Integrating BIM in Education: Lessons Learned

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Although we teach BIM since 2006 at the Faculty of architecture at Czech Technical University in Prague, the education has never been fully integrated into the curriculum of the school. In 2013/2014 this changed, and three tracks were initialized to integrate BIM: (1) teaching BIM in the first year; (2) applying BIM in a selected first year design studio; and (3) applying BIM in a selected third year Bachelor graduation design studio. The implementation of the work is described, results are presented, and we draw conclusions for future work.

Keywords: *Building Information Model, Education, BIM integration, BIM Pedagogy*

INTRODUCTION

At the Faculty of Architecture, Czech Technical University in Prague, we are teaching BIM since 2006 (see Table 1).

BIM adaptation in Czech republic is very low (Vinšova, Matějovská and Achten 2014): we can say there is an "island of knowledge" concerning BIM; support from normative, governing, and professional institutions is very low; initiatives to use BIM comes from developers or enlightened clients. In other countries in Europe (for example Germany, Belgium, UK, Finland, and Denmark) adaptation is at a much higher level (Russell and Elger 2008; Boeykens et al 2013; Kocaturk and Kiviniemi 2013; Ibrahim 2014; Dieckmann and Russell 2014). All this leads to the situation that BIM and CAAD are not perceived as a priority in our Faculty. Teachers who are also practitioners with their own architects' office are unwilling to consult software outputs, and the digital ability of students is not appreciated. Visualisations and schematic plans are supposed to be sufficient; therefore good quality 3D models are not considered essential to design studios. From this fact it is clear that boundary conditions for introducing BIM in a more structural way at our school are not favourable. Already in 2007 Techel and Nassar noted that a more comprehensive embedding of BIM in education yields better results than a specialized BIM course alone (Techel and Nassar 2007, pp. 635).

Within the curriculum, we were able to teach BIM in the first year Bachelor program in two semesters in compulsory courses, and in the second year in two voluntary courses. It has to be noted that in the compulsory courses basic CAAD skills have to be taught (AutoCAD, as it is the most used software in Czech republic), therefore exposure to BIM is rather small. It *de facto* concerns *BIM 1.0* level teaching (Revit and ArchiCAD): 3D model, 2D representations, and derived geometry. In the second year voluntary courses (focussed on Revit) the beginners' course teaches basic 3D building model using materials and components and deriving 2D representations. In the second semester advanced course parametric modelling and families are taught, project organization, collabora-

history of teaching BIM software on FA CTU (number of students, SW Autodesk Revit)									
	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Revit - BIM & basic skill	16	12	40	52	64	87	43	40	69
Revit - advanced skill	-	-	10	10	21	31	37	18	41
BIM-Revit in 1.year	-	-	-	-	-	-	-	-	43

Table 1
History of teaching BIM software at Faculty of Architecture, CTU

tion between various specialists, collision detection and so on.

In the winter semester 2013/2014 three parallel activities were started to better integrate BIM in education at our faculty: in the first year direct exposure of students to BIM and cooperation with one first year's design studio, and in the third year so-called Bachelor graduation project BIM integration in a selected design studio as pilot project. In the remainder of this paper we will present the integration process, discuss results, and present future continuation of this work.

TURNING POINT: INTEGRATION OF BIM IN CURRICULUM

In the winter semester of 2013/2014 we were able to widen the offer of BIM in education in the curriculum of the faculty:

- In first semester CAD course, students could choose between AutoCAD (traditional, non-BIM course), Revit (BIM), and ArchiCAD (BIM).
- In first semester basic design studio (called "ZAN") option to work out tasks with BIM software and digital sketching tools.
- In the Bachelor graduation project a selected design studio offered option to work out diploma project in BIM.

These tracks are incorporated in the regular curriculum of the faculty.

Option 1: First year starting BIM course

In Czech republic secondary education there are two types of schools: gymnasiums, offering general education (80% of total number of students); and special education secondary schools offering specialisations in technology (12% of total number of students), arts (6%), medicine, language, economy, and so on. Both school types provide entrance to university level education. Additionally there are secondary vocational schools offering more specialised education - those graduates typically enter practice after receiving their diploma. Future students from specialised schools in technology (and in a few cases arts) already have basic knowledge of CAD.

Before the start of their studies in the Bachelor programme of the faculty of Architecture, we contacted all enrolled future students and offered them a choice of three course types in the first semester CAAD course:

1. Regular AutoCAD (no BIM).
2. Revit (BIM).
3. ArchiCAD (BIM).

The students were informed about the options that they could choose. It is important to note that the teaching had to be prepared in such a way as not to disadvantage any choice over the others. Table 2 shows the proportion of students that choose a particular software.

Software	Students in total	Percentage
AutoCAD	161	60.8%
Revit	43	16.2%
ArchiCAD	61	23.0%

Table 2
Number of students that choose a particular software option in first year education.

For the course we set a number of requirements:

- No previous knowledge of CAD is required or expected from the students.
- No knowledge of building structures and experience of draughting techniques is supposed.
- We teach the basics of 3D modelling and the

design of BIM models (in particular elements from its library).
- We focus on the basic principles of creating BIM models using known factors and simplified foundations.
- Because the outputs had to be the same regardless the software that was used (AutoCAD, ArchiCAD, Revit) we were limited with the content that was taught.

From our experiences we noted that students who worked with BIM did not miss the traditional 2D approach based on AutoCAD (which is usually only requested from the other teachers). They were even able to produce the documents for another course, called *Descriptive Geometry*, using Revit or ArchiCAD.

In the following years in most cases students are handed documentation in the design studio in AutoCAD format, and the assumption of most design studios is that students hand in their work in AutoCAD format as well. Here is a task for us to convince our colleagues that students with BIM skills should be allowed to hand in BIM models as well. This is something which needs to be achieved throughout the whole faculty.

Option 2: First year integration with "ZAN"

In the first year curriculum students have a specific design studio called *"ZAN"* (*Basics of Architectural Design*). We established collaboration with one such design studio ("ZAN" first semester), in which students would not only try the task on paper but would also be given the opportunity to try the alternative in the form of BIM software and digital sketching. Students themselves stated that using the 3D model saved them a lot of work with 2D plans. Revit was used by approximately 30% of students optionally. The heads of the design studio reported that they saw particular advantage for the students that they could compare benefits and drawbacks of many ways of designing: hand drawing, scale models, CAAD drawing, and BIM modelling.

Option 3: Bachelor graduation project with BIM

In the Bachelor graduation project, students have to make a design and produce a comprehensive set of architectural drawings and engineering documentation that almost reach shop-drawing detail level. Potentially a lot of advantage can be gained from a BIM approach here, but we noted rather poor performance in this year's production because of reluctance to use BIM by most heads of the design studios (described above in the introduction).

We obtained an EU grant (project "BIM in bachelor project") that allowed us to implement BIM education in the Bachelor program of our school. This provided for us first opportunity for regular use of BIM in the design studio of the Bachelor Degree. It was our first attempt to introduce students to the whole complexity of BIM process. Students worked on their bachelor degree project based on the outline of their studies. In addition they created a simplified HVAC and plumbing model, isolated bearing parts of the designed building, and finally they detected collisions between models. Students were free to choose ArchiCAD or Revit for their BIM work.

The EU project also allowed us to provide successful students with a "BIM-certificate" (in association with *CZ-BIM - Council of BIM in Czech republic*), as an additional reward for the extra work to invested in the diploma work. At the moment this is not implemented yet. We expect that the engagement of students in their diploma work using BIM will have positive feedback on the BIM teaching in the regular curriculum, as we will get to know better their needs and requirements for the design process.

We found that 10% of the students did not complete their BIM work in time to manage the limit for the assessment of the bachelor project. This is actually the same proportion as those students who worked in traditional manner. The students who managed were all very enthusiastic. We observed that their exit level work was the same and sometimes higher than that of students in second year of their studies (compared on work produced by 2nd

year students using BIM software).

The knowledge how to create valid architectural BIM 3D models was expected due to previous exposure of the students to optional courses of CAD/BIM software. This knowledge turned out to be not as good as we anticipated as students were not able to model their tasks without further help. Students showed aspects of weaker 3D orientation in ArchiCAD since they tend to choose an easier way to get things done through in template finished way. In Revit we found the 2D documentation lacking since students often exported and finished 2D lines and texts in AutoCAD. Here a major stumbling block experienced by students is the requirement to produce shop drawings according to Czech norms for drawings. Converting BIM drawings to make them according to norms required a lot of effort with low added value.

In addition to architectural BIM process we introduced students to the option of analysis and simulation of the models. Although the students expressed interest in this aspect, none of them used it because of two reasons: (a) it implied a lot of additional work on top of their regular work load; and (b) the design project supervisors did not accept design decisions taken on basis of analysis and simulation.

The official requirements of a Bachelor graduation project is to include the design of the HVAC (esp. air conditioning) and plumbing systems. The procedure of BIM model was explained, example was shown to the students in many workshops during the semester, and they were granted sufficient time to work on it. Despite all this the results were underwhelming; only a low percentage of students were able to create the 3D model (Figure 1). Thus model coordination and collision detection were hardly used.

Through the Bachelor graduation project we obtained the following experiences:

- It is necessary to intensively help students complete their project using BIM, especially in detailed construction plan, otherwise they will revert to 2D finishing of the work in AutoCAD.
- It is necessary to provide the students with general overview in HVAC, Plumbing and Structural part of BIM model.
- It is necessary to improve knowledge of model sharing and (collaborative) teamworking.
- It is necessary to increase student interest about analysis and simulation.
- It is necessary to cooperate with other design studios and help BIM students to finish their bachelor's project by BIM rules.

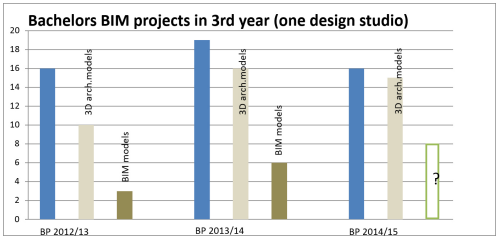

Figure 1
BIM usage in Bachelor graduation projects.

To assist the students with their BIM models, we relied on a team of expert students who were already proficient in the use of BIM. These students proved to be of critical importance as they were able to address problems very quickly and keep the students motivated to use BIM.

FUTURE WORK

Due to the low success rate of students and low quality of the BIM models we are considering future cooperation with students of profession from Faculty of Civil Engineering so the work would be separated and resemble practice more. This is in line for example with the approach presented by Gu and de Vries (2012). However so far we have not been successful on this front, because students in Civil Engineering are not sufficiently prepared for this collaboration.

To gain more finished BIM models we are planning to change entry conditions of the subject. We plan to cooperate with a larger number of design studios managed by preferably younger heads (who

would be less opposed to the notion of BIM). This co-operation would only extend to a small number of chosen students who will receive more attention during the years when they learn BIM software.

Students have a difficult time keeping up the discipline to maintain a BIM model during their studies. We need to keep them reminded and motivated, for example by pointing out increased likelihood of obtaining work after studies is much higher when a student has BIM skills.

Students are very well aware that the demand for graduates with BIM knowledge and skills is ever increasing, and that they need this in order to be competitive on the market.

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