

The Visualizations Methods of Geometrical Forms in teaching of Civil Engineering Students

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Abstract. Development of spatial representation (the ability to imagine three-dimensional objects using flat pictures or drawings), skills of the intuitive decision of spatial problems and more meaningful use of CAD software are essential for qualified education of students. Visualization of geometric problems helps students to understand and to solve the given geometric tasks. The paper describes types of visualization of geometrical objects from graphic exercises of compulsory subject "Civil Engineering Graphics". This course is specified for Civil engineering undergraduate 2nd year students of Riga Technical university.

Performance of a breadboard model, creation of the given model using ArchiCAD and using augmented reality (AR) software are included in the course "Civil Engineering Graphics" assignments. The examples of the tasks of 3D modeling in learning process are presented in this article. AR application allows faster understanding of complicated spatial problems and relationships and was used to entertain the students during the studies. Before mentioned approach was enabled to develop spatial skills of students, facilitate the students to obtain more practical experience in solving graphic exercises and was supposed enhance the quality of graphic education.

Keywords: augmented Reality, Engineering Education, Spatial Skills, CAD, 3D models.

I INTRODUCTION

The modern world is changing more and more rapidly. It is the reality of our times. So, the knowledge becomes obsolete very quickly and needs correction. Learning outcomes in the conception of the ability to learn are becoming more and more popular. New social needs determine the goals of education as a cultural, personal and informative evolution, providing the education as a competence "learning to learn". Various branches of learning theory are used to improve and accelerate the learning process.

The need to intensify training explains the use of visualization in educational process. Visualization improves the efficiency of the information; it's used as the way how it is represented for students, as a teaching method and as one of the most progressive educational technologies.

The visualization means any way to provide observability of the reality, and the result of visualization means any visually perceptible image that simulates the essence of the object of knowledge. Hence, it is especially important to develop the spatial ability of the students. The development of this ability is one of the graphical subjects' aims. Spatial ability and visualization skills, as component of this ability, may be developed with help of different training tools and methodologies: graphics courses using traditional

drafting method (pencil and drawing board) [1], [2], [4], Augmented Reality (AR) based application [3], [4], 3D CAD modeling[5], [6], Web-based graphics applications and a sketchbased modelling system[7].

Following to modern psychology metavisualization is a process to monitor and regulate the internal representation of the individual [8], [9]. Psychologists say that visualization is central in the thinking process. Considering the spatial intelligence, regarding the ability to perceive the visual world and all the intelligences at basic level can be developed. Therefore, the development of skills such as the ability to visualize and abstract thinking go beyond technical subjects, but connected with the concept of education and training of the technical intelligentsia.

The psychologists of the 20th century have argued that human's impellent activity and formation of his mental faculties have a direct link [10]. Movement of the hand, the development of eye estimation in the process of human development, leads to the formation of spatial representations, creating external space that is the basis of internal cognitive activity. In this regard, we believe that it is important to have exercises are performed manually and as a basic sketch. To realize these problems we offer students perform some tasks on the theme "Roof Construction". The first step of visualization of given

task is the performance of the cardboard model of the roof slopes intersection.

Currently in RTU there is a shortage of lecture hours in the engineering curricula for the subjects related to engineering graphics. The higher rate of learning process is relevant as ever.

In this article we would show the examples of graphical exercise with 3D models and represent content of subject “Civil Engineering Graphics”. We share our experience of the use of 3D CAD software’s, such as ArchiCAD and Revit Architecture, following to BIM (Building Information Modelling) conception. Visualization of 3D models applying Augmented Reality Technologies is given. The new generation, which grown up in the modern technology environment surrounded by computers, videogames and smart phones, prefers to get necessary information quickly and feels good in augmented reality space. The use of the different types of the visualization are necessary for qualitative and faster training of graphical skills, understanding of geometric problems and to make the educational process more attractive and positive.

II COURSE CONTENT

Subject “Civil Engineering Graphics” of Computer Aided Engineering Graphics Department is a compulsory for RTU Civil engineering second-year students. Course is related to the theoretical knowledge and standards used for representation of civil engineering constructions onto the plane. Methods of projections with level marks are able produce the cut and fill design for appropriate urban project. Descriptive geometry and engineering graphics background on surfaces intersection theme is developed by determining the roof slopes intersection line. Main principles of creation of civil engineering projects using Computer Aided Drafting and Computer Aided Design aspects are given.

The course structure has four modules: “Projections with level marks”, “Roof construction”, “Civil engineering drawing” and “Geometric modelling using ArchiCAD or Revit Architecture”.

The “Civil Engineering Graphics” course duration is 32 academic hours (spring semester, 2 hours per a week). Course consists of graphical exercises and practical training (10 hours) using ArchiCAD or Revit software. The aim of this training is to acquire a basic knowledge about possibilities of given software. During this training the students perform one variant of architectural model and individual exercise “Roof construction”. The kind of evaluation of the training tasks is pass/fail. Students perform exam at the end of the course. Graphical exercises and exam are evaluated at 10 point rating system.

A. Projections with level marks

The first part of the course consists in a 4 lessons where the principles of objects creation using method of projections with level marks are presented. Students perform individual assignment where it is required to locate given building site at a topographical surface and determinate the limits both cut and fill areas with given angle of repose for cuts and fills. Students carry out this task applying traditional way of creation drawing - by pencil and drawing board.

B. Roof construction

Module “Roof construction” concerning problems nearly related to determination of the roof slopes intersection. Module consists of following parts: construction of the plan and a front elevation of roof, finding of full size of roof slopes, performance of a breadboard model of roof, construction of roof model using 3D CAD software.

Students perform the first part as a sketch using handout material prepared by staff on separate A4 format sheets. Task concerning definition of full size of slopes may be performed by computer aided drafting (AutoCAD). It provides an opportunity to increase production of drawing, realize the construction more precisely and improve skills of AutoCAD use. Essential skills of AutoCAD drawing preparation students got on course “Interactive computer graphics”.

The breadboard model is visualization of task performed manually and may be constructed from cardboard, wood or plastic (Fig. 1). For students it is a quick and effective process to independently evaluate correctness and accuracy of construction of roof slopes intersection and determination of full size of slopes. Right constructed outcome model it is not only correct determination of polygons intersection but also correct selected dip direction. Given exercise improves spatial skills of students and develops ability of intuitive solution of spatial problems.

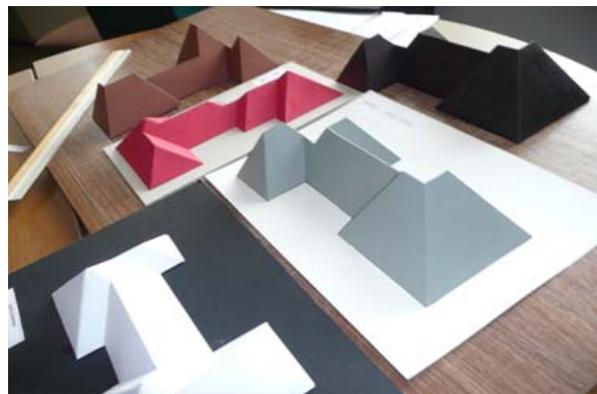


Fig. 1. Visualization of task “Roof Construction” performed in the form of cardboard model

Another kind of visualization of given task is creation of digital model of roof using ArchiCAD. Experience obtained from performance of previous exercises allows avoiding possible mistakes that might arise during construction of this model.

C. Civil engineering drawing

Third module of course provides knowledge about kinds and methods of creation of civil engineering drawings and also acquaints with ISO standards of drawing preparation. Students perform following civil engineering drawings: building plan, building section and front elevation. Students can choose method of drawing creation – traditional drafting or computer aided drafting.

Compared to drafting by pencil, CAD is faster, but computer is only a powerful tool to create correct drawings in the minimum term. Trained students who know engineering drawing very well are able to manipulate the CAD systems. After learning drawing by traditional drafting methods, one can use CAD software to develop the skill and speed for excellent performance.

It will be observed significant difference between making drawings on the computer and making it by hand and pencil. Creation drawing by traditional drafting instruments requires to imagine the various views of object while you develop the drawing. This technique develops the spatial representation of students and ability to analyze the shape and design of real objects. These skills are essential qualities for engineers and necessary requirement for successful work with 3D CAD software [11], [12].

Unfortunately we take note that in drawings performed by CAD method there are appreciable quantity of mistakes, which are linked with insufficient CAD background. Many of students perform drawings not autonomously by simple copy-pasting of drawing performed by other students.

D. Geometric modelling with BIM software

The high rate of technological and science-based innovation is requiring the implementation of new knowledge in education process. Engineering Graphics today has to consider BIM concept in Architecture and Civil Engineering [13]. BIM is a process of creating and managing building data from planning and design phase of the project, expanding throughout the building life cycle, on out to construction and cost management and facility operation. BIM software is three-dimensional, real-time and dynamic that allows increasing effectiveness and productivity [14].

Module number 4 of the subject “Civil Engineering Graphics” deals with an introductory level of BIM. Students perform small individual task using ArchiCAD or Revit Architecture BIM software. The aim of this task is to develop the ability of geometric modelling applying BIM supporting software. After

lecture the students create the 3D digital model of a building and study how to manipulate the model, types of basic construction components (doors, windows, panels, columns and stars) and their behavior. Using 3D model students have to create the basic supporting architectural documentation – plans, elevations, sections.

Visualization of 3D building model is realized by creation of axonometric projection using exterior and interior rendering. Figure 2 demonstrates example of individual task used in the introductory level of BIM concept study.

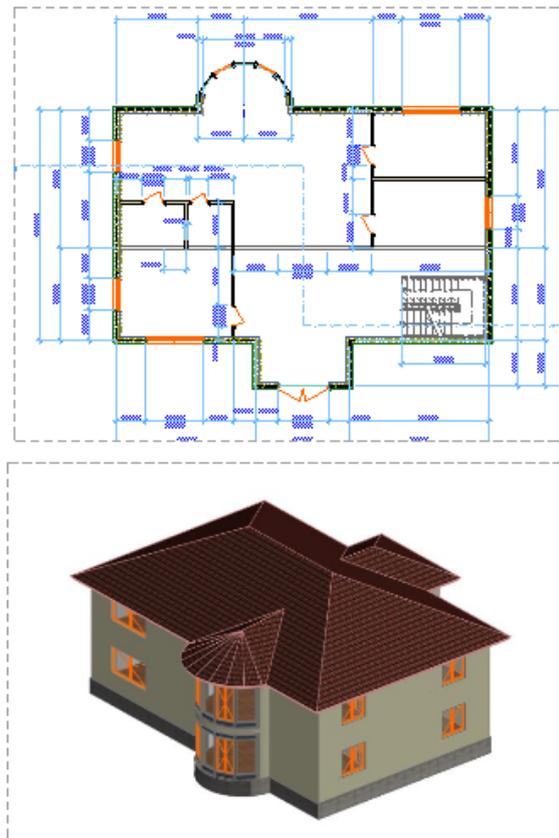


Fig. 2. Plan and visualization of two story building performed by civil engineering student for course “Civil Engineering Graphics”

BIM concept is introduced in different limited and free choice subjects of Computer Aided Engineering Graphics Department. Students can enhance skill level concerning BIM concept and continue study selecting corresponded subject. Using BIM supporting software, students perform project related to creation of their own „dream house”

E. Use of Augmented Reality application for visualization

The introduction of Augmented Reality technologies in the educational process brings new perspectives for civil engineering and architectural students. For example, by means of interaction of 3D

digital models with real environment, the all operational sequence of building construction in time and space can be simulated for better understanding of students.

AR application allows to place created 3D model of building in defined geographical location. This kind of project visualization helps to assess compatibility of building with real environment quickly and without resort to extra cost.

Advanced students visualize own building models, created with help of ArchiCAD, using AR technology. This visualization method is not obligatory for described course. For generation of AR scenes the BuildAR software is exploited. In software the marker-based method is realized, that requires associating the 3D model and physically printed marker. The virtual 3D model appears as part of the surrounding environment on computer monitor when the marker is picked up by the web camera (Fig. 3).



Fig. 3. Three-dimensional virtual model of building in Augmented Reality environment.

Students use AR application also during the studies of “Descriptive Geometry and Engineering Graphics” subject. In this case 3D models of engineering objects from the graphic assignments attached in Augmented Reality environment promote understanding of spatial problems and illustrate the relationship between the 3D geometry of object and 2D projections [4].

The students’ feedback on use of AR model in the Engineering Graphics courses of our department was very positive. The visualization of tasks using AR technologies is helpful in solving graphic exercises, makes learning process more attractive and interesting and supports learning activities.

Fast development of computer technology and creating an augmented reality browser that allows viewing computer generated elements superimposed on the live camera view of Smartphone [15]. Such AR application simplifies comprehension of complex spatial mutual relation between objects, motivates students to study Engineering Graphics subjects. Unfortunately, the nonsufficient financial resources at

the current economic situation at RTU prevent continued expansion and more extensive use of this technology in the engineering education process.

III CONCLUSIONS

- The use of different visualization methods in the educational process is a good way to get more sustainable knowledge, cognitions, and understanding in a variety of natural subjects of engineering education;
- Introduction of the modern BIM software in education process will allow to be competitive and flexible in a rapidly changing information technology environment;
- A certain number of drawings and models carried out manually is necessary for the development of spatial skills and understanding of the shape and objects geometry;
- The students apply AR technology with pleasure and great interest, consequently, such important components of cognition as motivation and wish, will be enhanced.

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