Interactive learning medium in contemporary engineering education accented for practical training of highly skilled personnel

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Abstract. The contemporary generation of students reluctantly uses traditional teaching tools such as textbooks, which makes it necessary to create interactive training materials using modern technologies. This article presents the experience of creation of interactive educational materials for graphical engineering disciplines, which is aimed for students of colleges and vocational schools. In the material developing, the didactic experience of technical universities teachers from five countries has been summarized. Elaborators of this course have got joint goals of improvement of quality of education and solving similar problems of fast and efficient presentation of educational material acceptable to the modern generation of students.

1. Introduction
In the modern world, the development of information technologies happens every day. Technological developments, which occupy an important place in people's lives, lead to changes in all spheres of our life, including education [1, 2, 3]. The rapid development of technology not only makes life easier for people but also increases the interaction with computers and the Internet. The era in which we live is a period of time, which is called the digital era when computers and the Internet occupy a central place.

Computer-aided technologies such as CAD, CAM, CAE, etc. as well as Building Information Modelling are widely used in engineering. The full use of the potential of these systems is possible only when the “language of engineers” is understood - engineering graphics. Currently, users have a huge lack of knowledge in the field of engineering graphics. There is a lot of different information on the Internet, but most of the teaching materials use the third-angle projection method to create drawings, it lacks an integrated approach and it does not consider various styles of student learning.

Data analysis showed that most intending students of vocational schools, colleges and universities do not even have basic knowledge of technical graphics. Teachers of vocational schools, teachers of colleges and universities have a difficult task in a very short period to help students master the graphical subject, develop spatial skills, without which it is impossible productive creative activity. From the trend of reducing the number of contact hours in the class, students spend more time to study the subject independently. Because of a deficiency of basic theoretical knowledge in geometry the first-year students experience difficulties in independently studying theoretical material of engineering graphics [4]. Analysis of Internet resources, articles, and conference reports suggests that there are not enough
educational materials prepared according to ISO standards that can help students learn graphical subjects, motivate and promote students interest in the study and support their learning [5, 6].

The article describes the pre-results of the project “Development of Interactive and Animated Drawing Teaching Tools” DIAD-tools. The aim of the project is to create teaching tools which would facilitate students of vocational schools, colleges and universities to master engineering graphical subjects teaching materials better and increase self-motivation to study [7,8]. Working with this interactive teaching material will help students to memorize necessary information and apply it practically.

2. Project description
In the project DIAD-tools participating members of eight organizations from five countries - Latvia, Lithuania, Poland, Slovakia and Estonia. The duration of this project is thirty months, the beginning of the project is October 2017. Target groups of the project are students of vocational schools, vocational teachers, students of higher schools and colleges, lecturers of higher schools and colleges and scientists and specialists in the field of Technical Graphics, Descriptive Geometry, Engineering Computer Graphics, Civil Engineering, Mechanical Engineering.

The DIAD-tools project partners were selected according to their work experience, competencies, skills that are necessary for the activities of the project. The following partners are participating in the project: Public Institution Vilnius Builders Training Centre - the applicant of the project, coordinator; the Slovak University of Technology in Bratislava - responsible for creation of training materials; Ida-Virumaa Vocational Education Centre is responsible for dissemination and valorisation activities; Aleksandras Stulginskis University - responsible for performance of methodological materials analysis and creation of training materials, the Lithuanian Society of Engineering Graphics and Geometry - monitoring the progress, quality and achievement of project activities; Riga Technical University - responsible for creation of training materials; Panevėžys University of Applied Sciences is responsible for preparation of testing methodology of project training materials, processing of testing results and creation of recommendations for improvement of the training materials; Silesian University of Technology - responsible for creation of training materials.

The objective of the project - creation of interactive and animated drawing teaching tools to help students the understanding the topics of engineering graphical subjects and motivates them to learn. The project gives the possibility for the partners to share their experiences and structure the conventional drawing symbols and drawing elements according to ISO international standard. Specialists of universities from four European Union countries (Lithuania, Latvia, Poland and Slovakia) are working on the creation of training materials [9]. Considering the need of project partners to improve technical and didactical competences of drawing there will be prepared the four chapters of interactive teaching tools:

1. Execution of drawings. Geometric drawing.
2. Basics of projection drawing. Images. Sections. Cuts.
3. Joints of parts. Working drawings of parts.
4. Construction drawing.

The creation of these materials takes place in several stages: 1. analyzing the content, the content description (English version); 2. the collection, structuring according to the content and creation of the materials (English version); 3. placement of prepared materials on the project website (English version); 4. translation of textual content of the training materials from English into the languages of project partners (Lithuanian, Estonian, Latvian, Polish, Slovak); 5. placing of translated teaching materials on the website of the project and preparation for the testing; 6. the testing of the prepared training material in the partner's countries; 7. processing the test results and making recommendations for improving the training materials; 8. enhancing the materials, the creation of the final version and publishing the project training materials on the project website.
3. Needs Analysis Study

On the stage of preparing the content of the training materials, the Needs Analysis Study was conducted. The survey was organized in five countries: Estonia, Latvia, Lithuania, Poland, Slovakia. The goal of this survey was to investigate the methodology of teaching the graphical subjects in countries of the project partners, the relevance of the training materials chapters, the standards used, labour market requirements to preparation level of vocational school graduates. Three questionnaires for different target groups were prepared: 1. teachers, lecturers, scientists; 2. students and 3. employers, labour market representatives. The 56 filled questionnaires from employers were received, 149 – from teachers and 349 - from students. The great part of questionnaires from employers and teachers were gotten from Lithuania, most of the student questionnaires were received from Latvia.

Comparing the first two target groups answers to questions about the difficulties arising from study certain themes of technical graphics, it can be concluded that the opinions of students and teachers are the same. Both teachers and students called the dimensioning in the shaping section the most difficult task for understanding students. Students also see difficulties in the theme of scales. Smooth connections and curves, according to teachers and students, are the topics of geometric construction that are most difficult for students. According to students and lecturers, the complicated themes in the mastering of the projection drawing are the creation of cuts and the identification of objects from an orthogonal projection drawing. For students, the creation of a section is also most often mentioned as the more difficult task of this section.

![Figure 1](image1.png)

**Figure 1.** Students and teachers answers on the question “What problems of shaping drawings seem more difficult to understanding?”

![Figure 2](image2.png)

**Figure 2.** Students and teachers answers on the question “Which geometrical construction themes seem more difficult to understanding?”

![Figure 3](image3.png)

**Figure 3.** Students and teachers answers on the question “Which projection drawing tasks seem more difficult?”

![Figure 4](image4.png)

**Figure 4.** Students and teachers answers on the question “What seem more difficult in machine drawing creation?”
Educators and students in the field of mechanical engineering drawing identified the topics of assembly drawings and specifications of assembly drawings as causing problems. In the construction drawing section, teachers and students identify drawing in cross section as the most difficult task for students.

After processing the survey results, it turned out that most of the teachers and students (78% of teachers and 63% of students) were in favour of the compulsory study of technical drawing in high schools. In accordance with the opinion of teachers, the lack of students’ knowledge and reluctance to learn are two of the main difficulties they encounter.

According to the opinion of employers, vocational and high schools’ graduates should have more practical abilities, the skill to personalize (customize) the CAD systems, understanding BIM programs and be able to use its. It is necessary for graduates also to have basic knowledge in the field of production technology, tolerance and fit, roughness, machine construction, which is necessary for correct design and reading of machine parts list. Freehand sketching is a desirable skill in the job market.

After analyzing the above-mentioned results, we can conclude that preparing the training material, more attention should be paid to scales, and dimensioning; inscribing polygons in a circle, curves and smooth connections; identifying objects from an orthographic projection drawing, cuts and sections creation; detail and assembly drawing creation, the specification of assembly drawings; drawings of elevations, plans and cross-sections.

4. Training materials
Taking into account the findings of the study, the content of each part of the interactive and animated drawing teaching tools was approved at the 2nd Partnership project meeting. The project partners made an agreement on the following content:

1. **Execution of drawings. Geometric drawing. Standards, their importance in plotting drawings**: 1.1. Scales; 1.2. Lines on engineering drawings and their application in practice; 1.3. Dimensioning; 1.4. Curves and smooth connections and their application in practice; 1.5. Dividing the circles into equal parts and drawing polygons.

2. **Basics of projection drawing. Views. Sectional Views. Sections**: 2.1. Projection methods. Orthographic representation. 2.2. Identifying objects from an orthographic projection drawing; 2.3. Cuts creation. 2.4. Sections creation. 2.5. Geometric body involutes and their application in practice.

3. **Joints of parts. Working drawings of parts**: 3.1. Threads and Threads Representation in Drawings; 3.2. Treaded fastenings; 3.3. Separable and permanent joints; 3.4. Making training assembly drawings; 3.5. Reading and Detailing of Assembly Drawing.

4. **Construction drawings**: 4.1. Architectural and construction drawings - general principles, creation of building images (elevations, plans, sections, scale marking in drawings); 4.2. Conventional
signs in building drawings, conventional markings of materials (practical assignments); 4.3. Principle of dimension on architectural drawings and application of the dimensional common modular system in building drawings (practical assignments); 4.4. Components of a construction project (practical tasks); 4.5. Examination of a construction project, reading of the drawings (practical assignments).

Researchers and teaching staff of the Computer Aided Engineering Graphics Department of RTU are responsible for the creation of the third part of training materials “Joints of parts. Working drawings of parts”. In the course of implementation of the project, five interactive materials (MP4 format) were developed. The duration of one teaching material is from 6 to 9 minutes. Within the framework of the approved content of this training material, the following issues were considered for selected topics. Threads and Threads Representation in Drawings: terms of screw threads, making threads, external thread representation, internal thread representation, threads designations, vanish threads, necks and chamfers. Threaded Fastenings: bolted joints, studed joints, screw joints, threaded fastenings drawing (simplified and conventional representation of threaded fastenings). Separable and Permanent Joints: keyed joints, splined joints, keyed joint and splined joint drawing, welded joints (basic terms of a welded joint, designation of the weld on the drawings, example of working drawing of welded joints). Assembly Drawing: steps to make an assembly drawing from component drawings, parts list, part numbers on the drawing, simplification and conventions for assembly drawings, training assembly drawing. Detailing Assembly Drawing: steps of making the detail drawing, limits, tolerances and fits, surface characteristics, parts drawings.

Figure 6. Example of the training material “Assembly Drawing”. Figure 7. Example of the training material “Assembly Drawing”.

These materials can be used as additions to classroom lectures. Educators will be able to demonstrate these training materials, complementing the topics of their curricula. They can give extra study time to students who cannot fully understand the course material through classroom activities and supporting materials such as a textbook. Students can view and learn interactive material as often as they want until they understand the material [10]. This learning resource is especially important in teaching many students when the teacher does not have the opportunity to devote time to each student. Video materials can provide the student audience with more complex study material that may be more interesting for many students [11]. Students of vocational schools will have the opportunity to independently study the material, as well as to test their knowledge performing the exercises and tasks. This material will be especially useful for students of vocational schools because not only theoretical material of the relevant topic is presented here, but also various processes, such as threading, welding, parts assembly into an industrial product.
5. Conclusions
The use of video materials has a positive effect on increase of student motivation and gives positive feedback from students.

It provides more fast transfer of primary necessary information to the students in comparison to the lecture form or independent work with educational literature.

The development of interactive training materials requires the determination of its optimal content, volume and duration of the video to achieve maximum efficiency of perception of the learning material.

Training materials are an auxiliary tool that allows lecturers to optimize their contact hours working with large groups of students and to focus on practical work that develops the skills and abilities required to train qualified professionals.

The video course allows students to master the study material in a convenient time for themselves and in a comfortable environment, creating a positive attitude to towards the subject being studied.

The possibility of repeated repetition, rewinding or forward solves the problem of individual pace of learning. These features make learning more personalized.

It should be noted that the developed educational video is not intended to replace completely the traditional forms of verbal and written presentation of the training topics of the course of graphical disciplines, but is an additional tool to improve the efficiency of the educational process.

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