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# BIM teaching strategies: an overview of the current approaches

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## Abstract

It is widely expected that Building Information Modelling (BIM) will lead to changes in the performance of professionals in the Architecture, Engineering and Construction (AEC) sector, particularly with regard to architects and civil engineers. It is essential for the designer to be aware of and to understand BIM concepts while undertaking studies at an academic institution. The literature has recorded several experiences regarding the use of BIM in the teaching of architecture and civil engineering in countries where BIM is currently being employed and is most widespread. At the same time, there have been some different approaches for introducing BIM in the curricula. However, it is still unclear how BIM should be taught, as most experiences are very recent. This study provides a brief review of how BIM teaching is being introduced into universities around the world.

*Keywords:* building information modelling, BIM teaching, curriculum, architecture, civil engineering

## 1 Introduction

Several experiences on the use of BIM in the teaching of architecture and civil engineering are reported in the literature, especially in countries where BIM is currently most adopted. Along with those accounts, there have been some discussions about the strategies for introduction of BIM in the curricula, with different approaches. The purpose of this study is provide an overview of the current status of the BIM teaching in universities around the world and show how BIM is being introduced in the curriculum through a literature review.

## 2 BIM Paradigm Shift

In 2006, during the BIM Symposium at the University of Minnesota, it was generally agreed that BIM would change the AEC professions, and the many issues raised at the time would be answered when the schools begin to incorporate BIM into their curriculum (Khemlani, 2006). A year late, during the III BIM Workshop sponsored by the American Institute of Architects-Technology Architectural Practice (AIA-TAP), participants discussed the difficulties in establishing methods for teaching as well as software and curricular content, but the consensus was that it would require teaching new levels of abstraction regarding the new concepts of BIM (Bronet et al. 2007).

Two years later, Kymmell (2008) identified the possible obstacles to the introduction of BIM in the curriculum. According to him, they can be categorized into three groups: difficulties in learning and using BIM software; misunderstanding of the BIM process and issues related to the circumstances

of the academic environment.The problems related to misunderstanding BIM concepts are the most important hurdle to overcome (Kymmell, 2008) because understanding the idea is more important than mastering the use of the tool (Hietanen and Drogemuller, 2008). The fundamental BIM concept to be taught and learned is collaboration (Kymmell, 2008).

Some schools have overcome some of these obstacles and are now identified as leaders in the teaching of BIM, but the process requires greater coordination of three levels: teachers, curriculum and university, and to achieve a significant change in pedagogy it will take at least two years (Berwald, 2008). About the curriculum, Önür (2009) proposes that they must be restructured throughout the departmental and inter-departmental levels, and by skill levels to be achieved in different learning cycles, also suggesting a survey of IDS practices in schools in the AEC sector.

However, many schools have not yet started the process of BIM implementation or they teach only a few tools. In 2007, two studies that investigated architecture and civil engineering programs in schools, technology institutes and universities in Ireland (Thomas et al., 2007) and in the United States (Guidera, 2007) found that BIM was not being widely addressed by educational institutions.

In 2007 BIMForum applied an academic survey with eight academic instituitions in the United States (*Arizona State University, Carnegie Mellon University, Drexel University, Lawrence Tech, Pennsylvania State University, Pittsburg State University, Wentworth Institute of Technology and Worcester Polytechnic Institute*) and three international schools (*Technion Israel Institute of Technology University, Universidad Autónoma de Yucatán and Universidade Católica Portuguesa*). The most of them (82%) teach or discusses BIM in courses or projects. The minority (18%) began to introduce BIM in curricula in 2002, others (27%) already introduced BIM before 2002 and the most of them (55%) began to introduce BIM from 2007.

In 2008, the presentations of Ecobuild (2008) confirmed that in the U.S., where BIM is more employed and widespread, the BIM pedagogy is not yet consolidated (Casey, 2008). Another study of Johnson e Gunderson (2009) found that BIM is one of the most challenging and recent trends for the Construction Management programs and that, on the twelve surveyed programs offering courses focused exclusively on BIM, most of them are mandatory and are offered for undergraduate students. Sacks e Barak (2009) also made a non-exhaustive list of universities that have incorporated BIM into their civil engineering curriculum and found that although BIM represents the major content of the courses listed, it has been more commonly introduced as a component within the traditional civil engineering courses.

## 3 History and current state of BIM implementation in the curricula

Excepting the *Georgia Institute of Technology*, that researches on BIM since the early '90s, and some schools that teach BIM techniques using pioneering BIM software as the *College of Architecture at Texas A&M University* (Texas A&M University, 2007), most schools began to introduce BIM from 2003 on. At that time, BIM was introduced in graduate and undergraduate programs at the *University of Minnesota* (Autodesk, 2007). The *Madison Area Technical College* have taught BIM software in the course "*Introduction to Architectural Third Party Applications"* (MATC, 2003) and the *Worcester Polytechnic Institute* have taught BIM in courses of the first and second year of civil engineering (Salazar, et al., 2006).

In *California State University at Chico* specific BIM classes have been taught since 2004, and the first few qualified graduating students were ready to enter the industry in 2007 (Kymmell, 2008). In 2005 the *Tongji University* began to practice the interdisciplinary collaboration with students of Civil Engineering in a Construction Management course (Hu, 2007).

The *Nevada University* began to introduce BIM in 2005. The *Penn State University* has introduced an Integrated Design Studio using BIM in 2006 for the first time (Önür, 2009). In the same year, the *University of Utah's College of Architecture and Planning* began a process for re-structuring its

curriculum through a research project (Scheer, 2006), *Montana State University* began to teach BIM to architecture students in its digital graphics and design curriculum (Berwald, 2008) and in the Advanced Building Systems courses the year before (Livingston, 2006).

Since 2006, other schools started offering specific BIM courses, for example, the *New Jersey School of Architecture* of the *New Jersey Institute of Technology* (Hoon, 2006) and the *Brigham Young University* (BYU, 2006).

In 2007, the *Auburn University* began a study on the teaching of BIM with a group of students. After some studies, the students developed a collaborative project and then the program also began to require a BIM model in the undergraduate capstone thesis project (Taylor et al., 2007). In the same year, Autodesk Inc. awarded the *New Jersey Institute of Technology* a Revit BIM Experience Award (Autodesk, 2009). At the same time, at the *University of Wyoming*, the engineering students collaboratively developed a complex project in which teams chose the model of collaboration and the roles of its members (Hedges, 2008).

Since then, many other schools begin to integrate disciplines with BIM. The *Texas Tech University* has begun to offer a course that unites building technology and representation/media as a pre-requisite for subsequent semesters of Design Studio with BIM (Rex et al, 2008). In 2008 the AIA-TAP awarded four universities in the education category: the *University of Illinois* was awarded for the project Studio 515 (portable modular home); the *Oklahoma University* was awarded for the interdisciplinary course that teaches process and software at the same time; the *University of Wyoming* was awarded for a paradigm shift in an architectural engineering course and the *Stanford University* was awarded by the experience of multidisciplinary analysis and modelling (AIA, 2008).

The *University of Wisconsin-Milwaukee* introduced BIM on several courses: Computers in Architecture which is online and teaches a BIM software (Stagg, 2009); Virtual Modelling that integrates Fundaments of Studio I and introduces CAD and BIM (Jordan and Tran, 2008); Microcosm Studio that explores BIM and prototyping (Talbott, 2009) and Design Studio that deals with Integrated Practices and BIM (Dicker and Snyder, 2008).

The *California Polytechnic State University* started teaching BIM in 2007 in the Building Design course which included students of architecture, engineering and construction management. This course has been structured around the concept that the instructors are a team of integrated project (Dong, 2009; Dong et al., 2009) and the faculty have significant experience of professional practice (Estes et al., 2009).

Since 2008 some schools have also began to experience local interdisciplinary collaboration and distance learning. In 2009, the AIA-TAP 2009 awarded the SARUP-UWM for the Integrated Design Studio IP/BIM and honorable mention to the *University of Wyoming*, to *Montana State University* and to the *University of Nebraska-Lincoln* by the connections made in the Design Studio Courses (AIA, 2009).

*Penn State* received in 2008, from *Autodesk Inc.* and *American Collegiate Schools of Architecture* (ACSA), a grant for the experience they developed (Hedges et al. 2008). In 2009, the Autodesk Inc. has granted an award to *Cal Poly*, *South China University of Technology* and *RWTH Aachen University* in recognition for their efforts to promote BIM (Businesswire, 2009).

Today, schools as *PennState*, *Georgia Tech*, *University of Southern California*, *Montana State University* and *University of Wyoming* are identified as leaders in BIM education. The *University of Southern California* has a rich tradition of offering courses focusing on sustainable design (Rundell, 2007).

In order to know how schools are introducing BIM into their curricula, this study conducted an analysis content of literature on the subject. This analysis led to categorize the academic experiences in the types of collaboration and ways to introduce BIM in the curriculum.

# 4 Collaboration types

Through a literature review it was possible to identify how 103 schools are introducing BIM into curricula. The vast majority, representing 75 schools, are in the United States and only 28 in other countries.

This study classified the academic BIM experiences into three categories: single-course; interdisciplinary; and distance collaboration. Most schools introduce BIM in only one discipline (90%) and few are trying to simulate the integrated practices: interdisciplinary (7%) and distance collaboration (3%). Note that it remains unknown if there are any multinational academic experiences of collaborative BIM learning.

## *4.1 Single-course*

In this category are the schools that are introducing BIM, but in only one discipline (e.g. engineering or architecture). Those courses can teach the use of BIM software, or how to create, develop and analyse BIM models or even teaching BIM concepts or simulating a real collaboration, but always with students of the same course. An example in this the category is the academic experience with undergraduate students of the Construction Management Program at *Tongji University* that have simultaneously developed a construction model based on online collaboration and 3D visualization (Hu, 2007). Another example is an experience with architecture graduates at Queensland University of Technology that simulated a real collaboration using a BIM software in a Design Studio course (Nielsen et al. 2009).

## *4.2 Interdisciplinary*

In this category are the schools that are teaching BIM concepts simulating a real collaboration with students from two or more disciplines, at the same school. The *Penn State*, *Oklahoma University*, *Auburn University*, *Cal Poly*, *Texas A&M University*, *Georgia Tech* and *University of Maryland* are examples of schools which are currently integrating courses of two or three programs where the students develop projects in collaboration using BIM software (Hedges, et al., 2008).

In this category stands a unique experience developed in Australia that happened at the *University of New South Wales*: students from several courses have developed a shared building model in which the standard Industry Foundations Classes (IFC) was used (Plume and Mitchell, 2007).

## *4.3 Distance Collaboration*

In this category are the schools that are teaching BIM concepts simulating a real collaboration with students from two or more distant schools. The *University Nebraska-Lincoln, Montana State University* and the *University of Wyoming* developed an important experiment that involved two programs: one of architecture and other of architectural engineering (Hedges et al., 2008). Two other schools are planning to establish a collaboration in a virtual BIM course: the *Ferris State University* along with the *Oklahoma University* (Dilg, 2008).

# 5 Approaches to introducing BIM in the curriculum

Schools are introducing BIM in different courses of the curriculum and this study grouped them into eight categories: Digital Graphic Representation (DGR); Workshop; Design Studio; BIM Course; Building Technology; Construction Management; Thesis Project and Internship. Note that in the same program BIM may have been introduced using more than one approach.

The predominant approach of these schools is to introduce BIM in Design Studio, however, there are cases that Design Studios are integrated with other courses. Another approach is to teach tools and BIM concepts in a specific BIM course.

BIM is also taught on courses related to DGR, Construction Management, Building Technology, Thesis Project and in Internships. There are also cases in which tools and BIM concepts are taught in courses of short duration (one week), known as Workshops.

A BIM Course may be elective or integrate the curriculum, in isolation or integrated with another course, which is generally Design Studio. Similarly, the Workshops can be isolated or integrated with some courses. Some workshops are also offered online for students or AEC professionals.

### *5.1 BIM in Architecture courses*

Most architecture programs introduce BIM as a Design Studio course (50.5% N=52). The second more frequent option is to teach BIM in courses related to DGR (12.7% N=13) and, third, to offer a BIM Course (elective or compulsory) (9.7% N=10). The other most common options are to teach BIM in Construction Management (2.9% N=3) and to offer a workshop (2.9% N=3).

### *5.2 BIM in Engineering courses*

Most courses in Civil Engineering, Architectural Engineering and Construction Management introduce BIM in a specific BIM Course (16.5% N=17). The other significative options are to teach BIM inside a Design Studio course (13.6% N=14), to teach BIM in courses related with DGR (11.6% N=12) and, to teach BIM in a Construction Management course (10.7% N=11).

## 6 Conclusions

The implementation process of BIM in schools revealed that it should not be simply to create a new course in the curriculum because, as claim Taylor et al. (2007), BIM has the potential to be introduced throughout the program. Some schools in the AEC sector are exploring BIM applications in their disciplines and struggling to integrate them with other ones. This is what all the schools should do, in the opinion of Camps (2008). The schools can maintain the strengths of traditional education based on disciplines and also become multidisciplinary (Bronet et al. 2007). A separate integrative approach, in which the subjects are divided into separate courses, but try to collaborate with each other, ensures no insulation (Techel and Nassar, 2007).

Thus, the principles of BIM can be first introduced into a subject and then between disciplines (Hietanen and Drogemuller, 2008). The first two years would focus on the individual skills of modelling and analysis of the model (Kymmell, 2008) (BIM Course and DGR). The subsequent years could focus more on teamwork and complexity through collaboration (Kymmell, 2008) (BIM Course, Design Studio and Building Technology). The last year could deal with actual construction projects in collaboration with companies (Kymmell, 2008) (BIM Course and Management).

The schools wishing to implement BIM are likely to face many problems, but the greatest of them are institutional, that is, to promote integration between different areas of the curriculum and to find programs from other departments, or even other distant schools, that are willing to promote integration. As reported here, there are some schools that are already teaching BIM concepts across disciplines, but as Scheer (2006) claims, soon this will become a rule rather than the exception.

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