New technologies to support students in a BIM design course

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ABSTRACT: The use of computers to train future architects entails frequent adjustment of the curriculum and the application of new technologies. Changes of this type should support the work and development of the students. New software and digital data exchange require that an analysis be conducted of e-learning platforms, tutorials and materials provided to the students. Data availability and forms of access do not guarantee efficiency in the learning process, even for the latest technology. The purpose of this article was to assess the new technologies supporting students' work, based on the curriculum and laboratory classes conducted as part of the BIM Techniques in Design course carried out in the Faculty of Architecture at Cracow University of Technology (FA-CUT) in Kraków, Poland.

INTRODUCTION

The curriculum of the BIM Techniques in Design course is based on the application of new software and technologies in the preparation of building designs [1][2]. Knowledge transfer during laboratory classes is supported by additional materials on an e-learning platform. This facilitates communication and exchange of information between students and teacher. Students may use tutorials in the form of manuals or videos [3].

This model of work with the support of digital materials combines laboratory classes at the University with remote communications. Over the past few years, a number of changes have been introduced to improve the quality of learning and the creative thinking of students. In this article, the author describes how tutorials and contact with students can improve the quality of classes in computer-aided design.

CLASSES WITH THE E-LEARNING PLATFORM

The BIM (building information modelling) Techniques in Design course provides an introduction for students of the Faculty of Architecture at Cracow University of Technology (FA-CUT), Kraków, Poland, to modern technologies to create three-dimensional models of buildings. The second semester of the programme, described in this article, ends with completion of a project at BIM maturity level 1 and some elements at maturity level 2.

From 2013 to 2015, students were given simple tasks, which consisted of designing a detached house with the ArchiCAD software. During the classes, students were assisted in designing the building, with support from e-tutorials. The tutorials provided instruction step-by-step, to guide the students in their design. While successful to a certain extent, these learning aids had some limitations. Universal skills acquisition and problem-solving were inadequate.

The teachers noticed that students who encountered a non-typical problem searched for solutions in the ready-to-use tutorials that largely provided straightforward guidance. Other observations from the classes included:

- Lack of verification of the design project - for some students changes in the project requirements were ignored - they perceived tutorials as the only correct solution. Additionally, students who missed a number of laboratory classes were catching up thoughtlessly, unreflectively using sample manuals on the e-learning platform. They followed instructions from the platform without checking if there were any changes to the training project requirements.

- Limited creativity - it was easier for students to follow the instructions presented during the classes. They did not have to search for solutions, as they were already given in the teaching aids as pdf and video files.

- Limited focus on the classes - some course participants assumed they could always rely on the material on the e-learning platform instead of focusing on understanding the problems during the classes.

- Low number of students attending the office hours sessions - this was related to the limited variety of buildings. Despite the design freedom, it was easier to stick to the scope presented in the tutorials. Consequently, there was no need to verify the solutions with the teacher.

An e-learning platform and teaching aids are not sufficient to realise the full potential of students in computer technology classes. Intending to combine the capabilities of modern software with the development of student skills, the teachers introduced programme modifications and changed the tutorials.

CHANGES TO THE CURRICULUM

To promote learning quality and increased creativity and independence among students, teachers conducting the BIM Techniques in Design classes proposed amendments to the curriculum for the 2015/2016 semester. More advanced elements were introduced to 3D models, such as walls and profiled partitions, structural walls, more complex terrain features and other BIM elements. This aimed to achieve BIM maturity level 1 [3].

Tutorials still provided support to laboratory classes. They concerned shapes and objects, with parameters other than those designed by the students. After learning, a student had to use a tool in a novel way not covered by the manual on the e-learning platform. Hence, learning was more universal. These changes to the curriculum have shown the following positive results:

- More focus on the classes - teaching aids explain only the method to perform a task, not the task itself. Students had to familiarise themselves with the tool and understand it.

- Improved creativity and willingness to search for original solutions - due to the increased diversity of exercises, students adjusted tool use to individual designs.

- Extended scope of computer technologies - new tools have been introduced around BIM technologies and the course has been linked to other courses at the University, e.g. design, construction engineering.

- Increased participation in office hours - teachers and students could perform a more in-depth analysis of a project. Improved creativity required a more individual approach to problems.

Tutorials did not provide step-by-step guidance, but were still related to the type and function of a detached residential house to be designed by the end of the semester. Requirements and parameters have been changed, including the floor area, number of storeys, the range of the surrounding area and additional descriptions. There were no direct references to the teaching aids on the e-learning platform.

CHANGES TO TUTORIALS

Other changes were introduced in 2017 due to the extended use of BIM technologies. A new type of building was introduced allowing students to extend their knowledge in design, structure, cross-sectoral co-operation and legislation. Students had to design a small utility and services building. This required in the design BIM maturity level 1 and some BIM maturity level 2. Tutorials referred to a different type of structure; they concerned only the functionalities of the ArchiCAD software needed to build individual 3D models and prepare relevant documentation. Conducting the classes also changed. Emphasis was put on the universal usage of software tools without reference to a single specific case.

Teachers spent more time on office hours sessions, with increased student participation. Less emphasis on tutorials providing step-by-step guidance has led to a shift to direct contact with students. These changes have resulted in:

- Extending the scope of the classes - more involvement and work from the students, with more time spent on office hours.

- Individual projects - students learn how to use tools to fulfil their concepts and ideas; the form, shape, layout and functions of the structure are unlimited except by imagination. Only some parameters are specified (e.g. maximum height and area) as guidelines on the e-learning platform.

- Students are encouraged to search for non-standard solutions, and to use new forms of knowledge acquisition, e.g. streams, on-line videos, blogs.

- Course participants preferred direct contact with the teacher than interaction with the e-learning platform.

- Teachers have more time to present BIM technologies. As a result, the classes in computer design technologies teach students how to apply knowledge gained in other courses, e.g. design, construction engineering, and so on [4].

Tutorials have not been eliminated and serve as a supplement and hints to exercises in the classes. Teachers explain how to use the tools. However, students must be more focused and work harder. Changes have led to an improvement in the quality of work in classes where software is used. This improvement has been confirmed by teachers conducting design classes and responsible for internal contests of semester projects.

A survey was conducted of 175 students from the year 2019/2020, who completed the second semester of the computer technologies course. They responded to the following question: *Do you prefer direct assistance and explaining the problem by the teacher to a tutorial describing the problem without the teacher's help?* The majority appreciated the role of the teacher and preferred this form of support. Most students were against increasing the number of tutorials explaining specific tasks in lieu of tutorship hours. Statistical data are shown in Figure 1.

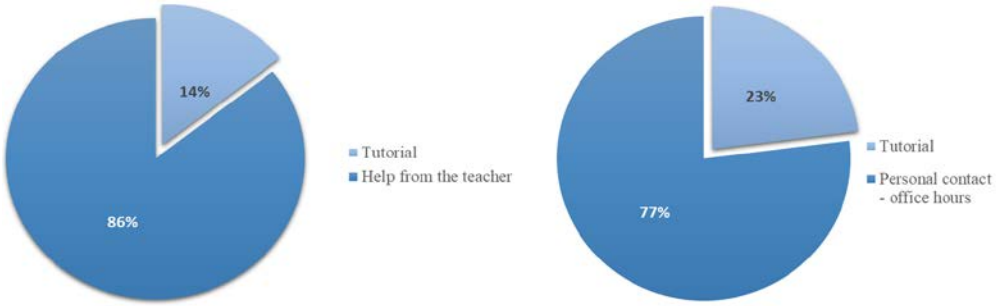

Figure 1: Students' preferred form of help.

Findings from the survey has also indicated another benefit of the changes introduced to the curriculum. Students have been encouraged to extend their knowledge beyond e-learning and tutorials. Searching for material, with the use of modern media, has a positive effect on self-development. Students were not discouraged from discussing with their teachers the information obtained from the Internet. The media used to support the exchange of information is presented in Figure 2.

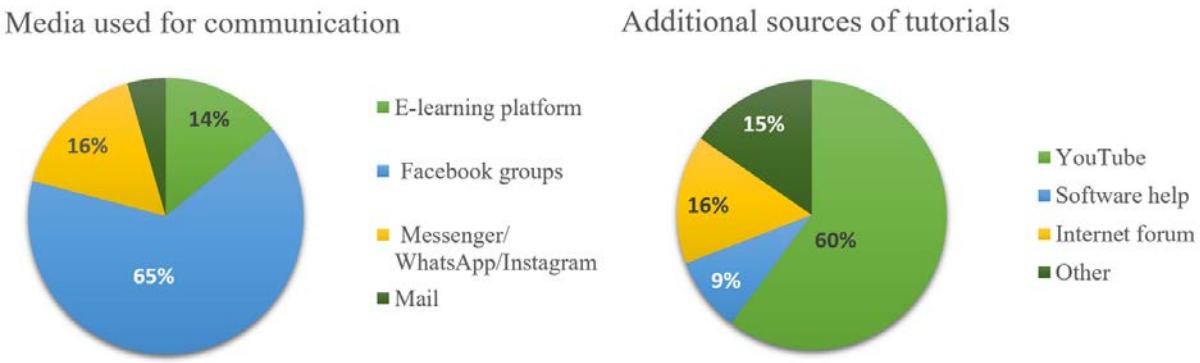

Figure 2: Sources of information.

The curriculum changes, method of conducting classes and tutorship have been driven by the need for improvement in course quality. Achieving higher BIM maturity levels was possible, because of the Descriptive Geometry and Digital Technologies Department dealing with computer-aided design. Some employees of that Department have helped in adjusting the syllabus.

All modifications also have been supported by the FA-CUT. Positive effects have been manifest in teachers conducting other design courses as reported by students. Improved course quality was apparent in the higher quality of semester projects in computer technologies. Students retained more technical information concerning their design as evident in the form of diagrams and bills of materials attached to the documentation.

TUTORIALS, STREAMING AND E-LEARNING DURING THE COVID-19 PANDEMIC

Restrictions on educational activities were imposed at Cracow University of Technology at the beginning of 2020 as a result of the COVID-19 pandemic. Courses for all subjects had to be held on-line. Consequently, e-learning platforms had to be adjusted for remote studying. The classes in BIM Techniques in Design have changed. Streaming sessions for groups of 90 have replaced classes of 12 students. The scope and schedule of the course has not been changed, hence avoiding any decrease in educational standards. Classes have been held through ZOOM and Teams (Microsoft Office) platforms. Teachers have been assigned in groups of two to conduct on-line classes. One conducted the class and presented the ArchiCAD tools, while the other responded to any questions asked in real time. Course participants were able to submit remarks when streaming ended and discuss questions concerning exercises.

Shifting to remote work has increased the significance of e-learning platforms, tutorials and teaching aids. After the end of a webinar, supplementary pdf files are provided, describing the tools used during the streaming activity. The form of the tutorials has remained the same as in previous semesters. They do not refer to specific problems, but universally explain the functionalities of the graphics software [5][6].

Considering the pandemic situation, direct contact with the teacher, developed in the previous semesters to ensure best results, has been eliminated. E-tutorship sessions have been introduced, allowing the students to discuss problems with the teacher, but these sessions caused difficulties. It was necessary to extend the duration of the meetings, from two teaching hours once a week to five teaching hours spread over two or three sessions per week. Despite that, their results were much worse than when using regular forms of communication. Students needed more time to understand the subject. There could be many reasons for this: from working in the same environment for several weeks to lack of equipment. The problems observed could be attributed to:

- Lack of direct contact with the teacher - communication and explanation of a given problem is much harder on-line.
- The teacher cannot see students' reactions - it is impossible to observe if the student really understands the subject or just claims to. It is difficult to access participants' computer screens to verify their work.
- The teacher is unable to ask the student to perform and repeat an exercise - it is harder to determine whether a given software tool is used properly.
- Students cannot observe the progress of peers - lowers competitiveness. Students cannot inspire one another.

In general, the increased number of tutorials in the form of videos and pdf manuals has proved insufficient. Extended office hours has resulted only in a marginal improvement. It is hard to replace direct contact with the teacher [7][8].

Before the end of the 2020 semester, the situation caused by the pandemic has shown that e-learning platforms and streaming activities cannot totally replace laboratory classes conducted at the University. It confirms the purpose of the changes introduced before the COVID-19 pandemic. However, it does not mean that remote teaching brings no positive results in education. Distance learning is a significant support for regular forms of education [9][10].

The conclusions presented here concern laboratory classes in computer technologies conducted at the Faculty of Architecture in the CUT. Analyses referred to tutorship sessions, where students must prove not only that they know the software, but also that they understand how to use it in architecture. This affects the results of on-line education. Some statistical data are presented in Table 1.

Table 1: Office hours vs. scope of classes in recent years.

Type of tutorial	Tutorial provides step-by-step guidance; same type of building with the same parameters	Tutorial provides a partial step-by-step guidance; same type of building with different parameters	Tutorial presents tools universally; based on other types of building with different parameters	Tutorial presents tools universally; based on other types of building with different parameters
Type of designed building	Detached house	Utility and service building	Utility and service building	Utility and service building
Office hours	1.5	2.5	4	8
Course hours	30	30	30	30
Office hours type	Personal contact	Personal contact	Personal contact	On-line
BIM model maturity level	Part of level 1	Level 1	Level 1 and part of level 2	Level 1 and part of level 2
Semester	2013/2014; 2014/2015	2015/2016	2016/2017; 2018/2019	2019/2020

CONCLUSIONS

In subjects such as computer-aided design, it is necessary to support students with tutorials that explain tools universally and enable a more creative approach to design. As a result, teaching aids can be applied to a wider range of building types. Elements at BIM maturity level 2 can be introduced during classes. Students can apply the knowledge acquired in other courses, which translates to a closer correlation between the subjects and the teachers.

The changes introduced indicated that tutorials serve as a significant but not exclusive form of support. Equilibrium should be maintained between the teaching aids accessible on the e-learning platforms and the office hours. Despite the

development of digital forms of data exchange and remote assistance available for the students, direct contact with the teacher is most important. Remote laboratory classes in computer technologies held during the COVID-19 pandemic may lack this contact.

These conclusions are limited by the nature of the subject and do not present the entire spectrum of remote tutorship sessions conducted at universities. However, they may serve as reference data and pave the way for further research.

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