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TEACHING BASIC ELEMENTS IN TECHNICAL DRAWING – ORTHOGONAL PROJECTIONS

Abstract: *The paper presents applications developed using AutoCAD and 3D Studio MAX programs. These applications are constructed such as to enable, gradually, the development of the spatial abilities of the students and, at the same time, to enable the understanding of the principles for the representation of the orthogonal projections of the parts, as well as for the construction of their axonometric projections.*

Keywords: *Orthogonal projection, axonometric projection, technical drawing, 3D Studio MAX.*

1. INTRODUCTION

The paper presents different types of applications which may be gradually performed, for the understanding of the principles used for the representation of the orthogonal projections of different types of parts, as well as their appropriate axonometric projections. The main purpose of these applications is represented by the development and improvement of the spatial ability of the students and, at the same time the development of the skills needed for constructing orthogonal projections of the parts, given their axonometric projections. In teaching technical drawing, teachers use appropriate methods that would enable students understand the spatial representation of different types of parts as well as the representation of the orthogonal projections of the parts considered. In order to achieve this goal, teachers use books for technical drawing, didactical materials, posters, as well as other methods that would make courses more attractive for the students, such as computer presentations, animations. A major problem to deal with in teaching technical drawing is that this course is taught in the first year of the university studies. When starting this course, the spatial abilities of the students are usually not satisfactory; they are reduced to those gained by the students in the former schools attended or in the university, at the descriptive geometry classes. Descriptive geometry subject is taught before the technical drawing subject or in parallel with this subject.

The applications which are presented in the paper help students understand the methods which may be used for constructing and modeling different types of parts as well as their appropriate orthographic projections. They help students develop their spatial abilities such as to imagine the 3D shape of a certain part and to construct the orthogonal projections of the part, by using its appropriate axonometric projection. The applications presented help students understand and construct the minimum number of orthogonal projections needed for defining a certain part. In the applications presented in the paper, both the AutoCAD and the 3D Studio MAX programmes were used, for the drawings and for the spatial representation of the parts considered; also, the rendering and the mapping techniques developed in 3D Studio MAX programme were used for the spatial representation of the parts considered [1]. The applications designed are used for presentation (video, posters) at the classes.

The applications presented in this paper continue and complete other applications which have been developed for teaching technical drawing [2], [3], [6], [7] and they all can be easily applied in teaching technical drawing and any other subject involving graphical representations.

2. CONSTRUCTING ORTHOGONAL PROJECTIONS OF THE PARTS

The drawing of a part must contain exhaustive information in order to enable the description of the shape of the part and the writing of all the dimensions needed for completely defining the part [4], [5]. In order to study the construction of the orthogonal projections of a certain part, the part to be represented is considered to be placed inside a projection cube. By using the method of orthogonal projection, one obtains on each internal face of the cube a certain projection, obtained by facing the object from a projecting direction perpendicular to the respective face of the cube. Students are taught to arrange the projections obtained for the part, according to the projecting method used [4], [5] and also, to decide upon the minimum number of orthogonal projections needed for completely defining a part in terms of shape and dimensions, due to the fact that in standards is written that the number of projections contained in a drawing must be minimum but sufficient in order to define the shape and the dimensions of the object.

In the classical method of teaching the construction of the orthogonal projections of a part, one consideres a certain part which can be observed and analysed by the students and the teacher represents it in axonometric projection; then, all six orthogonal projections, corresponding to the faces of the projection cube, are constructed. Students realize the symmetry of the views obtained on the parallel planes of the cube and the fact that three projections are not needed for defining the part. The three orthogonal projections left – front/main view, top view, left-hand view are considered by most of the students to define the part. The three projections called front view, top view and left-hand view are corresponding to the projections of the part on the three planes of projection considered in descriptive geometry – vertical, horizontal and profile planes of projection, [V], [H] and [L]. At this point they need to realize that the three orthogonal projections considered might not be all necessary for defining a certain part and that one could need less than three orthogonal projections to define a certain part, these things being used later on when drawing different types of parts. As applications, in the classical method, students are invited to draw six orthogonal projections for certain parts available in the technical drawing laboratories and then to draw three orthogonal projections for parts drawn in axonometric projections. It is assumed the fact that students have the necessary knowledge from the descriptive geometry course.

In the proposed/presenting teaching method, besides the appropriate explanations, students are reminded basic elements regarding the orthogonal projections of common planar shapes, through applications which bring descriptive geometry very close to technical drawing, and then, they are conducted gradually through applications designed to improve their spatial abilities towards the identification and modelling of the spatial shapes of parts and the minimum number of orthogonal projections needed for defining a part.

The applications presented in the paper are oriented on prismatic parts. As a first application, one considers a rectangle drawn on a format, as a main view. In case the main view is represented by a rectangle, this might be the orthogonal projection on plane [V] for a rectangle which is placed in one of the following positions:

- parallel to plane [V], being contained by a vertical plane (Figure 1). The vertical projection represents the true size of the rectangle, while the other two projections, on planes [H] and [L] are totally deformed (line segments);

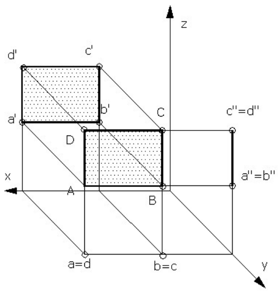


Fig. 1 Projections of a rectangle parallel to plane [V].

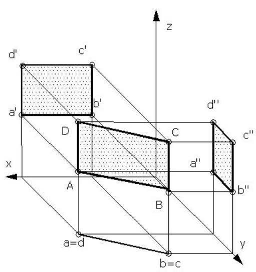


Fig. 2 Projections of a rectangle perpendicular to plane [H].

- perpendicular to plane [H], being contained in a horizontal projecting plane (Figure 2). The vertical and profile projections are partially deformed, they preserve the shape of the surface, while the horizontal projection is totally deformed (line segment);

- perpendicular to plane [L], being contained in a profile projecting plane (Figure 3). The vertical and horizontal projections are partially deformed, they preserve the shape of the surface, while the profile projection is totally deformed (line segment).

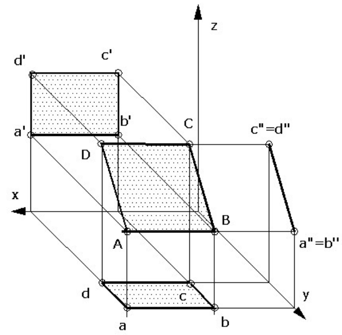
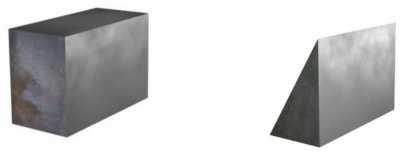


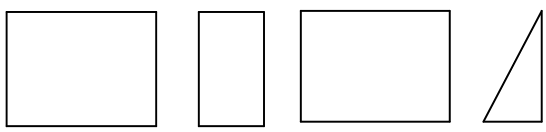
Fig. 3 Projections of a rectangle perpendicular to plane [L].

The rectangle as a main view does not reveal much of the 3D shape of the part, it indicates mainly a prismatic part, without defining completely the part; in order to define completely the part, another projection, besides the main view, is needed. As an example, students are offered two examples of parts, Figure 4, a, b, for which the main view is represented by the same rectangle. The solids are mapped with different patterns, the faces which define the main view for each solid being indicated by the same material. The orthogonal projections of these parts are presented in Figure 5, a, b. By using these examples, they are invited to imagine and construct/draw the 3D shape for other parts whose main views are rectangles, some of them being presented in Figure 6; then, students need to construct the two projections needed for completely defining the part, according to the examples in Figure 5.



a b

Fig. 4 Parts having the same main view – a rectangle.



a b

Fig. 5 Orthogonal projections for the parts in Figure 4.

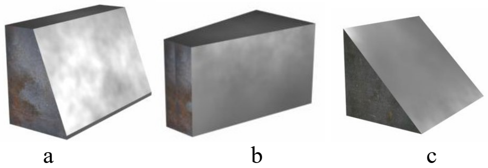


Fig. 6 Parts having the same main view – a rectangle.

In order to develop their spatial ability, students need to solve other exercises which involve the construction of the 3D shape of a part, and the number of appropriate orthogonal projections needed for defining it. In Figure 7, a, b, other two examples of main views for parts are presented. Figure 8, a to f, presents a few possible cases of parts whose main view is the one presented in Figure 7, a. and in Figure 9, a to d, some parts having as main view the one presented in Figure 7, b.

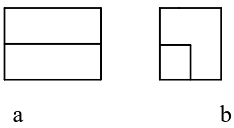


Fig. 7 Main view of a part.

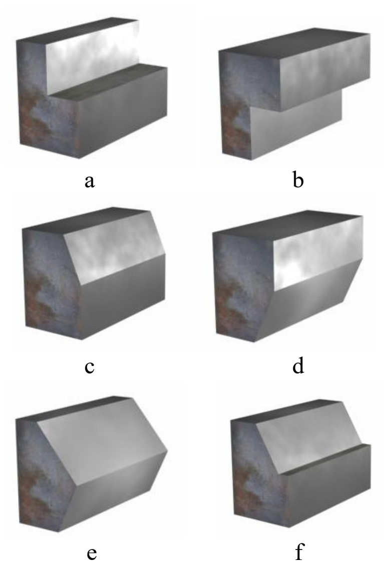


Fig. 8 Parts having the same main view (Figure 7, a).

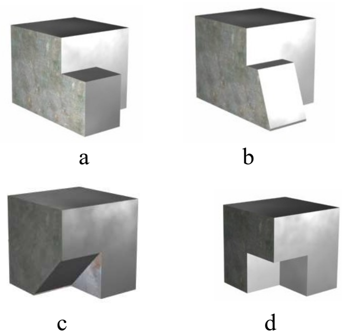


Fig. 9 Parts having the same main view (Figure 7, b).

By using the examples provided, students come across to the fact that a certain part can be modelled by combining two or more simple solids (prisms, pyramids, a.s.o.), by adding or by subtracting them. Also, they gain the competences to solve similar problems, to imagine and to sketch parts in 3D projection and to construct the appropriate number of orthogonal projections for the complete definition of the parts. When constructing the projections of a part, the part to be represented is placed such as most surfaces are parallel to the planes of projection. In this way, one obtains on the planes of projection the true sizes for the respective surfaces. In the case in which the part contains surfaces located in planes perpendicular to the planes of projection, two projections of the surface are partially deformed, while the third projection is totally deformed (line segment). In the next types of applications students are invited to model different plane shapes contained by planes which are perpendicular to the planes of projection. Figure 10 presents the case of a plane shape contained in a profile projecting plane, where the horizontal and vertical projections are partially deformed and the profile projection is totally deformed.

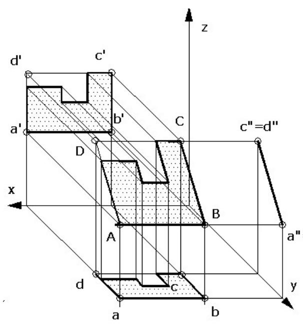


Fig. 10 Orthogonal projections of a surface perpendicular to the profile plane of projection.

Starting from the modelled surface from Figure 10, students are invited to construct an object containing that surface. In constructing the axonometric projection of the object, they are to use the method of extrusion, which is explained in the presentation as being another method used for modelling a part. One has to consider a closed outline, as in Figure 11, a, outline which is extruded along a certain direction, on a specified length, as in Figure 11, b. Figure 11, c presents the axonometric projection of the object. Figure 12 present the three orthogonal projections – main view, left-hand view and top view for the part in Figure 11, c.

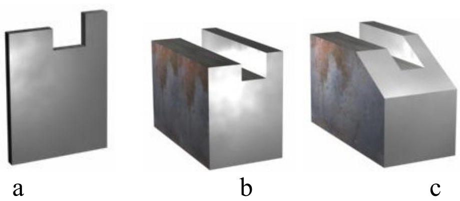


Fig. 11 Graphical modelling of a part.

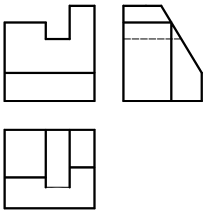


Fig. 12 Three orthogonal projections for the part in Figure 11, c.

Figure 13 presents the case of a plane shape contained in a vertical projecting plane, where the horizontal and profile projections are partially deformed and the vertical projection is totally deformed.

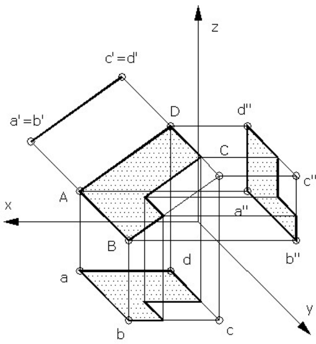
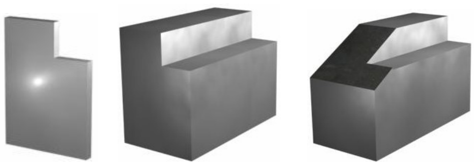


Fig. 13 Orthogonal projections of a surface perpendicular to the vertical plane of projection.



a b c

Fig. 14 Graphical modelling of a part.

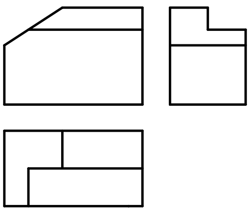


Fig. 15 Three orthogonal projections for the part in Figure 14, c.

Starting from the modelled surface from Figure 13, students are to construct an object containing that surface, using the method of extrusion. They can consider a closed outline (Figure 14, a), extruded along a certain direction, as in Figure 14, b. Figure 14, c presents the axonometric projection of the object. Figure 15 presents the three orthogonal projections – main view, left-hand view and top view for the part in Figure 14, c.

With the applications presented above, students develop more rapidly the necessary skills for making the connection between the spatial shape of a part and its appropriate number of orthogonal projections and they gain experience towards the modelling of the parts.

3. CONCLUSIONS

The paper presents applications which are designed such as to develop, gradually, the spatial skills of the students, by helping them understand the principles for the representation of the minimum number of orthogonal projections needed for completely defining different types of parts, by using their spatial representation and to create the premises for the construction of their appropriate axonometric projections. The facilities of 3D Studio MAX program, the mapping techniques and the rendering, increase the realism of the 3D shapes of the objects, thus helping students to identifiy properly the shape of the part to be represented.

The applications developed in the paper can be applied in teaching technical drawing, being a helpful tool in learning and education in engineering.

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