BUILDING INFORMATION MODELING IN CIVIL AND CONSTRUCTION ENGINEERING CURRICULA

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ABSTRACT

Building information modeling (BIM) brings many benefits to the Architecture, Engineering, Construction and Operations (AECO) industry when compared to the traditional design and construction approaches. To properly prepare students, many schools are introducing BIM in their curricula as a response to the current and future needs of the AEC industry. The aim of this research was to evaluate the current implementation of BIM and to identify trends in the teaching of BIM in civil and construction engineering academic programs. A survey that investigated the implementation of BIM into existing civil and construction engineering curricula was sent to civil and construction engineering academic programs in the U.S. The survey results indicated that over 40% of the responding civil and construction engineering academic programs either had an interest in or had already implemented BIM into their curriculum. The majority of these academic programs expected students to have at least a basic knowledge of BIM upon graduation, perceived BIM as important to industry, and planned to fully integrate BIM into their curriculum.

KEYWORDS: BIM, Construction Engineering, Civil Engineering, Implementation, Curriculum

1 INTRODUCTION

Building Information Modeling (BIM) is the process of generating and managing information about a building during its entire lifecycle. BIM is a collaborative tool which when used in virtual design and construction allows us to explore and evaluate different design alternatives and to rehearse and evaluate different construction alternatives to achieve optimal value before construction starts. Once construction is completed the modeled information can be transferred to computerized facility management software systems to effectively manage facilities. This life cycle approach to the adoption of BIM maximizes its value to the Architectural, Engineering, Construction and Operation (AECO) industry. Over the last few years, this trend has been gaining enormous momentum in different countries. In the U.S., the General Services Administration (GSA 2008) has had since 2008 a policy in place requiring all building designs to be in BIM format.

Currently, BIM is the modeling approach of choice in many leading design and construction companies. To properly equip students with the BIM skills demanded by the AECO industry, many schools are introducing BIM in their curricula and hiring new faculty with expertise in BIM.

The extent of BIM implementation in architecture and construction curricula at universities in the U.S. has not yet been fully determined. Information about the current state of BIM education would be helpful to both the industry and to academia. Therefore, the aim of this study was to evaluate the current implementation of BIM into curricula and to identify trends in the teaching of BIM in civil and construction engineering academic programs.

2. BACKGROUND

Colleges and universities in the U.S. recognized the need for CAD and began implementing CAD courses into their engineering curricula in the 1980s. Although CAD has been one of the primary design tools, BIM is becoming more utilized due increased awareness of its collaborative and visualization capabilities. Colleges and universities are restructuring curricula to reflect this change from CAD to BIM. Students do not need to know CAD to learn BIM; once they learn BIM, they easily extract 2D drawings out of their models. With the increased utilization of BIM in the AEC industry, its incorporation into civil and construction engineering programs has been vital for the advancement and preparation of students. Engineering students are expected to interpret and understand 3D project designs. In addition, construction engineers are expected to perform quantity take-offs, cost estimating, and scheduling tasks. One of the largest challenges faculty face in teaching BIM is promoting its integration of different areas within the curriculum.

3. METHODOLOGY

A survey was developed to investigate the implementation of BIM into existing architecture and construction curricula. The survey was made accessible to invited respondents via the online survey tool Zoomerang™. The survey collected the following information from the respondents:

1) Demographics (number of students, background and position of faculty teaching BIM).
2) Current BIM implementation (number and level of classes implementing BIM, BIM software taught, scheduling and estimating software taught).
3) Type of BIM implementation (3D, 4D, 5D, 6D, etc.).
4) Academic philosophy of BIM implementation (plan to implement, introduce/become familiar, fully integrate, etc.).
5) Students' expected level of BIM knowledge upon graduation.
6) Perception of importance of BIM to industry.

4. RESULTS

4.1 Demographics

As shown in Figure 1, a majority (60%) of the respondents had between 101 and 300 students. The results also indicated that 42% (13) of the respondents had implemented BIM in the curriculum with 23% (7) offering at least one dedicated course in BIM.The responses from the rest of the respondnets indicated that some acacdemic programs are waiting for student interest, others lack faculty expertise and yet others have not yet determined the need to implement BIM in their curriculum.

Some of the responses as far as the philosophy behind implementing BIM in their academic programs were:

- BIM is a useful skill for design/build applications and for students entering the consulting world.
- Try to integrate the introduction of BIM with decision science and mathenatical modeling, use cases to organize related functionalities of software tools
- Using BIM as a teaching tool. Teaching BIM is not about teaching BIM, it's about doing a better job of teaching building design, sciences, construction, and engineering.
- Discipline specific - move towards discipline collaboration
- That Civil Engineering students need to know more about it, since it is the change in the industry. And also, from a research stand point of view, the department is looking into becoming a leader in BIM related research.

- One professor, Mitchell, believes it is important and has introduced it into his courses as projects within the overall framework of the course.
- While we don't have a formal philosphy, I would state that it is a tool, like many of our other engineering technology tools.
- To provide a basic understanding of what BIM is and what it is used to accomplish.

The respondents were asked about the position and background of the faculty teaching BIM. As shown in Figure 2, the 42% (13) of the respondents indicated that they had implemented BIM in the curriculum by using a faculty from a variety of different employment status to deliver the BIM course content. Note that respondents were asked to select "all that apply" when answering this question.

The respondents were subsequently asked about the number of classes implementing BIM in their curriculum. As shown in Figure 3, a majority (9) of the 13 respondents indicated that they had implemented BIM in 1-2 classes.

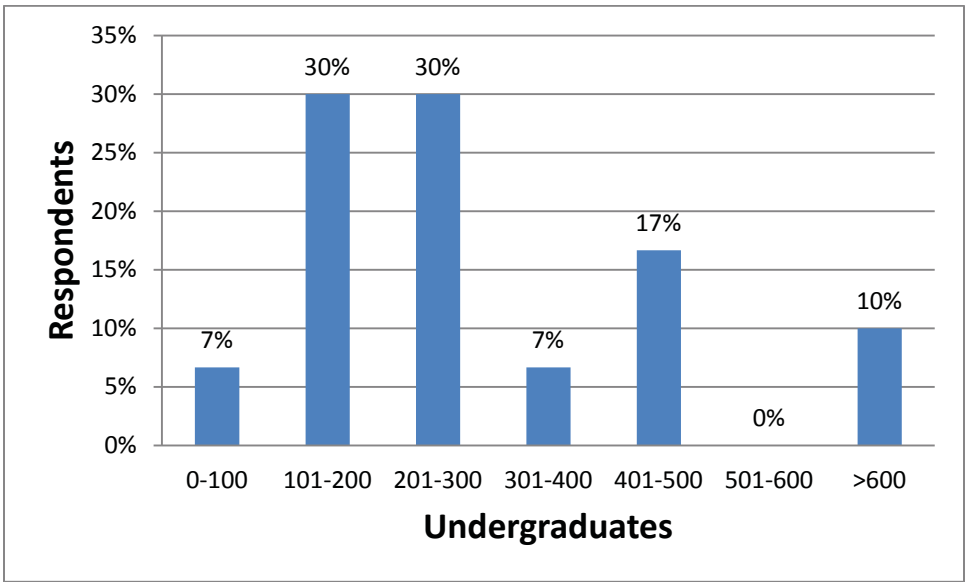

Figure 1. Student enrollment in responding Civil Engineering programs.

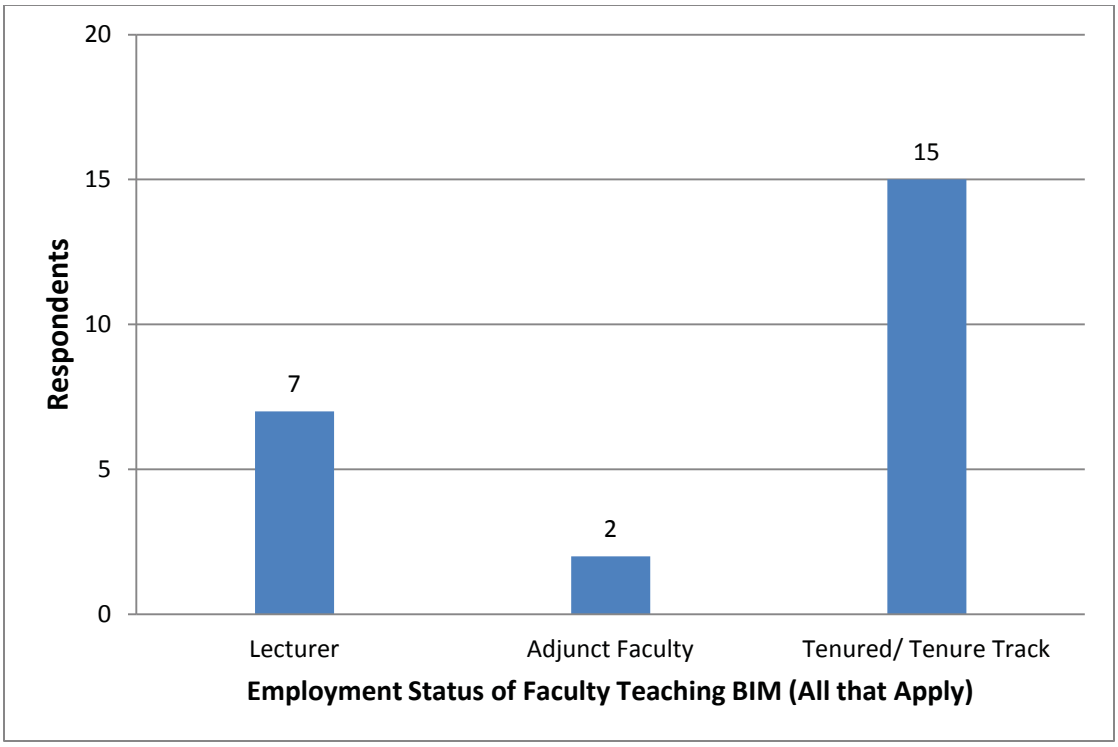

Figure 2. Employment status of faculty teaching BIM.

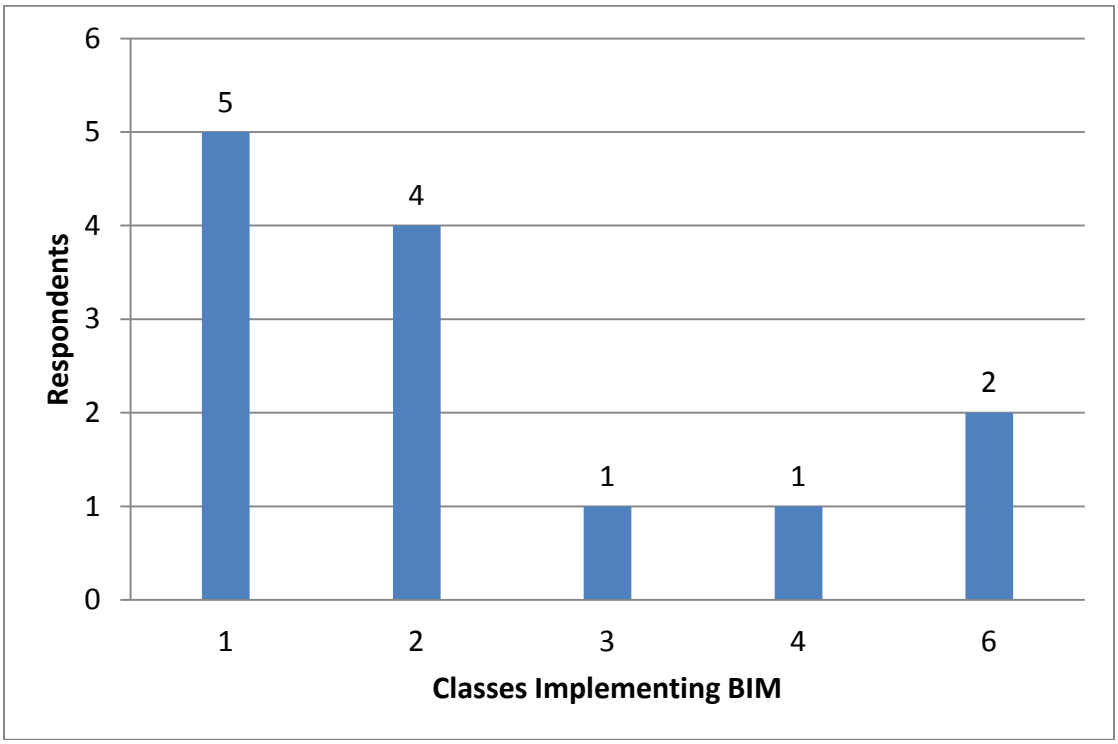

Figure 3. Number of classes implementing BIM.

Regarding the academic level of the class in which BIM was implemented in the curriculum, the majority of the 13 respondents had implemented BIM at the Senior class level (see Figure 4). BIM was implemented at the graduate level by 6 of the 13 respondents. Note that respondents were asked to select "all that apply" when answering this question.

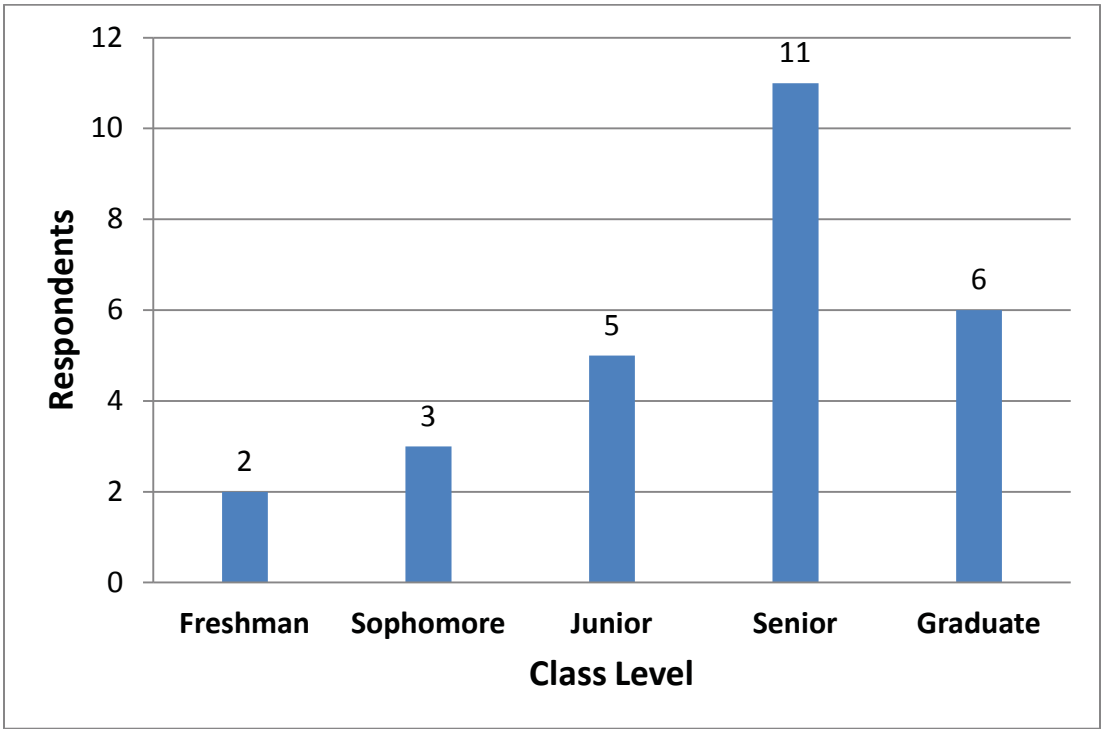

Figure 4. Level of classes in which BIM was implemented.

4.2 BIM software used

Autodesk Revit was the BIM software used by the majority (12) of the 13 academic programs that implemented BIM. Bentley was used in four of the 13 academic programs that implemented BIM. Note that respondents were asked to select "all that apply" when answering this question.

4.3 BIM knowledge expected at graduation

Eight of the 13 civil and construction engineering programs that had implemented BIM indicated that they expected they expected their undergraduate students to have at least basic knowledge of BIM upon graduation (see Figure 7). Of the remainder (5) of the 13 civil and construction engineering programs, four indicated that they expected their undergraduate students to graduate with intermediate knowledge of BIM and one expected their undergraduate students to graduate with advanced knowledge of BIM.

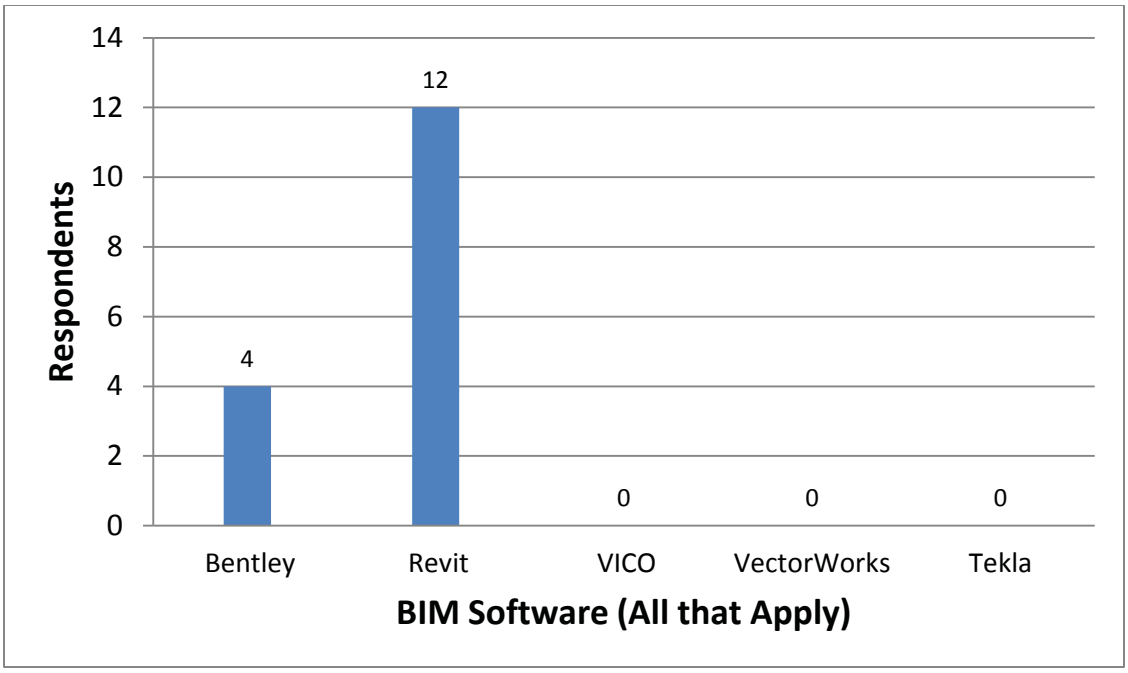

Figure 6. BIM software taught.

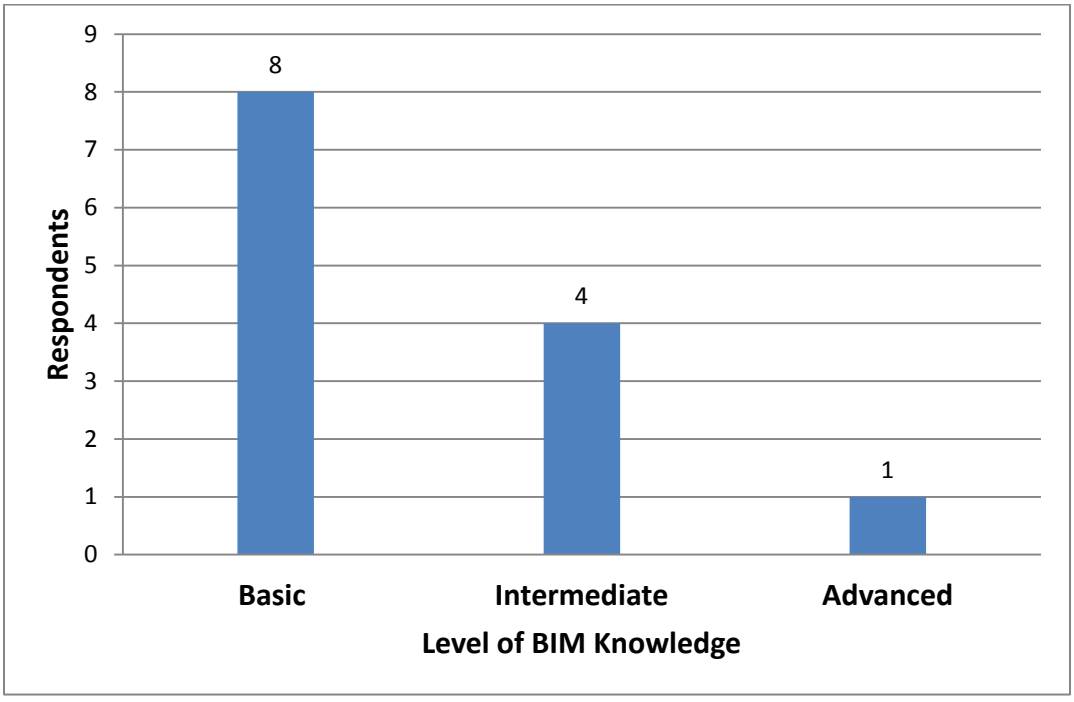

Figure 7. Level of BIM Knowledge Expected at Graduation.

4.4 Type of BIM implementation

Respondents were asked to describe the type of BIM implementation in their programs. The respondents were able to select one or more of the following BIM implementation categories: create models for 3D

coordination (3D), implement scheduling into models (4D), implement cost into models (5D), implement other information into models such as "operations and maintenance" (6D), "none", or "other". Regarding the undergraduate curriculum, more than half (62%) of the respondents stated that in their schools BIM was used for 3D coordination (Figure 9). Fifteen percent of the respondents (2) indicated that in their schools BIM was used for 4D, and 5D modeling. Responses for "other" types of BIM implementation included validation of laser scans and energy and environmental analysis..

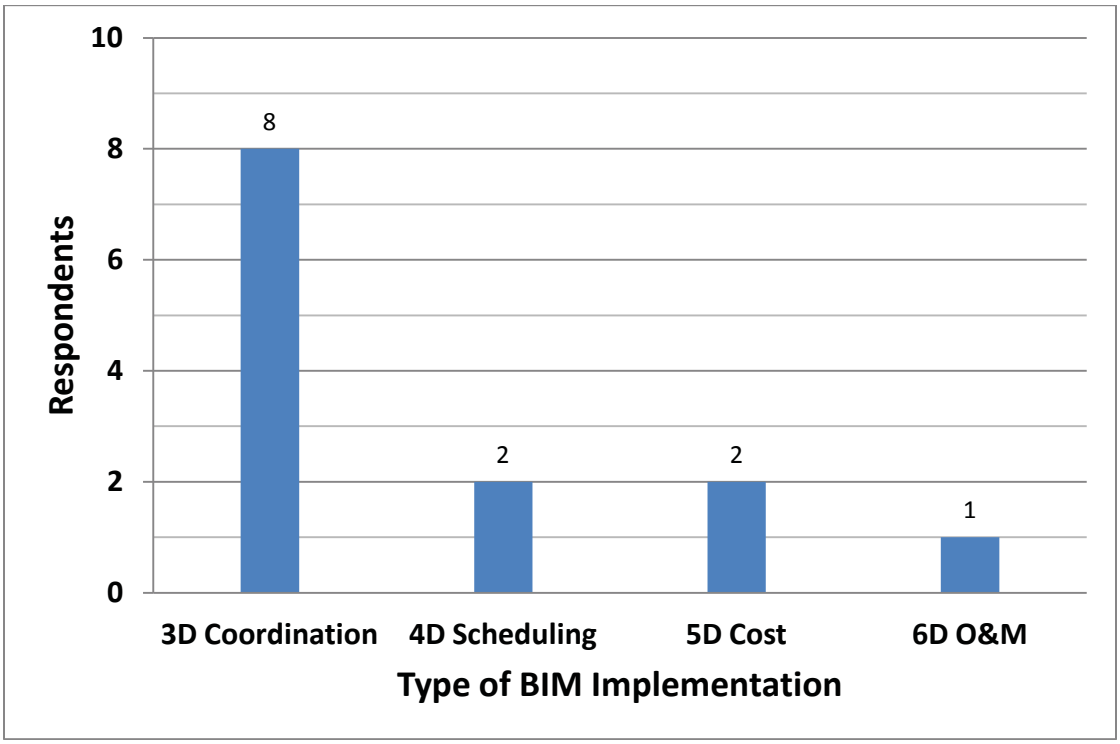

Figure 9. Type of BIM implementation in undergraduate curriculum.

4.4 BIM research

Most of the programs that had implemented BIM in the curriculum also had active research programs in BIM, which included research in the following BIM topic areas:

- Integrating BIM with laser scanning data for error/change analysis
- Using BIM based design analysis for achieving net zero energy
- BIM in Facilities Management
- BIM implementation in the Mechanical Industry
- Incorporation of safety and risk data into BIM
- Pedagogical approaches in utilizing BIM as a teaching tool
- BIM in Sustainability
- Using BIM model for supporting spatial analysis of buildings for Facility Maintenance

5. CONCLUSIONS

The response rates to the survey were encouraging; the survey yielded a xx% response rate. As interest in the implementation of BIM into educational curriculum grows, schools in the U.S. are restructuring

curriculum and hiring faculty with expertise in BIM to better prepare students for the growing demand for BIM knowledge by the industry. There was a wide range in the size of the schools that responded indicating an interest in BIM which is not limited to large schools.

Forty two percent (13) of the civil and construction engineering academic programs have implemented BIM as a response to the industry's demands and a majority of programs that had implemented BIM expected their students to have at least a basic or intermediate level of BIM knowledge upon graduation. These forty-two percent of the respondents felt that BIM was important to the AEC industry and that students graduating with knowledge of BIM were very important in satisfying industry demand.

6. REFERENCES

US GENERAL SERVICES ADMINISTRATION, 2008. *3D-4D Building Information Modelling, Series 04 - 4D Phasing, 3D-4D Building Information Modeling.*