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QUALITY IMPROVEMENT OF ENGINEERING EDUCATION: DESIGN OF AN APPLICATION FOR LEARNING TECHNICAL DRAWING

Abstract: *The fundamental purpose of an engineering drawing is to carry, control and maintain a product's definition in a precise and clear way with no risk of misinterpretation or assumption. To satisfy this, engineers need to develop an understanding of spatial objects in the graphic communications. Therewith the students should learn the rules of drawing, technical drawing course must enable them to properly understand the shape. Internet and available computational platforms are suitable for modernizing existing courses of technical drawing with new contents. The paper presents the authors' efforts to modernize technical drawing course by interactive content that accompany conventional teaching. The developed web based application is used in exercises to support the existing practicum. The methodology used in the preparation of exercises and its application to several examples is presented. Polls indicate that students are very satisfied with the new methods of learning available to them in this way.*

Keywords: *technical drawing, CAD/CAM/CAE, web based application, Internet, computational platforms*

1.INTRODUCTION

Engineers use technical resources or mediums to solve variety of problems [1]. The solution starts with an idea in the mind of the engineer. One of the best ways to communicate one's ideas is through some form of drawing. Technical drawings provide a means to communicate complexity in a comprehensible and effective manner thanks to visual abstraction [2, 3]. This description must show every aspect of the shape and size of each part and of the complete structure. To construct the geometric shapes, engineers have to know some principles and procedures of geometric construction. Multiview orthographic projection, the primary means of graphic communication used in engineering work, is a procedure used to completely describe an object's shape and dimensions using two or more views that are normally projected at 90˚ to each other, or at specified angles.

For most of the engineering curriculums, the technical drawing is the first course in which students begin to learn the basics of engineering [4-7]. One of the skills that students are difficult to learn in the course is the ability of finding information on the 3D features based on two-dimensional (2D) representation and vice versa.

There are many disadvantages and

difficulties that students have in mastering the physical understanding of the parts and their graphic representation [7]. Many research studies analyze different concepts, methods and practical procedures for implementation and verification of knowledge in the field of student understanding of physical objects [8-11]. Most of authors agree that the spatial understanding skills can be improved not only through experience, but also using new technologies such as simulations, animations and virtual reality [12]. Conventional teaching of technical drawing provides very little practical experience and encourages students to learn a set of rules, not to develop a deeper understanding [13].

Authors proposed several solutions in content creation and improvement of teaching, such as: dynamic curriculum, online survey and evaluation, and improvement of teaching methodology [14]. Interactive techniques in virtual reality (VR) help users to increase their understanding of objects, which leads to better communication in the professional training and education, and professional practice [15].

The major changes in science and technology, especially in the field of information and communication technologies, have created environment for the modernization of the teaching process. Most educational materials can be more effective when integrated on the Web. Web opens up significant possibilities of using different computing platforms in education of engineers [16]. The Web provides several distinct advantages over other communication media, including interactivity and user-involvement, time-independence, and worldwide access [2], [17]. Lately, Web Graphics Library (WebGL) is widely used [18]. One of the most anticipated features is native 3D graphics in browsers [19], [20]. Without installing plugins or enduring long loading times or security popups, users interact with models in 3D. On desktop platforms, WebGL support for the main browsers is nearly complete. Smartphone and Android open even more possibilities for application in the field of education [21].

Our conventional technical drawing course comprise the following practical exercises: (1) Projection of points, lines and triangles, (2) Orthogonal drawing of the model; relationship of orthogonal views, (3) Drawing the missing views, (4) Orthogonal drawing; the sections in the technical drawing, (5) Thread drawing and dimensioning; scanning and sketching of mechanical parts, (6) Drawing and dimensioning the orthogonal projection and section, (7) Example of exam, and (8) Assembly drawing.This was foundation for creating web application that supports the training process of technical drawing.

2. WEB APPLICATION DEVELOPMENT

Preparation process was carried out in parallel with the two types of models. On one side, it was prepared the model contained in the practicum [22] that already exists and follows the conventional course content. All models shown in the practicum are modeled using software CATIA and prepared for interactive display on the Internet. On the other side, the existing physical models are digitized. These models are used in an exercise for scanning - sketching the projections and taking model's dimensions.

In order to view the model over the Internet and provide their free download, the following types of models are developed: volumetric watertight model (high, medium and low resolution) and poligonized model integrated in software for manipulation and measurement of object. In the following text a minimal processing pipeline is described.

Scanning of 3D shape of educational models was performed using optical

device GOM ATOS IIe 3D Scanner (Fig. 1). Overall scanning process with the ATOS IIe system covers following phases: (a) calibration, (b) preparation and setting of device, (c) preparation and setting of measurement object, (d) measurement/ scanning, (e) processing of measured/ scanned data, and (f) post-processing (processing of results). The result is a detailed triangulated mesh, i.e. the 3D model is expressed as an assembly of polygons. The obtained models are registered into the appropriate coordinate system (Fig. 2).

Figure 1 - Digitizing of models with high-end industrial 3D scanner ATOS

Using decimation the number of triangles is reduced without derogation of consistency and topology. The former is aimed to decrease the size of the data being transmitted over the Internet. After all the post processing steps the 3D high definition models are generated. Although it was possible to decimate the model significantly, the big amount of triangles was preserved in order to save the high quality and details of the object. Nevertheless, preview model via Internet is enabled through the model with a low resolution so that the users with lower connection bandwidth can comfortably use the portal. All models have size up to 200 KB. These models are downloaded and showed in less than a second.

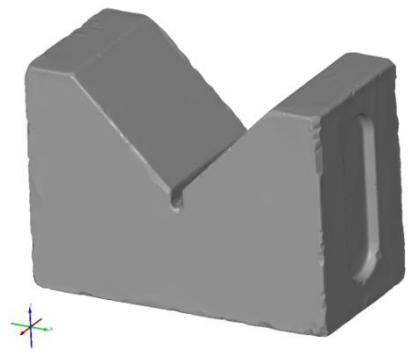

Figure 2 - Randomly selected digitized 3D model

During the development of applications, intention is to enable students to use the content while they are in a classroom, at home or when traveling. Therefore it was necessary to make content available via the media that are mostly available to students. In this sense, the interaction between users and the applications is enabled using the PC/Smartphone.

We build a website to host the content using Joomla and deliver content to the widest range of computing platforms.Interactive 3D models are rendered within any compatible web browser without additional configuration. User preview is enabled through JavaScript API for rendering called Web Graphics Library (WebGL) [18]. It uses the HTML5 canvas element and is accessed using Document Object Model interfaces. WebGL program consist of control code written in JavaScript and shader code that is executed on a user's computer [18].

3. RESULTS

The method requires the equipment cabinet for one student per computer for learning. Although not designed for it, the software can be used in the form of frontal teaching. Using the proposed technique, students improve the ability to construct and manipulate mental representations of objects in 3D space. Application contains all the models from this exercise that can be viewed in space on all sides, through the simple and intuitive interface (Fig. 3).

For exercises 3 and 4 is possible to display the model with the required sections, which are open to student inaccessible models' interior. In addition, there are clearly marked areas of a model to be hatched in the model sections. Planar section can be viewed so this rule of technical drawing cannot remain a mystery to the course students.

Models implemented in exercises 5, obtained by 3D scanning, are intended for use inATOS Viewer. ATOS Viewer is free 3D inspection and mesh processing software for dimensional analysis of 3D point clouds and viewer for ATOS and GOM Inspect Professional data sets. The software allows creating user-defined sections (sectioning) and taking measures of digitized objects (dimensioning).

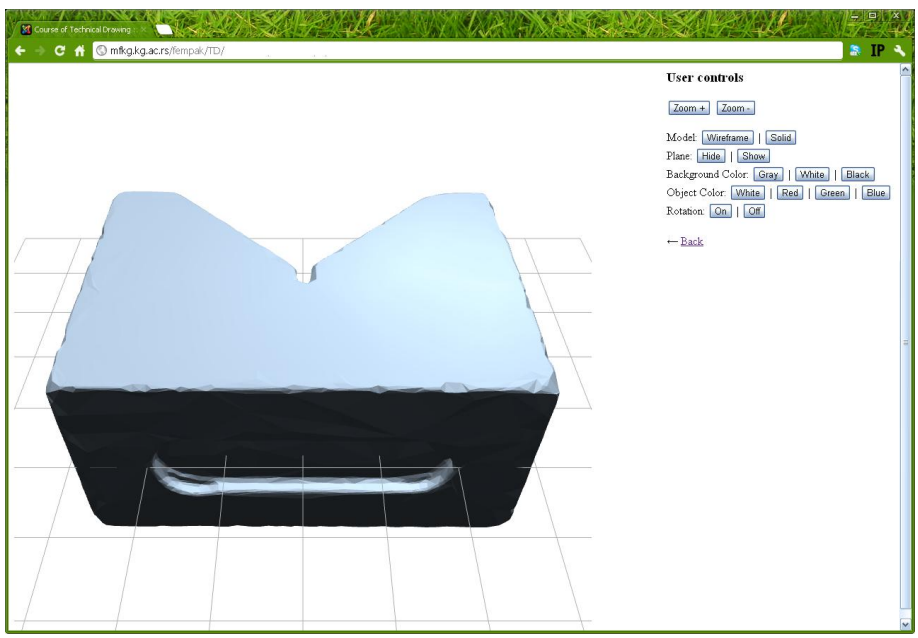

Figure 3 -Screenshot of interface with randomly selected model available in application

4. CONCLUSION

This work aims to make classes more modern, more interesting and effective. The concept is focused on active learning. Students can learn with them and practice teaching material and check their knowledge. The material can be used in various forms of teaching (frontal, group, pair work and individual) depending on the level of equipment for the office work as well as from our own conceptions of class organization and to achieve the best results.

The main teaching objective of the application is to be a support to conventional forms of teaching in the classroom. The teaching content of the software is adapted to the curriculum. With the help of modern teaching

methods, learning technical drawing is no longer boring but it is a lively and creative. In addition, it can be used in the training of distance-based e-learning technology platforms. These methods characterize efficient knowledge transfer for learning models using 3D-realtime display and animation, bringing good visibility and students' satisfaction. Presented objects become personal; they can individually be zoomed, rotated and animated. The user has the specific model virtual in his hand and can explore the model interactive and personalized. The game and control instinct brings an emotional link and an enhanced interest for the model [24]. With such learning tools, interaction with the learning materials is quite possibly the most important aspect for learning to occur efficiently and effectively.

Due to the fact that the developed models are freely available on the Internet and cheap open-source and open-hardware 3D printers are appeared, it is certain that in the near future these models will be printed and widely used for the purpose of the proper shape understanding.

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Acknowledgment: The part of this research is supported by Ministry of Education and Science, Republic of Serbia, Grants TR32036 and TR35033.