DIDACTIC MATERIALS SUPPORTING CAD/CAE SYSTEM TEACHING

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Abstract

The paper is focused on issues of alternative teaching practices of CAD/CAE systems. From the authors’ point of view, traditional way of teaching these systems has been no longer adequate to the requirements of practice on the competency profile of secondary technical school graduates. Through teaching the subject Technical Graphics (taught in secondary vocational schools within the study branch Electrical Engineering and Technical Lyceum), the authors analyse strengths and weaknesses of the alternative methods proposed by them. This they do in comparison with the traditional method of teaching, which is focused on creating technical drawings in 2D form, what does not develop students’ creativity. At the alternative way of teaching, emphasis is placed on 3D modelling, which also leads to a technical drawing, but beside that there is created also a 3D component. The paper presents methodological aspects of the proposed alternative way of CAD/CAE system teaching and description of teaching materials, which are currently under development and which should support this way of CAD/CAE system teaching.

Keywords: Alternative teaching forms/methods, CAD/CAM systems, innovative didactic strategies, labour market needs, supporting teaching sources.

1 INTRODUCTION

In the period of rapid technological advancement and formation of the fourth industrial revolution, the role of educational institutions is to respond to these phenomena, both by creating adequate curricula design and by ensuring necessary materials and technical equipment needed for learner professional training [1]. Unfortunately, in Slovakia the founders of schools do not respond adequately to this trend and therefore teachers must often take over the task to implement innovative elements reflecting social development and needs of practice into the learning and teaching processes themselves.

On the other hand, a main pioneer in innovation and technical novelties is industry. Industry is a dominant creator of each country image and has an impact on the future of students, who are its potential employees. Teachers have many surveys available offered by reputable agencies that reflect current enterprises’ needs [3]. Based on the results of these surveys, teachers can tailor their educational curricula to the subjects they teach. In this context, secondary vocational schools – which prepare students for their future profession - have an outstanding role in forming students’ technical thinking. Slovakia, in terms of the structure of its economy, is one of the significant car and car components manufacturers. Therefore, preparation of qualified labourers for automotive industry is currently one of the priority tasks of secondary vocational schools in Slovakia [2]. One of the means which are broadly utilized in the engineering industry, including the automotive industry, are CAD/CAE systems. They are used in every production phase (from machine part design, through production planning, assembly to storage and transportation) as they enable performance of different engineering activities (drawing, constructing, dimensioning, projecting etc.) [4]. In our point of view a problem is that the traditional teaching method already is not adequate to the current practice requirements for the competency profile of a secondary vocational school graduates.

The issue of CAD/CAE systems is taught within the subject Technical Graphics at secondary technical schools. This subject is taught in the study branches Electrical Engineering and Technical Lyceum in the first and second years. In our proposed alternative way of teaching CAD/CAE systems, as opposed to the traditional teaching method, the emphasis is on 3D modelling. The result is also a technical drawing, but also a 3D part.

In the first year, the aim of the subject is to acquaint students with the issue of technical graphics and its use in practice. Students learn the basics of making technical drawings. First of all, it is about the use and the size of the drawings. The next step is the lines, their types, their sizes and ways of how they are used. This is followed by a technical font. The first year is mainly being focused on the practical aspects. Students make technical drawings that include line types, technical fonts, and
gradually technical parts. These already contain dimensions, axes, and description fields. A teacher follows the curriculum, which includes the technical drawings that the students submit. The main tools for students to create the first technical drawings are pencil, ruler and paper. Students use the pencil to transfer the first lines to the paper and then create technical drawings according to the specified pattern. We do not consider it necessary to change the teaching strategy used in this year.

In the second year, the subject Technical Graphics continues. Students transfer the knowledge they acquired in their first year of study to the computer. The tools of their design activities are no longer pencil, ruler and paper, but keyboard, mouse and monitor. The traditional teaching method starts with AutoCAD, in which students acquire the ability to create technical drawings. Two thirds of the school year students are using this program. In the last third of the school year they switch to Inventor. Inventor is focused on 3D modelling, resulting in a technical drawing, but also to a 3D part. It is up to the teacher what methods s/he will use to familiarize students with the work with these software environments. There exist various exercises prepared either in pdf or video form for AutoCAD. In some schools, teachers also have their own publications, created by them, which they have been teaching according to. A problem is, that these teaching materials, and the procedures described in them, no longer meet the requirements of industrial practice and are uninteresting for students. They lose their creativity, and students become "robots" who merely imitate the technical drawings already created. This problem is associated also with the fact that AutoCAD is still the most widely used in industrial practice, but no longer offers the same level of capabilities as before. Inventor is increasingly used in industrial practice, offering designers a better view of the resulting component. Thus, e.g. when designing a mudguard for a car, designers, thanks to the 3D model can better present their ideas and thoughts. This program provides better visuals of the resulting model and then better possibilities for their corrections.

The presented problems were the reason why we decided to propose an alternative way of teaching the subject Technical Graphics in the second year of secondary schools. Nowadays this method is already applied in practice and didactic materials supporting this new alternative way of CAD/CAE system teaching are under development.

2 METHODOLOGICAL ASPECTS OF THE PROPOSED ALTERNATIVE WAY OF CAD/CAE SYSTEM TEACHING

As shown above, the traditional process of teaching technical drawings is aimed at creating 2D drawings which do not utilize creativity of their creators (students), currently highly appreciated in practice. One possibility, as to how the requirements of technical practice could be reflected in secondary vocational schools, is to increase time allocation for CAD/CAE system teaching. This would result in a need to decide from which area the relevant number of lessons would be reallocated to increase the number of lessons required for CAD/CAE system teaching, and to modify relevant school documentation.

The new, unconventional method of CAD/CAE system teaching keeps the total number of the CAD/CAE system teaching lessons, but it is based on the inverted ratio of the lessons allocated to technical drawing and CAD/CAE system teaching, in particular the ratio has been inverted from 2 : 1 to 1 : 2. The time allocated to teaching the creation of technical documentation was significantly reduced by half, and the time allocation for CAD/CAE systems was doubled. In this method, students start immediately with machine element draughts and modelling and in the next stage they create the necessary technical documentation to the proposed and modelled element. The standard teaching process has devoted two thirds of the allocated time to technical drawing (theory, drawing on paper, or drawing on a PC in a CAD system) and only one its third to the topic of CAD/CAE systems.
3 METHODOLOGICAL ASPECTS OF THE CREATED DIDACTIC MATERIALS

Two main didactic materials, which have been under development to support implementation of the new alternative way of CAD/CAE system teaching into practice, are two publications having the textbook character.

The first publication will contain texts focusing on the gradual understanding of the principle of working with Inventor. Modelling standards given in each country will be described here, as it is important to know the matches and differences between them. Another important feature of Inventor is its environment or 3D space, which is made up of three axes. It is one of its greatest advantages over the CAD program, which works only in 2D space, i.e. with two axes. The 3D space is related to the term "parametric modelling", which will also be explained in this publication. Considerable space will be devoted to dimensions and dimensioning and their importance in 3D modelling. The conclusion of the first part of the publication will be devoted to technical drawings as a result of modelling. The second part of the publication will at first describe the basic and then more advanced tools of the Inventor product. The conclusion of the second part of the publication will include assemblies, explanations of their principles and clarification of their importance in industrial practice. Assemblies are made up of two or more components, such as gears and chain. The entire publication will end with "tips and tricks" that can be applied to the work with Inventor and make it easier to work in this environment.

The second publication will focus on practical exercises. The assignments will be ranked according to difficulty, while adhering to the order of the Inventor tool explanations from the first publication. For example, when explaining the extrude tool, a practical task will also be mentioned, focusing on the use of this tool. The publication will include an initial tutorial on the program, its installation, a library description, and occupational safety rules at the beginning. The first tasks will be devoted to basic tools, work in 2D and 3D space. They will be followed by more demanding assignments and at the end, the assignments will be focused on assemblies, which belong to the complex tasks. The result of each task will be a technical drawing and a modelled 3D part. The assignments will be primarily focused on technical components, but tasks focused on commonly used objects will be included there, too. The publication must, as a priority, fulfil the educational function. But it must not forget its attractiveness. Therefore, task assignments will not only consist of technical drawings. One part of the tasks will be specified by 3D models with exact dimensions. Assignments of the next part of the tasks will be presented by physically given parts, which the students will be able to "feel up" and measure their size using a ruler and calipers. And, of course, tasks with classical input will be also included, i.e. assignments specified by using the given technical drawings and their dimensions.

Both publications will be created in a similar way and will follow up on each other. The first publication will primarily focus on acquiring new knowledge (familiarizing with the theoretical foundations of the subject matter) and the second one will focus on practical activities (developing practical skills in the relevant software environment). Tasks will be prepared for two thirds of the school year in the span of 45 lessons. Primary is the subject Technical Graphics at secondary vocational schools being taught once a week for two lessons. Since the total lesson subsidy is 66 lessons, the remaining 21 lessons creates room for students to learn about AutoCAD software. The assignments will be designed for this
software environment so that we can teach students the basic tools of this environment within the
given time grant and its importance for the creation of technical documentation.

4 EXAMPLES OF THE PREPARED OUTPUTS

Tasks in the second publication will be ordered according to their difficulty. The program tools will be
taken into account in the ordering. An example is the task focused on the Circular tool. The modelled
part of this task is the Fidget Spinner, which has now become known among students. The key point
in this task is that it contains three equal parts (arms). Students have dimensions available at the
beginning of the task, which are redrawn in 2D space (Figure 2).

![Figure 2: Part dimensions.](image)

The component shown comprises of three identical arms. The Circular tool has the ability to calculate
arms, parts of a component based on its centre and size. Thus, the students use this tool and the
program itself completes the other two arms. It is important to determine the number of arms of the
part and the angle at which the arms program is supposed to illustrate (Figure 3).

![Figure 3: Creating parts arm.](image)

When the 2D sketch is complete, the task continues into 3D space. The task of students is to model
the rest of the component based on the visual aid. The first step is the Extrude tool, which lets you pull
the part into space. Consequently, it is important to bevel the edges of the part. Another task is to
model the centre bracket and the bearings that are located in the component arms. The final step is to
determine the material and colour of the part. This step is a voluntary step, based on student creativity (Figure 4).

Another example is using the Revolve tool. A good example is the creation of a brake disc, used in the automotive industry. This tool is space-based, where it is enough for students to create a cross-section and the program calculates the resulting model based on the input information. Students have the dimensions of the cross-section of the brake disc, the size of the cooling groove and the auxiliary line that is the axis of this component available (Figure 5).

After sketching, we will use the tool Revolve, in which we have to mark the part with which we are going to work and the auxiliary line around which the tool renders the brake disc. We enter the 360 degrees value. Thanks to the input information, which is the size of the section, the rotation style specified in degrees and the auxiliary line that is the axis of this part, the program itself can model this part. The big advantage of the program is its associativity, which means that in any step of the design we can change the entered values and the program will change them in the final model itself. In this task it is possible to show this feature practically on the cooling groove. Students return to the 2D sketch, change the groove width dimension, and then just return to 3D space. The result will be that the program, thanks to the associativity itself, will also change the width of this slot in a 3D model (Figure 6).
As a result, a brake disc is created. The task for students will be to complete it and adjust its characteristics. The minimum requirement is to create 4-5 holes for the wheel attachment. Students can use the Circular tool. The brake disc gets the property of steel. An optional requirement is the creation of cooling holes and auxiliary holes for holding the disc. The resulting brake disc is presented in Figure 7.

5 CONCLUSION

A key question related to proposed alternative way of CAD/CAE system teaching is whether the reduction of technical drawing teaching will have a negative impact on the students' attainment. This will be tested together with the application of the supportive teaching materials. Within the verification of the proposed method and the didactic materials created by it, the results of classical and alternative forms of teaching will be compared. This means that we will compare the learning achievements of two groups of students, those taught by the traditional way and those taught by the alternative way.

The level of theoretical knowledge acquired will be tested through a didactic test. Both groups will be given a test that will include questions on basic knowledge which is also important for industrial practice.

The level of acquired practical skills will be tested through three tasks.

The first task will be focused on testing of the acquired skills for working with Inventor, specifically the abilities to create 3D parts. Students will receive a technical drawing and their task will be to create the
corresponding part in 3D space and then export its technical drawing. The rate and manner of execution will be assessed, taking into account the level of assistance from the teacher.

The second task will be focused on creating a technical drawing. Thus, the ability of students to create 2D parts and technical drawings will be tested. Students will be provided with a part, its sizes and dimensions. Their task will be to create a technical drawing of this part in AutoCAD. The evaluation criteria will be the same as in the previous task.

The third task will build on the previous two tasks. The task of the students will be to model a plastics component on the basis of a technical drawing. The level of imitation of the technical component and its visual aspect will be assessed.

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