# A Tool for Assisting Teachers in Planning BIM Courses

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## ABSTRACT

In view of the importance of teaching BIM concepts and tools to architecture and civil engineering students, a number of schools have sought to introduce this subject into their curriculum. However, as the curriculum is already overloaded, with little space for new courses, a useful strategy is to spread the BIM material over various courses. This paper proposes a tool that assists teachers in planning courses with BIM content. It consists of a survey that sets out criteria to help teachers determine whether or not the course is appropriate for the inclusion of BIM material and what should form its syllabus. This instrument is divided into four parts: (a) course information; (b) defining the objectives of teaching BIM; (c) making recommendations to the professor on the most appropriate level of BIM proficiency for the course, BIM tools and applications, pre-requisites, projects to be carried out and collaboration types to be taught and; (d) a graph to show what BIM specialist areas are addressed in the course. The following factors were taken into account in devising this tool: the program (Architecture or Civil Engineering); the year in which the course is offered in the curriculum; the uses of BIM; BIM concepts and BIM skills. The proposed tool will be employed in the analysis of the syllabuses of courses of the Architecture and Civil Engineering programs of a Brazilian university. Courses involving Information Technology (Digital Graphic Representation, Design Studio and Project Management) will be selected first to improve and refine the instrument.

## INTRODUCTION

A number of schools have sought to introduce Building Information Modeling (BIM) into their curriculum. The schools have generally adopted two basic approaches: using BIM in several courses across the curriculum or teaching BIM in just one or two courses (Chasey and Pavelko 2010; Lee and Dossick 2012) such as technology (IT) and a new autonomous BIM course (Becerik-Gerber, Gerber and Ku2011). In the first approach, BIM is used as a facilitator to teach course content and, in the second scheme BIM is the centerpiece of a revised curriculum and pedagogical strategy (Wu and Issa 2013). When BIM is offered in just one or two courses, the BIM tools are usually taught at the beginning of the programs (freshman or sophomore) and at the end (junior or senior). When BIM is taught in several courses, the BIM model is used as a teaching resource to improve students´ understanding by visualizing certain issues.

When the second approach is adopted, the first step is to select the courses of the curriculum that have the potential to achieve the objectives and the level of BIM proficiency (introductory, intermediate and advanced) intended (Barison and Santos 2011b; Gordon, Azambuja and Werner 2009; Gao, McEntyre and Ge 2012; MacDonald 2012) once BIM customization is performed on them.

However, many teachers lack the necessary experience and/or knowledge to plan a BIM course. This paper outlines a proposal for a tool to assist teachers indetermining whether or not a course is appropriate for the inclusion of BIM content and, if so, what should be included in its syllabus.

## THE INSTRUMENT

The proposed instrument is a questionnaire that must be answered by the teacher who is responsible for the course.

First of all, the respondent provides course information such as: the name of the school, program area, course and the year in which the course is offered in the curriculum. The respondent then defines the objectives of teaching BIM: (a) if is to learn concepts related to BIM and/or the uses of BIM or (b) if is to improve BIM skills.

Additionally, when choosing BIM concepts (see Table 1), the respondent must select one of the six levels of cognitive thinking outlined in Bloom's Revised Taxonomy (Anderson et. al. 2001) or ‘N/A’ if the concept is not to be covered in the course.

**Table 1.Concepts related to BIM**

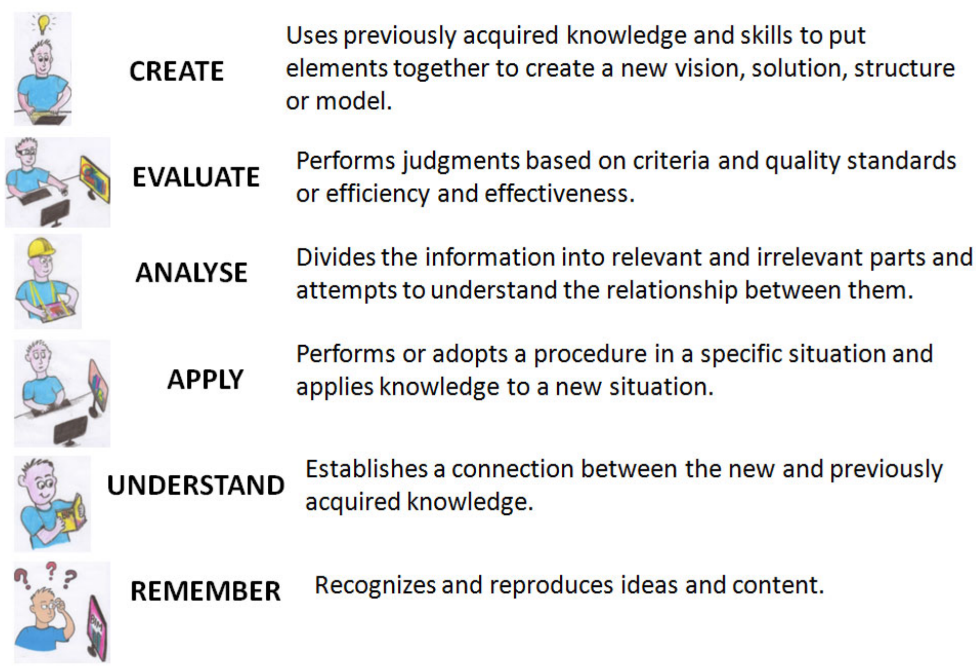
| | |
|---|---|
| 1 | Parametric Modeling |
| 2 | Intellectual property of the BIM Model or BIM Objects |
| 3 | Object-Oriented Programming |
| 4 | Generative Modeling and Complex Geometry |
| 5 | Consistency and information integrity of the BIM Model |
| 6 | Restrictions and rules that define the behavior of BIM Objects |
| 7 | Interoperability (file formats, standards and structure for data sharing) |
| 8 | BIM standardization (in organizations and projects) |
| 9 | New forms of contracts for the AECO industry (IPD concepts) |
| 10 | BIM Workflow |
| 11 | Model-progression specification (MPS) and level-of-detail (LOD) |
| 12 | Data security |
| 13 | Contractual and legal issues in BIM implementation |
| 14 | Central data bases/information repositories |
| 15 | Communication tools, media, channels and feedback |
| 16 | Storing/sharing information (cloud computing, networking) |
| 17 | Selection and evaluation of BIM tools, processes and/or technologies |

| | |
|---|---|
| 18 | Changes in management processes and procedures |
| 19 | Advantages of BIM for design and construction processes and associated risks |
| 20 | Changing roles (hierarchy of responsibilities) |
| 21 | Obstacles in BIM implementation |
| 22 | BIM Maturity Level of Projects and BIM´s organizational capabilities |
| 23 | Collaboration (integrate with project partners database) |
| 24 | Management of information flows |
| 25 | Overall construction, design management and contracting procedures |

Source: adapted from (Sacks and Pikas2013)

The survey provides an explanation to enable the respondent to understand the different levels of Bloom´s Revised Taxonomy (see Figure 1).

**Figure 1. Levels of cognitive thinking based on Bloom's Revised Taxonomy.**




Similarly, when choosing the uses of BIM intended to be included in the course, the respondent must also select one of the six levels of cognitive thinking or ‘N/A’. There are various listed uses of BIM for each stage of the building lifecycle (Plan, Design, Construct and Operate).

We have established thirty-eight (38) BIM uses from the literature (Computer Integrated Construction 2011; Sacks and Pikas 2013): 1.existing conditions for modeling; 2.perform automated cost estimation; 3.integrate BIM with ERP; 4.perform automated quantity takeoff; 5.perform 4D visualization of construction schedules; 6.perform site analysis; 7.programming of spaces; 8.design reviews and assessment; 9.modeling with standard catalog elements; 10.creating and modeling with custom elements; 11.massing/solid modeling; 12.generate immersive environments; 13.create renderings and representations for aesthetic evaluation of the project; 14.create 3D detail drawings; 15.perform automated generation of documents and drawings; 16.check code compliance with code building; 17.check code conformance with program/client values; 18.perform energy analysis; 19.perform structural analysis;20.perform lighting analysis; 21.perform mechanical analysis; 22.perform constructability review and analysis; 23.perform discrete event simulation; 24.sustainability evaluation (LEED, etc.); 25.other engineering analysis; 26. detect clashes; 27.3D Coordination; 28.virtual construction; 29.export data for computer-controlled fabrication; 30.site utilization planning; 31.BIM at the field; 32.planning and 3D Control; 33.as-built modeling – record model; 34.facility maintenance scheduling; 35.space management/tracking; 36.asset management; 37.building system analysis and; 38.disaster planning.

However, if the respondent chooses to develop BIM competencies, he/she can select from 8 sets of individual BIM competencies which are divided into 51groups (see Table 2). These sets of related individual and team competencies have been based on Succar, Sher and Williams (2013), Computer Integrated Construction (2011) and Barison and Santos (2011a).

**Table 2.Individual BIM competencies**

| Subgroup of BIM competencies | | Group |
|---|---|---|
| 1 | Basic Technical Skills | Technical |
| 2 | Document Management | Technical |
| 3 | Equipment-specific skills | Technical |
| 4 | Model Management | Technical |
| 5 | Modeling and Drafting | Technical |
| 6 | Documentation and Detailing | Technical |
| 7 | General Management | Managerial |
| 8 | Strategic Planning | Managerial |
| 9 | Organizational Management | Managerial |
| 10 | Business Development and Client Management | Managerial |
| 11 | Partnership and Alliancing | Managerial |
| 12 | Leadership | Managerial |
| 13 | Finance, Accounting and Budgeting | Administration |
| 14 | General Administration | Administration |
| 15 | Office Procedures and Policies | Administration |
| 16 | HR and Recruiting | Administration |
| 17 | Marketing | Administration |
| 18 | Tendering and Procurement | Administration |
| 19 | Contract Administration and Compliance | Administration |
| 20 | Risk Management | Administration |
| 21 | Quality Control | Administration |
| 22 | Collaboration | Functional |
| 23 | Functional Basics | Functional |
| 24 | Team and Workflow Management | Functional |
| 25 | Project Management | Functional |
| 26 | Planning and Programming | Operation |
| 27 | Quantifying and Estimating | Operation |

| | | |
|---|---|---|
| 28 | General Model Use | Operation |
| 29 | Analyzing and Simulating | Operation |
| 30 | Selecting and Specifying | Operation |
| 31 | Checking and Monitoring | Operation |
| 32 | Operating and Controlling | Operation |
| 33 | Linking and Extending | Operation |
| 34 | Designing and Conceptualizing | Operation |
| 35 | Component Development | Implementation |
| 36 | Guides and Manuals | Implementation |
| 37 | Implementation Fundamentals | Implementation |
| 38 | Standardization and Templates | Implementation |
| 39 | System and Process Testing | Implementation |
| 40 | Technical Training | Implementation |
| 41 | BIM Library Management | Implementation |
| 42 | Software and Web Design | Supportive |
| 43 | Data, File and Network Management | Supportive |
| 44 | General IT Support | Supportive |
| 45 | Software-related Troubleshooting | Supportive |
| 46 | Change Facilitation | Research and development |
| 47 | Research and Assessment skills | Research and development |
| 48 | Strategy Development and Planning | Research and development |
| 49 | Teaching and Coaching | Research and development |
| 50 | General Research and Development | Research and development |
| 51 | Knowledge Engineering | Research and development |

Sources: (Succar, Sher and Williams 2012; CIC 2011; Barison and Santos 2011a)

After its questions have been answered, the proposed tool makes several useful recommendations to the respondent. For example, on the basis of the selected level of cognitive thinking (Figure 1), the tool determines a set of related individual BIM competencies for each selected concept and/or uses of BIM. Similarly, there is a set of related concepts and uses of BIM that corresponds to each set of BIM competences that is selected. In addition, a graph is drawn to illustrate the percentage of each BIM specialist's knowledge/skills that are covered in the proposed course, helping to determine its target professional.

Moreover, the tool identifies the most appropriate level of BIM proficiency for inserting the course (introductory, intermediate or advanced) by showing in a graph the percentage of its contents in each level. The tool also makes recommendations based on (Barison and Santos 2011b) about the following items: pre-requisites, projects that may be carried out, types of collaboration to be formed and suggested BIM tools and applications (Computer Integrated Construction 2011).

Additionally, the instrument shows the appropriate level of cognitive thinking for the year in which the course is offered and the subjects in the program (Architecture or Civil Engineering) allowing the user to make new simulations.

In the end, the respondent can have an idea of the BIM skills that can be acquired in the course and which BIM specialist it will be able to prepare. An Excel spreadsheet is generated and two electronic messages are sent out, one to the user and other to the authors (see Figure 2).

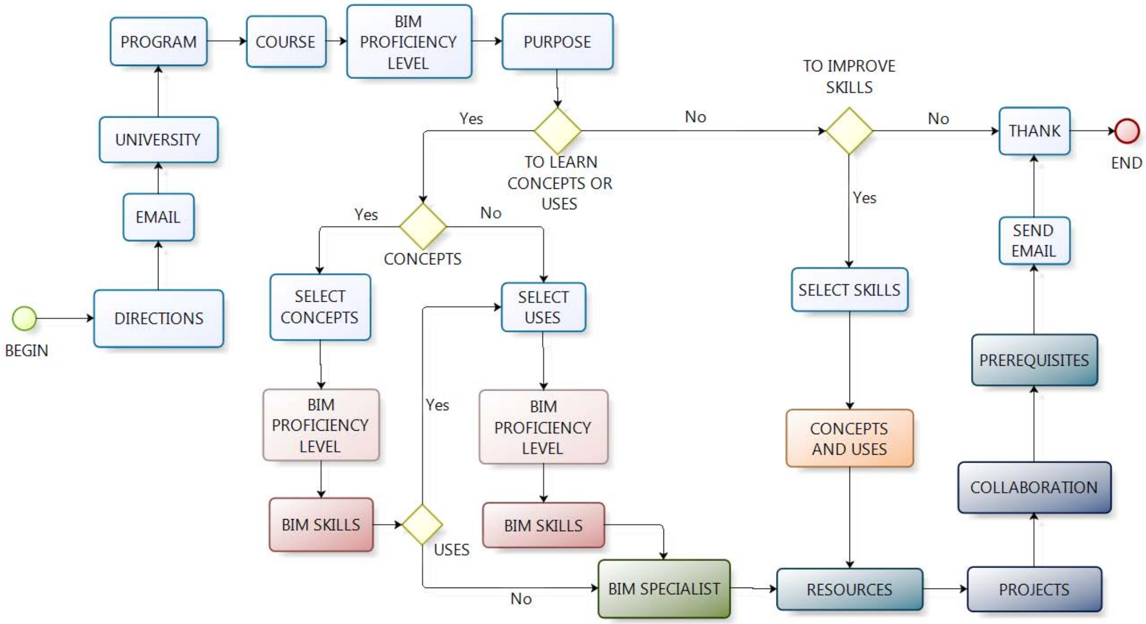



**Figure 2. Flowchart of the tool.**

## RECOMMENDATIONS PRINCIPLES

The technical literature shows that there is a wide range of different BIM specialists, each of whom has a specific set of responsibilities. In practice, a professional can carry out the tasks of one or more of the specialists, depending on the degree of complexity of the project and the size of the company he/she works for.

Barison and Santos (2010) have outlined a hierarchy of BIM specialists and their respective functions and responsibilities. The following ones work in AEC companies: BIM Modeler, BIM Analyst, BIM Facilitator, BIM Operator, Facility BIM Manager, BIM Coordinator, BIM Detailing Manager, Model Manager, BIM Coordinator, BIM Construction Manager, BIM Office Manager, BIM Chief Officer and BIM Construction Officer. The following specialists work in virtual building environments, the software industry and BIM consulting firms: Modeling Specialist, BIM Software Developer, BIM Director of Technology, BIM Consultant, BIM Marketing and Business Development Manager, BIM Corporate Trainer, BIM Checker, BIM Researcher and BIM Educator.

Barison and Santos (2011a) defined the BIM Manager as being responsible for most BIM-related tasks in the company, including BIM training and implementation. Succar, Sher and Williams (2012) defined generic individual BIM competencies and Computer Integrated Construction (2011) the competencies of BIM teams.

In this study, we linked each individual BIM competency to its respective BIM Specialist to show the user which BIM specialist the BIM course is mostly preparing its students to be.

Barison and Santos (2011b) designed a BIM course proficiency matrix which consists of three levels: introductory, intermediary and advanced. In each level, there is a group of features which shows the nature of the didactic BIM project that should be carried out by students, and determines whether the activities, prerequisites and type of collaboration are appropriate for a given stage of BIM education.

Sacks and Pikas (2013) devised a methodology for schools to define what type of syllabus content should be taught in AEC courses. This methodology involved a research project with professionals and resulted in a list of 39 individual BIM competencies that appear in Bloom´s Taxonomy. In this study, we drew on these results to determine the relationship between cognitive skills and levels of BIM proficiency for each concept and use of BIM. However, we used Bloom´s Revised Taxonomy which has one extra level.

Computer Integrated Construction (2011) determines a set of necessary resources for a BIM team related to each use of BIM. This study is based on these recommendations and also on the BIM tools Matrix (BIM Forum 2011). The proposed instrument aggregates all the referred knowledge in an easy-to-use interface.

## CONCLUSION

This instrument is being implemented online (https://docs.google.com/forms/d/11pF-_tm_CvjeBNmTL2Iici4UkkQE_AnEkJX_XEPVfaE/ viewform) from a preliminary Excel spreadsheet version. As this tool is in its initial stage, it still requires further improvements. Several courses from two syllabuses of a Brazilian university will be analyzed to refine and validate the instrument. The next step is to propose an instrument for analyzing several courses of a program by adopting a vertical-and-horizontal approach.

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