Implementation of Building Information Modeling into Architecture and Construction Curricula

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ABSTRACT

Building information modeling (BIM) brings many benefits to the construction industry when compared to the traditional approach to design and construction. To properly prepare students, many schools are introducing BIM in their curricula as a response to the current and future needs of the construction industry. The aim of this research was to evaluate the current implementation of BIM and to identify trends in the teaching of BIM in architecture and construction academic programs. A survey that investigated the implementation of BIM into existing architecture and construction curricula was sent to architecture and construction schools in the U.S. The survey results indicated that both architecture and construction schools either have an interest in or have already implemented BIM into their curriculum. The majority of the schools expected students to have a basic knowledge of BIM upon graduation, perceived BIM as important to industry, and planned to fully integrate BIM into their curriculum. The results show that more architecture than construction schools implemented BIM into curriculum. Construction schools were more likely to use four-dimensional (4D) and five-dimensional (5D) models in teaching construction scheduling and estimating when compared to architecture schools.

Keywords: BIM, construction, architecture, 3D coordination, Estimating, Scheduling, Education

1. INTRODUCTION

Nowadays building information modeling (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 construction industry, many schools are introducing BIM in their curricula and hiring new faculty based on their expertise in BIM.

The extent of BIM implementation in architecture and construction curricula at universities in the U.S. has not been fully determined yet. 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 architecture and construction education programs.

2. BACKGROUND

Colleges and universities in the U.S. recognized the need for CAD and began implementing CAD courses into curricula in the 1980s. Although CAD has been one of the primary design tools, BIM is becoming more utilized due to its 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 architectural and construction programs has been vital for the advancement and preparation of students. Students are expected to understand project drawings, quantity take-offs, cost estimating, and scheduling. One of the largest challenges faculty face in teaching BIM is promoting integration of different areas within curriculum.

3. METHODOLOGY

A survey was developed to investigate the implementation of BIM into existing architecture and construction curricula. The survey was made accessible in fall 2010 to invited respondents from Association of Collegiate Schools of Architecture (ASCA) and American Council for Construction Education (ACCE) 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) School's philosophy of BIM implementation (plan to implement, introduce/become familiar, fully integrate, etc.).
5) Students' expected BIM knowledge upon graduation.
6) Perception of importance of BIM to industry.

Responses were received from 43 out of 119 US ASCA institutions surveyed (36% response rate) and from 38 out of 70 US ACCE institutions surveyed (54% response rate).

4. RESULTS

4.1 Demographics

A majority (82.5%) of the respondents from the construction schools and about half (51%) of the respondents from the architecture schools stated their school had between 101 and 400 students (Figure 1).

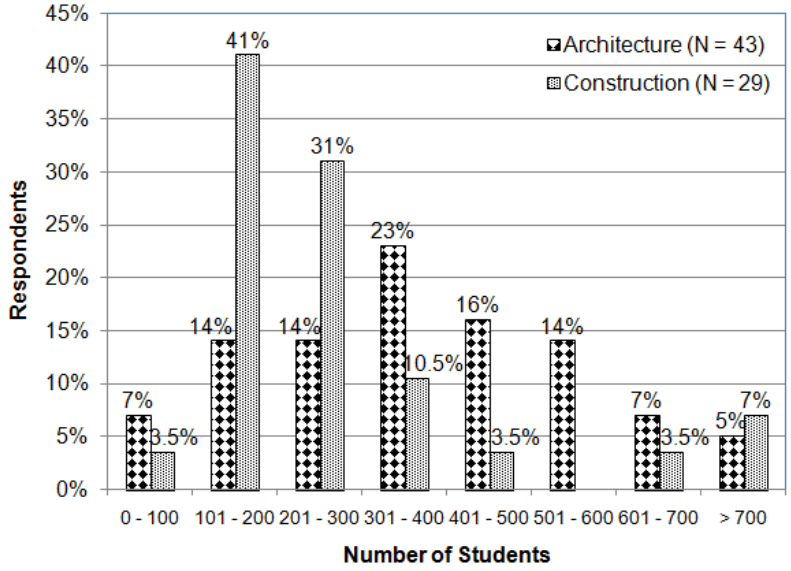

Figure 1. Student enrollment in school/department.

The respondents were asked about the position and background of the faculty teaching BIM. Regarding the position of faculty teaching BIM, nearly half (47%) of the respondents from the architecture schools stated their BIM faculty held an "Adjunct Faculty" position, while half (50%) of the respondents from construction schools stated their BIM faculty held a "Tenure Track Faculty" position (Figure 2). Note that respondents were asked to select "all that apply" when answering this question.

Regarding the educational background of the faculty teaching BIM, 37 architecture schools and 12 construction schools had BIM faculty with a background in architecture (Figure 3). On the other hand, 20 construction schools and three architecture schools had BIM faculty with a background in construction. Note that respondents were asked to select "all that apply" when answering this question.

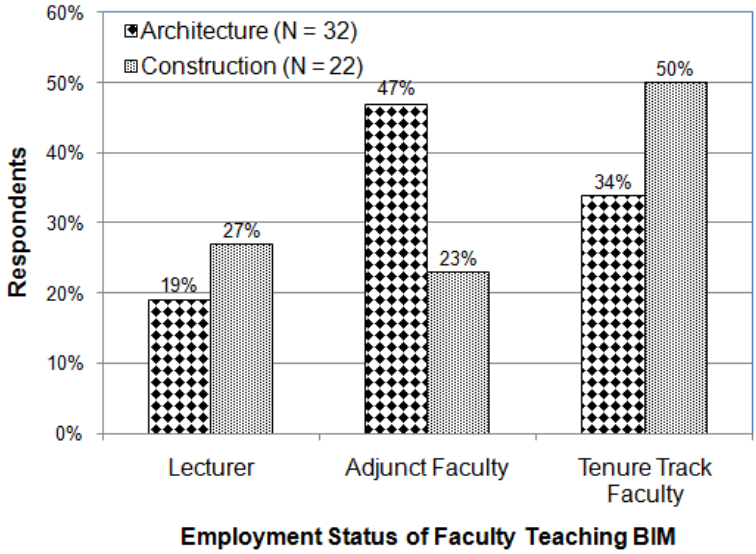

Figure 2. Employment Status of faculty teaching BIM.

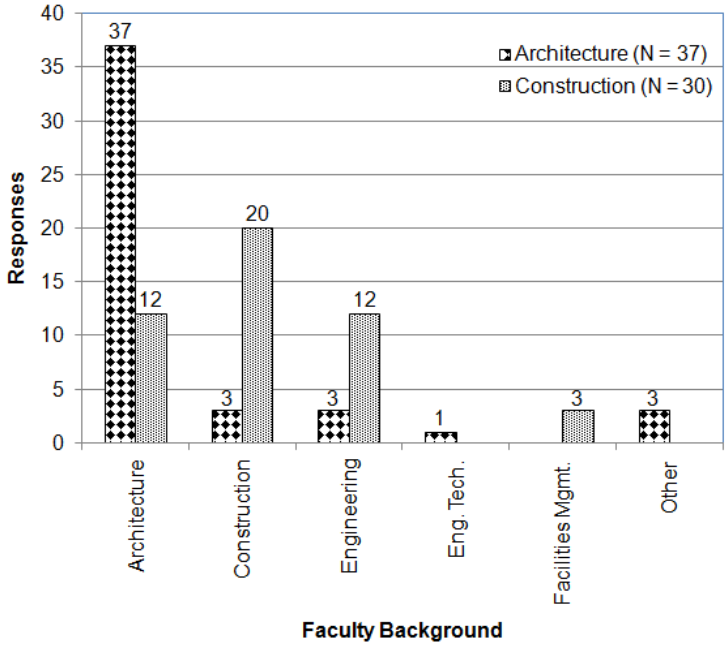

Figure 3. Educational background of faculty teaching BIM.

A majority (78%) of the respondents representing both the architecture and construction schools stated that BIM was implemented into their curriculum. A greater percentage of the respondents from the architecture schools (67%) than the respondents from the construction schools (53%) stated their program had a BIM-dedicated course as part of the existing curriculum.
The respondents were asked about the number of classes implementing BIM in their curriculum. About a third (31%) of the respondents from the architecture schools and a fifth (20%) of the respondents from the construction schools stated they had one class implementing BIM (Figure 4). Nearly half of the respondents from the architecture schools (44%) and more than a third of the respondents from the construction schools (37%) stated their program offered two or three classes that implemented BIM. Seventeen percent of the respondents from the construction schools and 5% of the respondents from the architecture schools stated their program did not implement BIM in any classes.

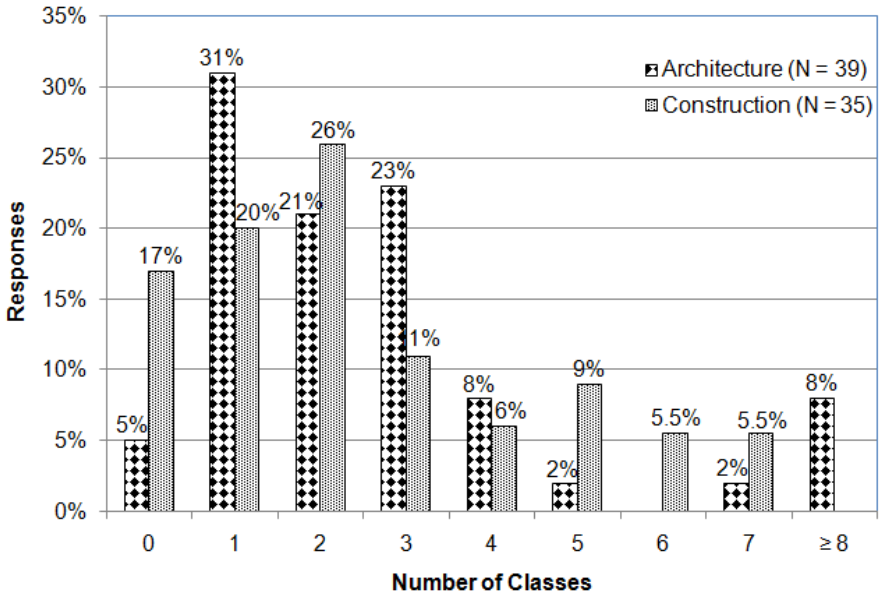

Figure 4. Number of classes implementing BIM.

Regarding the academic level of the class in which BIM was implemented in the curriculum, 21 construction schools and nine architecture schools implemented BIM in their freshman and sophomore classes (Figure 5). BIM was implemented in the junior and senior classes at 26 architecture and 27 construction schools. The largest difference was found in the responses related to BIM implementation at the graduate level. Sixteen architecture schools and five construction schools implemented BIM in their graduate level classes. Note that respondents were asked to select "all that apply" when answering this question.

4.2 BIM, Scheduling and Estimating Software Taught

Autodesk Revit was the BIM software taught in the majority of the schools, i.e., in 37 architecture schools and 30 construction schools. Graphisoft's ArchiCAD was taught in five of both the architecture schools and construction schools (Figure 6). None of the respondents from the architecture schools stated they taught VICO as compared to three respondents from the construction schools. Responses for "other" BIM software taught included Digital Project and Tekla. Note that respondents were asked to select "all that apply" when answering this question.

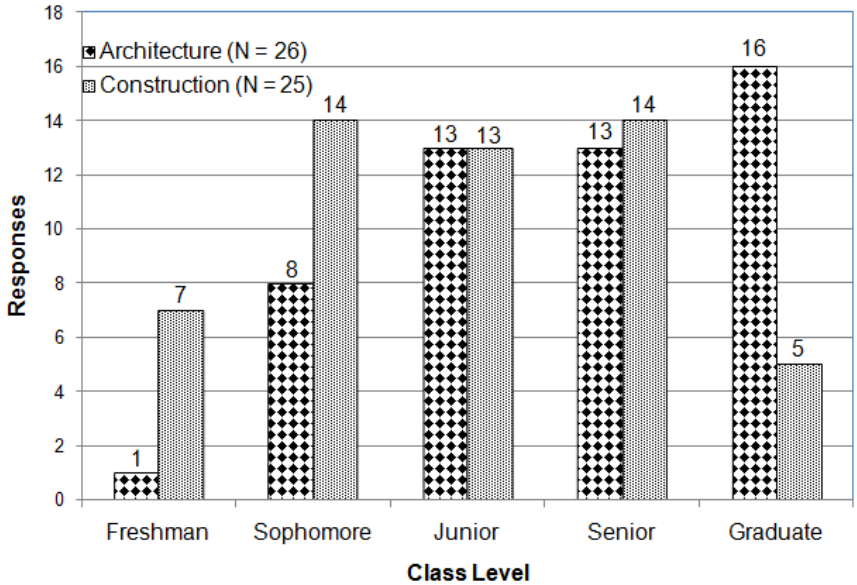

Figure 5. Level of classes in which BIM was implemented.

Primavera and/or Suretrack were the scheduling software taught in 64% of the construction schools and in 13% of the architecture schools, while Microsoft Project was taught in 29% of the construction schools and 26% of the architecture schools (Figure 7). More than half (59%) of the respondents from the architecture schools stated that no scheduling software was taught in their curriculum.

The majority (69%) of the construction schools taught Excel-based software, Timberline Precision and On Screen Takeoff estimating software (Figure 8) in their estimating classes. Fifty-seven percent of the respondents from the architecture schools stated that they did not teach any estimating software. Responses for "other" estimating software taught included Autodesk Quantity Takeoff, MC², HCSS-HeavyBid, BSD Building Systems Design, and Quick Bid software. Estimating software D4Cost or HardDollar was not taught in any of the schools.

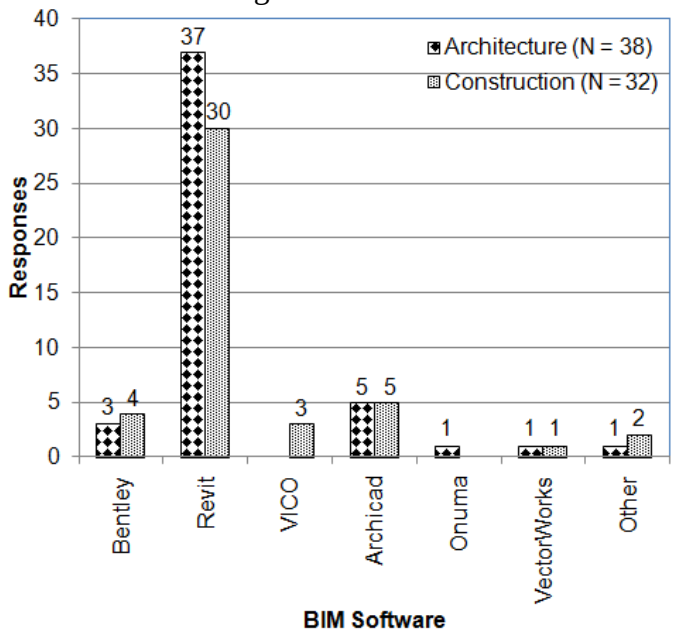

Figure 6. BIM software taught.

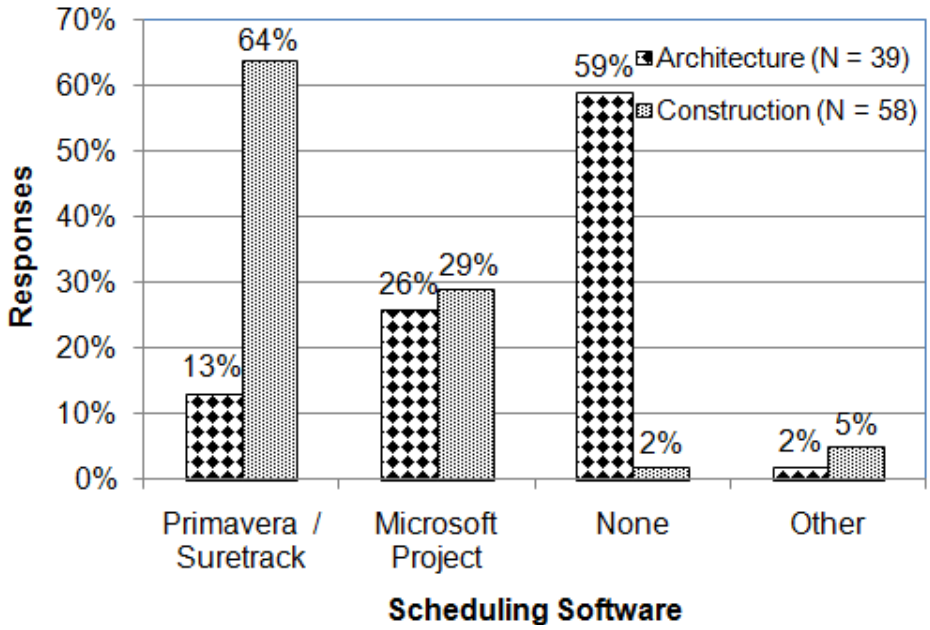

Figure 7. Scheduling software taught.

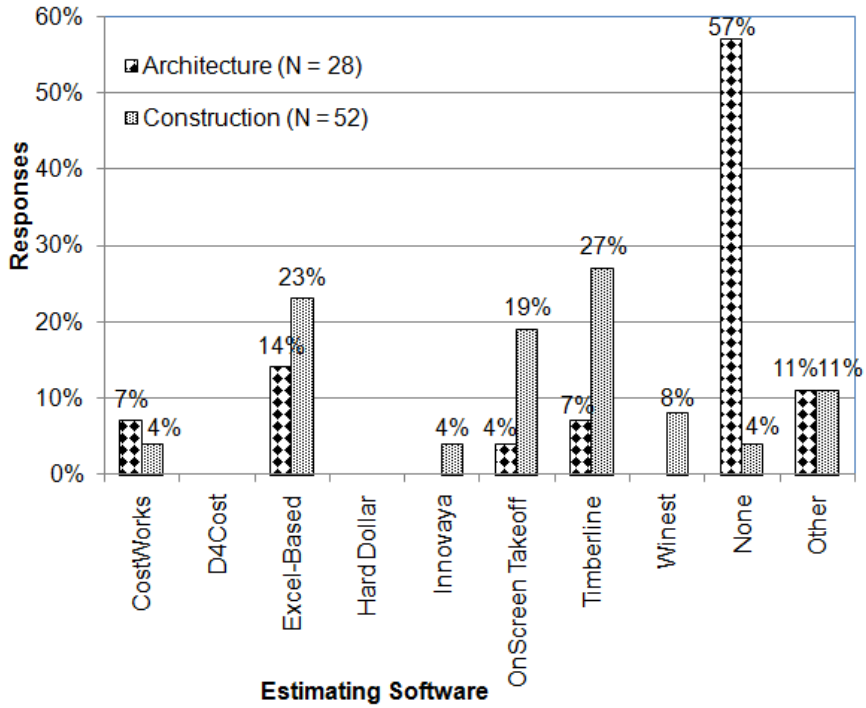

Figure 8. Estimating software taught.

4.3 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

(59%) of the respondents from the architecture schools and more than a third (37%) of the respondents from the construction schools stated that in their schools BIM was used for 3D modeling (Figure 9). Half (50%) of the respondents from the construction schools and about one fifth (17%) of the respondents from the architecture schools stated that in their schools BIM was used for 4D, 5D, and 6D modeling. Responses for "other" types of BIM implementation included visualization, simulation, clash detection, value and life-cycle issues, and exploration of architectural design possibilities.

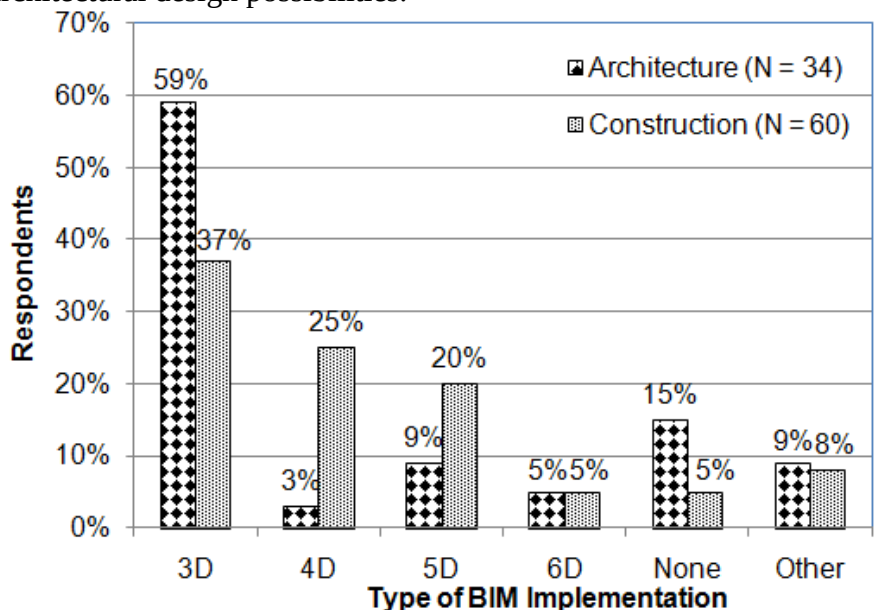

Figure 9. Type of BIM implementation in undergraduate curriculum.

Regarding the graduate curriculum, more than half (53%) of the respondents from the architecture schools and about one fifth (18%) respondents from the construction schools stated that in their graduate program BIM was used for 3D modeling (Figure 10). Nearly half (45%) of the respondents from the construction schools and about one third (31%) of the respondents from the architecture schools stated that in their graduate program BIM was used for 4D, 5D and 6D modeling. More than a third of the respondents from the construction schools selected "none" as an answer to this question. Responses for "other" types of BIM implementation included energy modeling and analysis.

A similar percentage of the respondents from the architecture schools (23%) and from the construction schools (29%) stated that they use BIM models to teach the coordination process. More than one third (35%) of the respondents from the construction schools and 7% of the respondents from the architecture schools stated that they used 4D models to teach construction scheduling. Nineteen percent of the respondents from the construction schools and 10% of the respondents from the architecture schools stated that they used 5D models to teach construction estimating.

5. CONCLUSIONS

The response rates to the survey were encouraging; the survey yielded a 36% response rate for the architecture schools which were ACSA members and a 54% response rate for the construction schools which were ACCE members. As interest in the implementation of BIM into educational curriculum grows, schools in the U.S. are restructuring curriculum and hiring

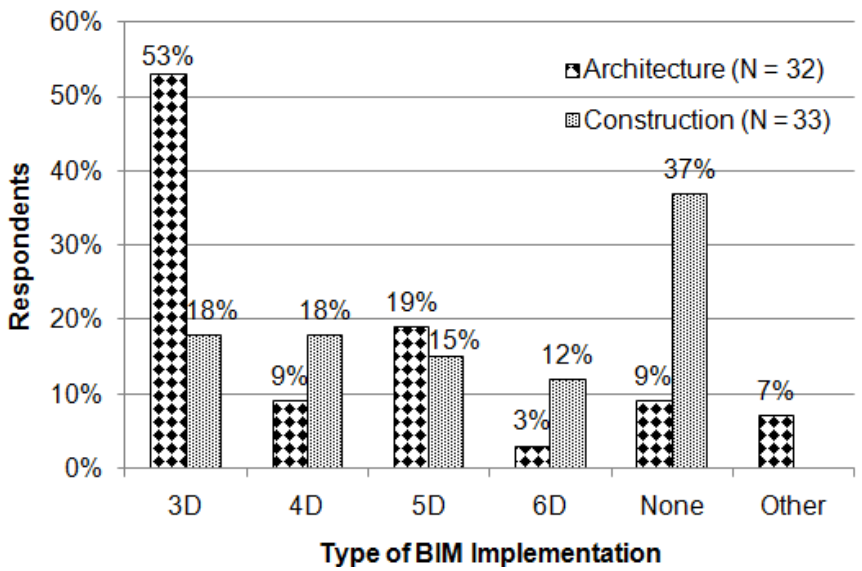

Figure 10. Type of BIM implementation in graduate curriculum.

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**.** Nearly half of the architecture schools had BIM faculty in an "Adjunct Faculty" position, while half of the construction schools had BIM faculty in a "Tenure Track Faculty" position. A greater percentage of the architecture schools than the construction schools had BIM faculty with a background in architecture, while a greater percentage of the construction schools than architecture schools had faculty with a background in the construction**.**

While a comparable percentage of the architecture and construction schools implemented BIM into their curriculum, a greater percentage of the architecture schools than the construction had a BIM-dedicated course as part of existing curriculum and implemented BIM into existing courses. Nearly half of the architecture schools and more than a third of the construction schools had two or three classes which implemented BIM. A greater percentage of the construction schools than the architecture schools implemented BIM at the freshman level, while a greater percentage of the architecture schools than the construction schools implemented BIM at the graduate level.

Construction and architecture schools are implementing BIM as a response to the industry's demands; the majority of schools that participated in the survey expected students to have a basic or intermediate level of BIM knowledge upon graduation. The majority of respondents from both the architecture and construction schools felt that BIM was important to industry and that knowledge of BIM was important in satisfying industry demand.