialists in a modern university must also change [1], [2].

Currently the Engineering Graphics curriculum in bachelor education institutions provides the study of the rules of creating technical documentation with or without the use of graphical software.

The introduction of the study of spatial modelling would raise the level of future specialists, as well as presenting a support to the understanding of technical drawings [3], [4], [5].

### 2. APPLICATION FIELD

At the Faculty of Computers, Informatics and Microelectronics of the Technical University of Moldova, Engineering Graphics is studied as a fundamental subject. In this discipline, future engineers study the general rules of perfecting technical graphic documentation.

According to the Curriculum it is necessary to execute all graphic works on the computer with the help of AutoCAD software. During 45 hours (3 credits) it is necessary to acquaint students with the rules and standards of technical documentation perfection, to develop the spatial imagination necessary for the execution of individual tasks, as well as to create working skills in AutoCAD.

Given the interest in spatial modelling from both students and the teacher's part, we decided to respond to the challenge by introducing students to the methods of creating 3D models in AutoCAD, without increasing the number of academic hours and without reducing the amount of theoretical material provided by the Curriculum. The solution we came up with is to supplement the lecture with a limited number of modelling commands, which allow us to create the spatial model of the graphical task proposed in the respective practical work

### 3. THE METHODS IN USE

We propose to study the rules of creating technical documentation by making drawings using AutoCAD. In this context, AutoCAD commands are studied in a step-by-step manner, only in that volume, which allows the creation of a drawing on the subject.

Parallel to the 2D drawing commands, a minimum number of 3D commands are studied in each lesson. These commands make it possible to create a 3D model of any given exercise that previously was done only in 2D. The tasks have been designed in such a way as to allow the use of a common algorithm for obtaining the 3D model for all the variants in the topic studied.

We propose to make spatial models from a plan drawing. The 3D model created leads to the formation of the link between the planar drawing and the real object, as well as the adjustment of the initial drawing.

We use the tab called **3D Tools** which is added to the Ribbon. Thus, it is not necessary to switch to the modelling space. This way we can use 2D and 3D controls in the same space.

We have developed a methodical material that contains the guidelines for the graphic work. The theoretical material is supplemented with variants of individual tasks [6]. The individual tasks have been adapted to the methods of acquiring spatial models in the topic. For example: for the theme "Views" the surfaces are projective (Figure 1).

For the theme "Offset Sections" the surfaces are prismatic, cylindrical or conical (Figure 2).

For each task an example is given, as well as a link to YouTube, where the execution of the 2D and 3D works are shown (Figure 3).

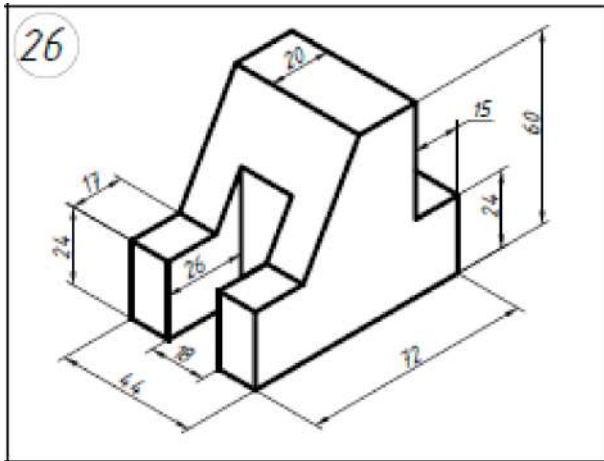


Figure 1 Individual tasks for the theme "Views".

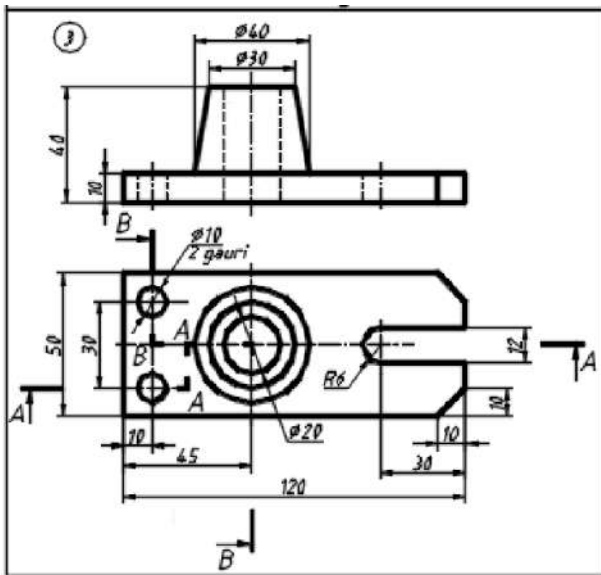


Figure 2 Individual tasks the theme "Offset Sections".

We have divided the tasks as follows:

**Topic 1.** To begin with, the AutoCAD interface, data entry, selection methods and text writing methods are studied.

A concrete and detailed guide is used to determine the text styles and layers required. Only the commands for drawing lines and rectangles (commands **Line** and **Rectangle**) are sufficient for drawing the Indicator. Accuracy is achieved by entering absolute Cartesian coordinates and using **SNAP** and **GRID** modes. The pointer is written with the **Text** command.

These elements are part of the prototype design, which will later be used to place all designs.

**Topic 2.** For simple "Gasket" pieces, consisting of polygons, ellipses and circles, students need to know the commands for drawing primitives, use **OSNAP** and **ORTHO** modes. In order to scale up this piece the dimensioning style will be established, and the dimensioning commands will be studied.

Only grips that allow the axes to be shortened or lengthened will be used while drawing.

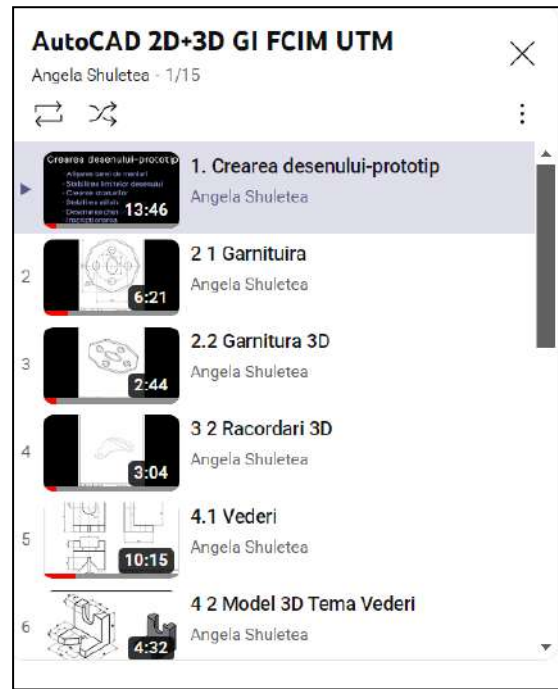


Figure 3 YouTube videos, with the execution of the 2D and 3D works.

The **Presspull** command is used to create the 3D model (Figure 4). For visualization we use the **View Controls** at the top left of the screen.

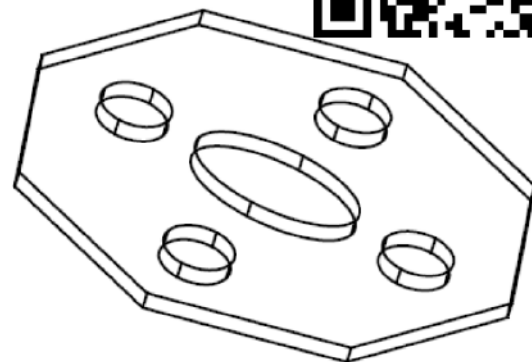


Figure 4 3D model of gasket.

**Topic 3.** In this topic we study the **Fillet** editing commands and the command for executing connections with Circle (**TTR**). For constructing parallel lines, we use the **Offset** command, and for lines tangent to arcs - the **OSNAP Tan** mode.

While creating the 3D model for the gasket we use the **Extrude** command. The contour is transformed into a region with the **Region** command and the holes are

formed with the **Subtract** command in order to apply the **Extrude** command.

**Topic 4.** The task of this assignment is to make 3 orthographic projections of a piece represented as a three-dimensional view. We will study the **x-Line** command for providing the projective connection.

The 3D model is acquired by rotating the front and side views of the part with respect to the **Ox**, **Oy** and **Oz** axes, extruding, overlapping and intersecting them. For this we will study the **Gizmo** of displacement and **Rotation** and the **Intersect** command (Figure 5).

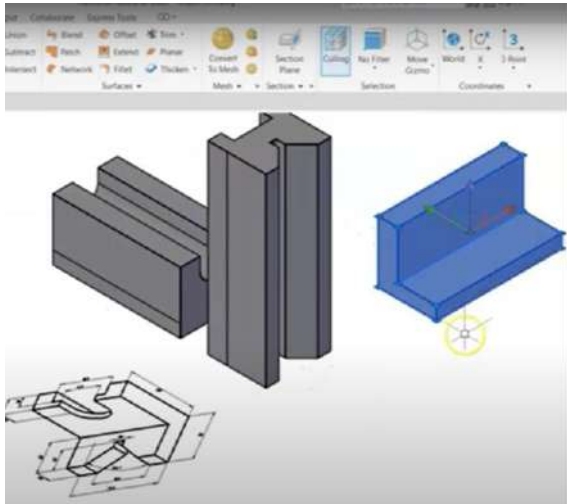


Figure 4 Execution of the 3D model for the theme "Views".

**Topic 5.** While "Section" topic is resolved, we will additionally study the **Hatch** command for the making of crosshatching and the **Polyline** command for the representation of the sectioning path.

In the process of making the 3D model of the part, we will insist on the analysis of the component surfaces. We make suggestions for modelling in the guidelines (Figure 5).

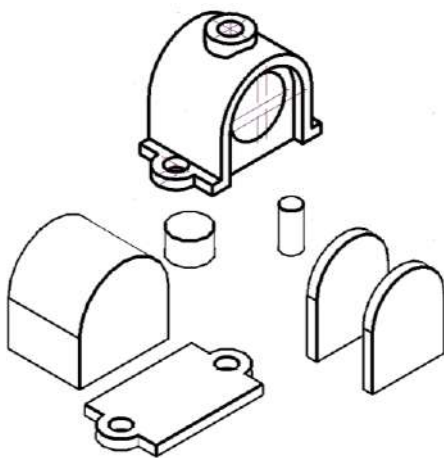


Figure 5 3D modelling suggestions for the topic "Sections"

Each individual surface is acquired by extrusion or revolution. Then, all the elements are rotated, placed in

the right place and joined together. Holes are captured by subtracting volumes. For these actions we study the **Revolve** and **Union** commands.

**Topic 6** The 3D model of the part in the "Offset Sections" topic is made from primitives. The **Box**, **Cylinder**, **Cone**, **Wedge** commands will be studied. Then the students can section the piece according to the sectioning path with the **Slice** command (Figure 6)

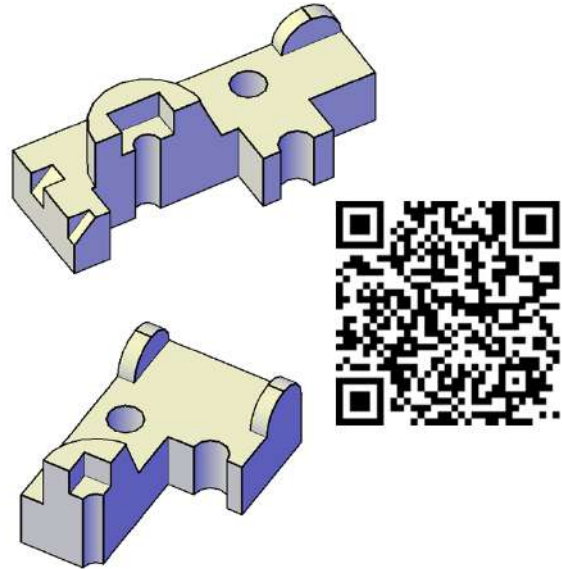


Figure 6 3D modelling suggestions for the topic " Offset Sections".

**Topic 7.** In the topic "Execution drawing" it is proposed to execute the metric thread.

For modelling we use the true dimensions of the metric thread profile. We study the profiles and dimensions of the threads during the course hours (Figure 7).

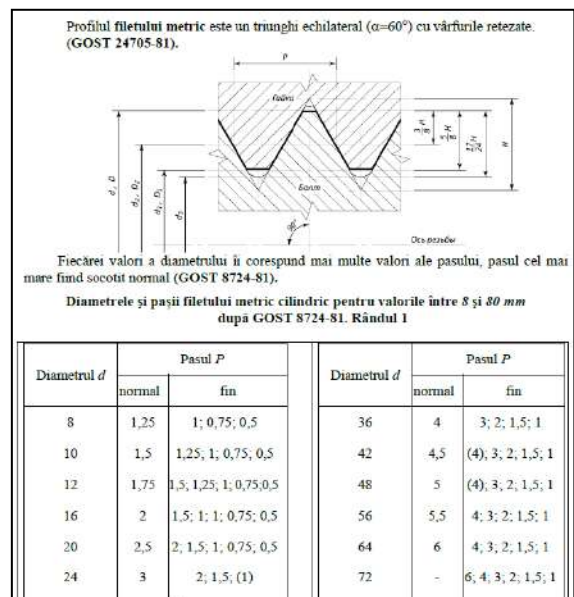


Figure 7 The profiles and dimensions of the metric threads

**Helix** and **Sweep** commands are studied for this (Figure 8).

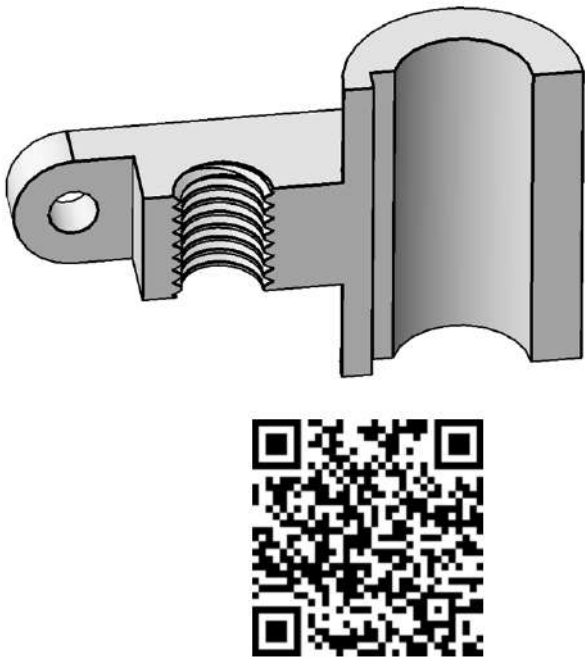


Figure 8 Part with metric thread.

### 3. RESULTS

Although the modeling tasks proposed to students are currently optional, there has been an increased interest across all the students.

### 4. CONCLUSIONS

Creating three-dimensional models requires a careful analysis of geometric surfaces that make up the piece. Since 3D models are mainly acquired based on the 2D drawing created previously, students can check the correctness of the execution of that drawing, which is often acquired using descriptive geometry algorithms. 3D modelling contributes to the students' spatial imagination and recognition.

It has been found that the presence of videos is very useful for students. The combination of visual material with written theoretical material contributes to the acquisition of working skills in AutoCAD. In addition, each student can adjust to his or her personal pace of work.

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