The Implementation of BIM application in University Teaching: Case Study of Construction Management Program

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Construction Management students are the future driving forces of the construction industry advancement. The purpose of this research is to analyze the students' perception of the Building Information Modeling (BIM) application in the construction management program in a university. This study investigates five major aspects of students' perceptions toward a BIM application including, (1) the source of knowledge of BIM; (2) the perception of the BIM software applications with a level of competency; (3) the awareness level of BIM to get a job in the construction industry; (4) the perception of BIM-related jobs; the perception of the future of BIM in the construction industry; and (5) the importance of BIM education within the CM degree program and CM undergraduate capstone projects. Thus, this study conducted a survey with different levels of construction management students. Adopting the student population from Kennesaw State University as the case study, this research initiated a questionnaire-based approach followed by statistical analysis. The research from the student perspective would address perceptions of BIM implementation, especially construction management students' opinions related to BIM implementation and help to get feedback from industry opinion to implement into the curriculum.

Keywords: Building information modeling; BIM implementation; BIM teaching; curriculum development; construction management

Introduction

Building Information Modeling (BIM) has brought tremendous opportunities to enhance the project performance (e.g., cost, schedule, and quality) architecture, engineering, and construction (AEC) industries by its adoption into project activities and establishing collaborative working practices. According to McGraw Hill Construction's SmartMarket Report, the report indicated that the number of construction firms, reporting engagement with BIM grew by 45% between 2009 and 2012 [1]. In addition, BIM users in the United States increased by three-quarters (75%) of users by 2015 [2]. With significant demand for BIM in the construction, several universities have continually incorporated the BIM curriculum in their education. Since institutional education plays a pivotal role in transforming a BIM learner to a BIM industry practitioner, students' perception in BIM implementation is critical to connecting institutional BIM education with industry practical needs [3]. The purpose of this research is to analyze the degree of competence in using and understanding Building Information Modeling (BIM) among the construction undergraduates at the Kennesaw State University, from the beginning of their degrees until they get their first jobs. To achieve this, a questionnaire-based survey was conducted followed by statistical analysis.

BIM Implementation in academic organizations has been investigated by several studies. For example, Woo studied students' perception of BIM implementation in construction educational environments [4]. The author identified the key pedagogical challenges in utilizing the BIM software, such as the level of knowledge required to use Revit, lack of reference materials, and intelligent error detection and correction in the Revit software. Besides, a study conducted by Clevenger et al. [5] conducted the exploratory study to evaluate the student's perception in the BIM adoption in the construction management curriculum and used students' perception of BIM modules in their curriculum. The authors concluded that the exploratory study of students' perceptions provides motivations for integrating BIM in the construction management curriculum. Moreover, Azhar et al. analyzed perceptions of students in an ACCE accredited construction program who completed a BIM centered capstone project (thesis) at the culmination of their undergraduate degree [6]. Through the survey with students who completed the BIM in the undergraduate capstone project, the authors found that the students lack understanding of all aspects of the BIM technology and the BIM

allows them to improve their skills of the BIM technology. The authors noted that embedding BIM in the undergraduate capstone project is critical to keep students current with the industry.

Wu and Issa explored the relationship between BIM education and student career development [7]. Through the survey with the educational and professional communities, the authors showed that there is significant attention in BIM adoption and implementation in educational and professional communities. The authors also concluded that a gap exists between college BIM education and the expectations from the AEC industry and recommended that a strong partnership between the educational and professional communities is required to improve the college BIM curricula to bridge the gaps between theory and practice.

Shelbourn et al. conducted a qualitative approach with the focus groups (i.e., interior design, architecture, and construction science students) in the U.K. and U.S. to study the students' perceptions of their education in collaboration and BIM [8]. The authors identified key pedagogical challenges, such as collaborative activities, relevance to the industry, and role of the professor/lecturer, for teaching and learning collaborative working and BIM at the university level. The authors provided several pedagogical recommendations, identified from the focus session, for the BIM education. For instance, the authors noted that the construction project management students need to know how to interact with BIM and use it for construction projects.

Moreover, Suwal and Singh analyzed the students' perception of online BIM learning platforms and BIM tools through the interviews, surveys, and group discussions with civil engineering students [9]. The authors found that the online BIM learning platforms can lead to the improvement of student engagement in the BIM learning activity and the positive outcome of BIM assignments. Furthermore, the authors identified key positive factors in implementing online BIM platforms, including easy access to BIM learning materials and contents, improved student learning by linking all relevant information and activities, and high usability with assistance.

Jin et al. surveyed with students in three different universities about students' perceptions of BIM's functions, BIM's usefulness to multiple AEC professions (e.g., structural design), desired BIM-related industry jobs (e.g., BIM coordinators), and challenges in BIM practices [3]. This study found that the students have more positive perceptions regarding BIM functions as a project management tool and a digital platform for interdisciplinary collaboration rather than as a 3D visualization tool. Also, the authors noted that an education program/curriculum of BIM should cover the different aspects of BIM (e.g., architecture design, structural design, and construction project management) to help students prepare their future careers in the AEC industry.

Sanchez et al. studied students' perceptions of the BIM implementation in the degree in industrial engineering through the survey and multiple regression analysis, this study identified the advantages and difficulties of BIM implementation [10]. The authors found that the BIM implementation is significantly correlated with skill acquisition (i.e., teamwork skills), which indicated that BIM implementation can improve students' teamwork skills. Moreover, the author noted that the incorporation of BIM in the curricula should be encouraged because it increases the degree of student participants.

The main synthesis of this research is to analyze the students' perception of the Building Information Modeling (BIM) application in the construction management program in a university. This study investigates five major students' perceptions of BIM application. These five investigations are: finding the first source of knowledge of BIM; the perception of the BIM software applications with a level of competency; the awareness level of BIM to get a job; and the importance of BIM education within the CM degree program and CM undergraduate capstone projects. This study surveyed with different levels of construction management students

Methodology

This study conducted a survey with the different levels of students (i.e., freshman, sophomore, junior, and senior levels) in the construction management (CM) department in the university to identify the importance of BIM coursework familiarity and competency. The survey was developed to examine five major aspects of students' perceptions toward a BIM application including: (1) the source of knowledge of BIM; (2) the perception of the BIM software applications with a level of competency; (3) the awareness level of BIM to get a job in the construction industry; (4) the perception of BIM-related jobs; the perception of the future of BIM in the construction industry; and (5) the importance of BIM education within the CM degree program and CM undergraduate capstone projects.

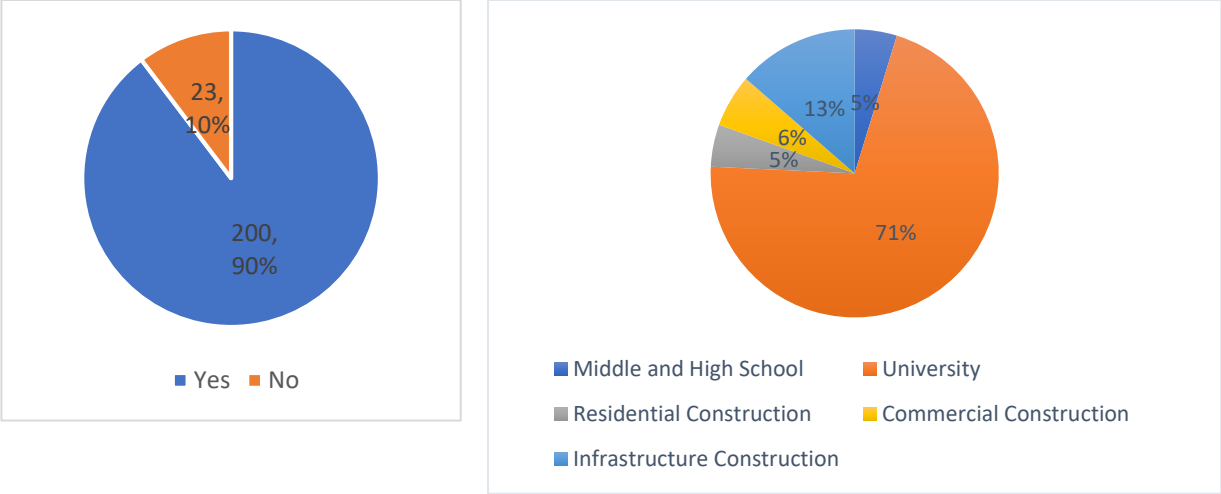
The survey consisted of questions that were multiple choice. The survey questions were designed in such a manner that the respondents could complete the survey within 10 minutes, provided they possessed all the answers. The survey respondents were undergraduate students from University. Students respondents were undergraduate students from freshman, sophomore, junior, and senior levels. The most relevant questionnaire to implement BIM application on the construction degree program is shown below.

1. Please select where you have heard BIM?
2. Your familiarity with BIM.
3. On the scale of 1 (lowest) – 5 (highest) please rate your competency of using BIM.
4. Do you think that you should learn BIM application in your university degree program?
5. Do you think that the BIM component should be incorporated into the capstone project?
6. What do you use BIM for?
7. Do you think that you will be a BIM user in the coming years?
8. Do you think that it is important to learn BIM to get a job in the construction industry?
9. Most relevant BIM-related job positions.
10. How you forecast future usage of BIM in the construction industry?

Results Analysis and Discussion

A total of 224 students responded to the survey. The results of the survey showed that the majority of the male respondents were 192 (86%) and female respondents were 31 (14%) from the CM program. To determine the level of studies and degree program, respondents were asked, "In which year you are enrolled currently?" The largest group, 38% or 84 of the 224 respondents, are seniors. 39 (17%), 35 (16%), and 65 (29%) respondents were freshman, sophomore, and senior students respectively.

To investigate the students' first exposure to BIM, the students were asked to answer the following questions: "Have you heard BIM (Building Information Modeling) in the last ten years?" and "Please select where you have heard BIM?" The result indicated that 90% of the respondents heard BIM and 71% of the respondents who knew BIM, heard it at University. Figure 1 shows the results of the survey regarding the students' first exposure to BIM.



A. Have you heard BIM (Building Information Modeling) in the last ten years?

B. Please select where you have heard BIM?

Figure 1: Students' first exposure to BIM

To determine the students' familiarity and competency with BIM, students in the CM program were asked to evaluate and rate their familiarity and competency of BIM on a scale of 1 (lowest) – 5 (highest). Figure 2 shows the students' familiarity and competency level with BIM. The results of the BIM familiarity and competency indicated that many of the responded students had the average and low levels of the BIM familiarity and competency. The level of the students' familiarity along with competency increased as the students progressed from Freshman to Senior level as shown in Figure 3. The students at the freshman level have more familiarity with BIM than competency. However, the students at the senior level have a higher level of the BIM competency than the familiarity. It can be concluded that as a student approaches the senior level, the students' competency of the BIM application tends to increase. Table 1 shows mean and standard deviation (SD) of BIM familiarity and BIM competency of freshman (39 students), sophomore (35 students), junior (65 students), and senior (85 students). Data distribution is normal and consistent because more than 68 percent of the SD data values are within one standard deviation of the mean. Figure 3 shows the mean BIM familiarity and competency with SD Bar. Average BIM familiarity and average BIM competency from all levels of student groups are calculated as 2.10 and 2.19 respectively. Figure 4 shows the percentage of BIM familiarity and BIM competency based on reference to average data. Junior students have BIM familiarity and competency are close to average. Freshman students have BIM familiarity and competency below 29% of average familiarity and below 34% of average competency. Senior students have BIM familiarity and competency above 28% of average familiarity and above 42% of average competency.

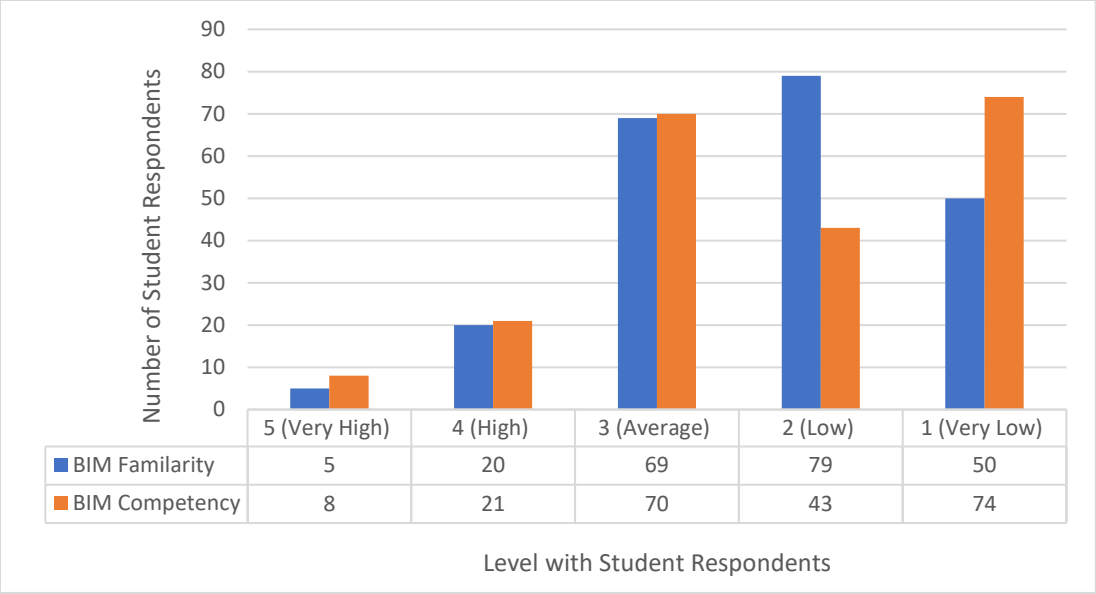


Figure 2: BIM Familiarity and Competency Level

Table 1: Mean and Standard Deviation Data of BIM Familiarity and BIM Competency

CM Degree	Familiarity Mean	Competency Mean	Familiarity SD	Competency SD
Freshman - BS	1.564	1.395	0.68	0.82
Sophomore - BS	2.088	1.848	0.97	0.97
Junior - BS	2.292	2.172	0.91	1.12
Senior -BS	2.812	2.975	0.93	0.95

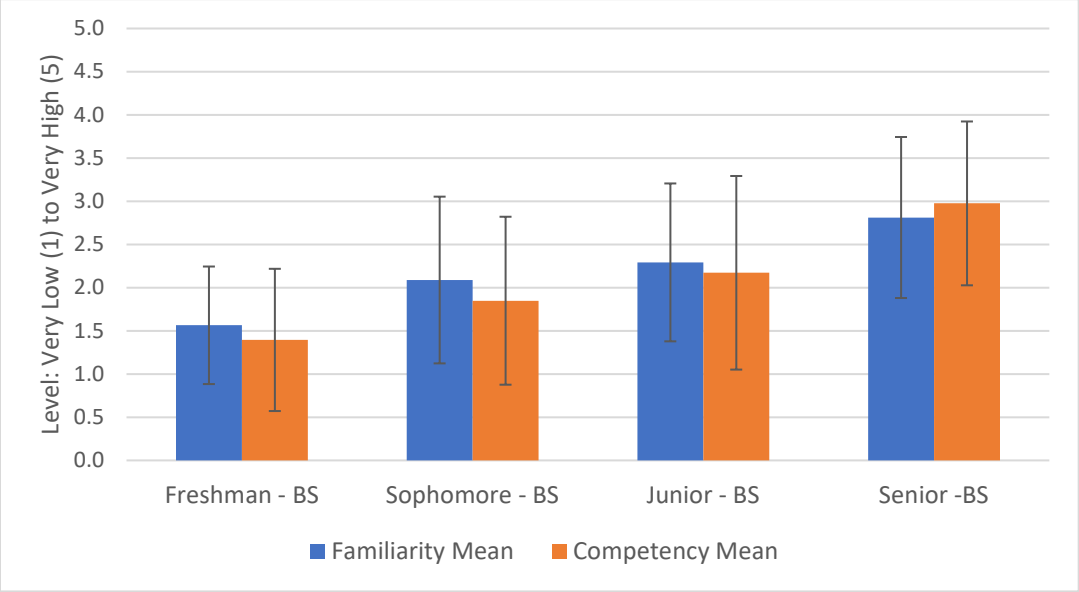


Figure 3: Average BIM Familiarity and Competency with Standard Deviation Bar

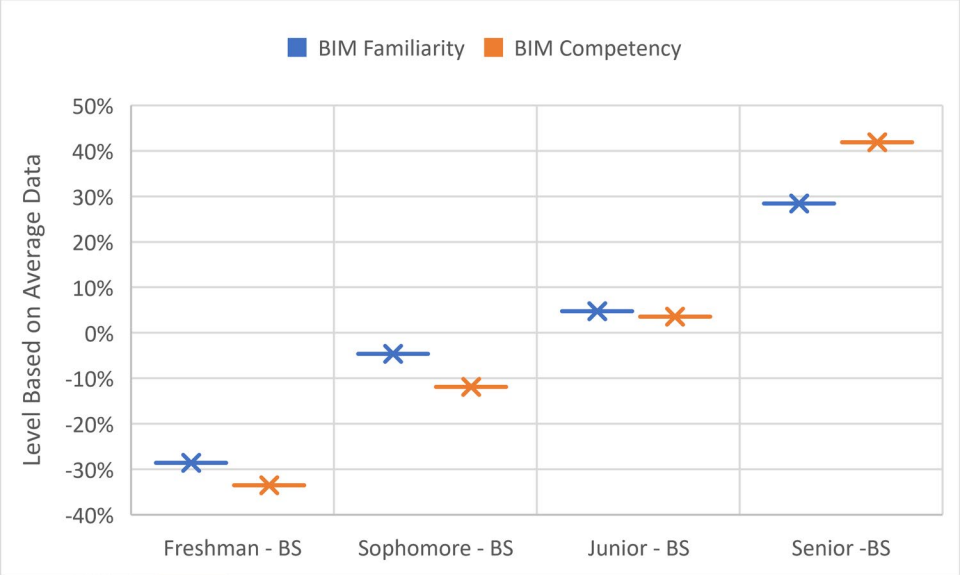


Figure 4: Percentage of BIM Familiarity and BIM Competency Reference to Average Data

To determine the students' perception of the BIM application in the CM program and the CM capstone project, the students were asked to answer questions, including "Do you think that you should learn BIM application in your university degree program?" and "Do you think that BIM component should be incorporated into capstone project?". Figure 5 shows the results of the student's perception of the BIM application in the CM program and the capstone project. The results indicated that the majority of the students (107 respondents and 52 respondents out of 224 students) strongly agreed for the incorporation of BIM in the CM degree program and a capstone project. BIM usage by the students corresponds closely to their level of competency.

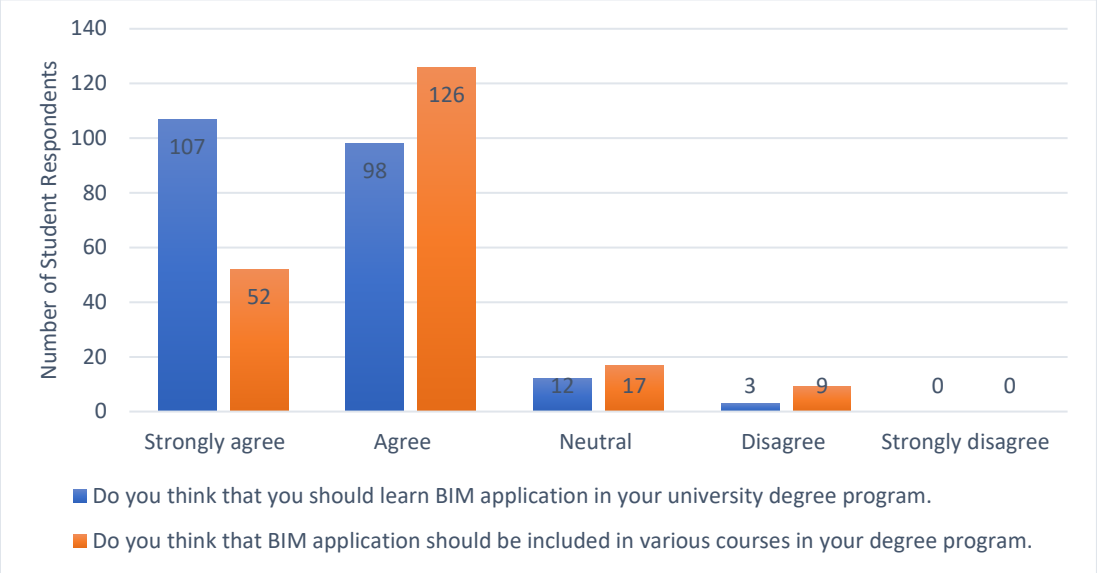


Figure 5: BIM application in degree program and capstone project

The responses of the students 'perception of BIM usage is shown in Figure 6. The Students' perceived BIM usage as follows a) Architecture Model is 103, b) Structural Model is 102, c) Mechanical is 59, d) Plumbing Model is 59, e) Quantity take off is 53, f) Cost Estimate is 58, g) 4D Modeling is 51, h) Clash Detection is 48, i) Project Coordination is 44, j) Electrical Model is 29, k) Low Voltage Model is 19, l) None of the above is 63. Most respondents rated their competency as average on architecture and structural model. As the BIM competency level increases, the students able to apply more application of BIM.

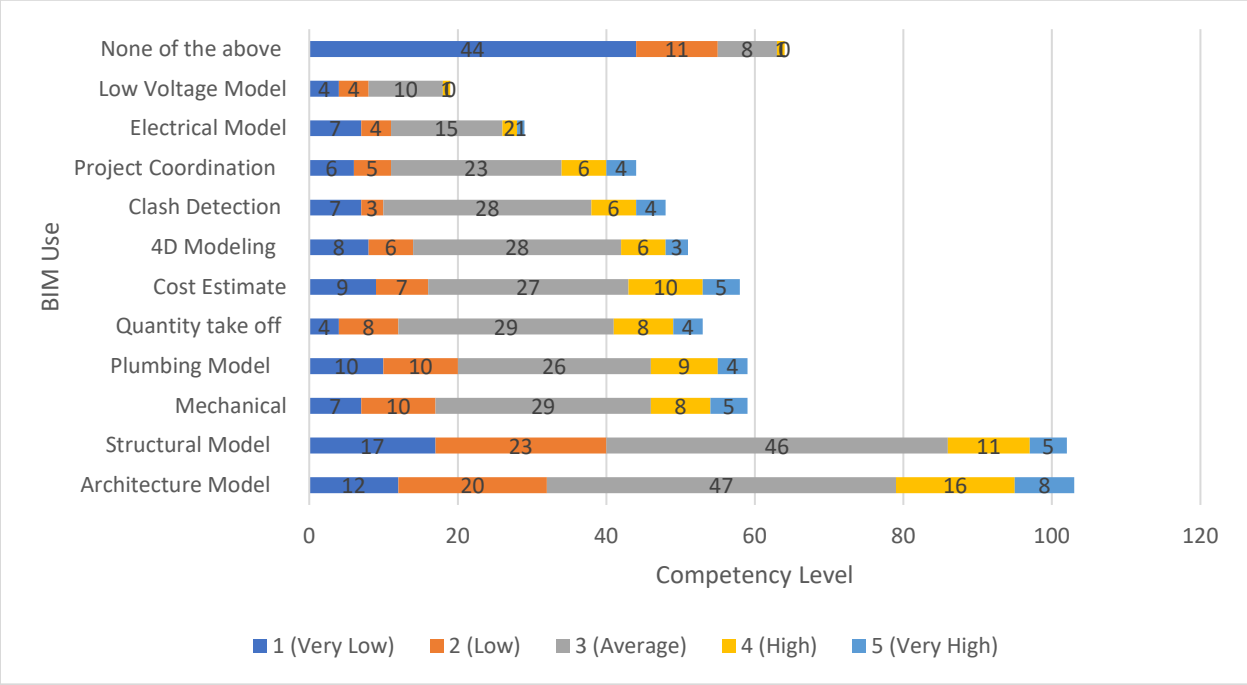
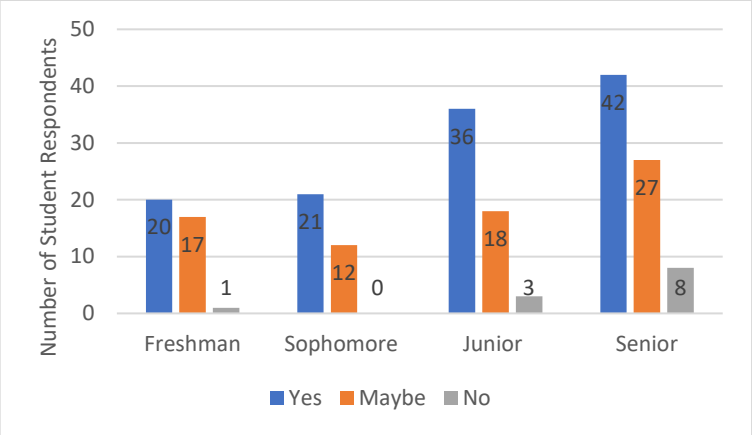
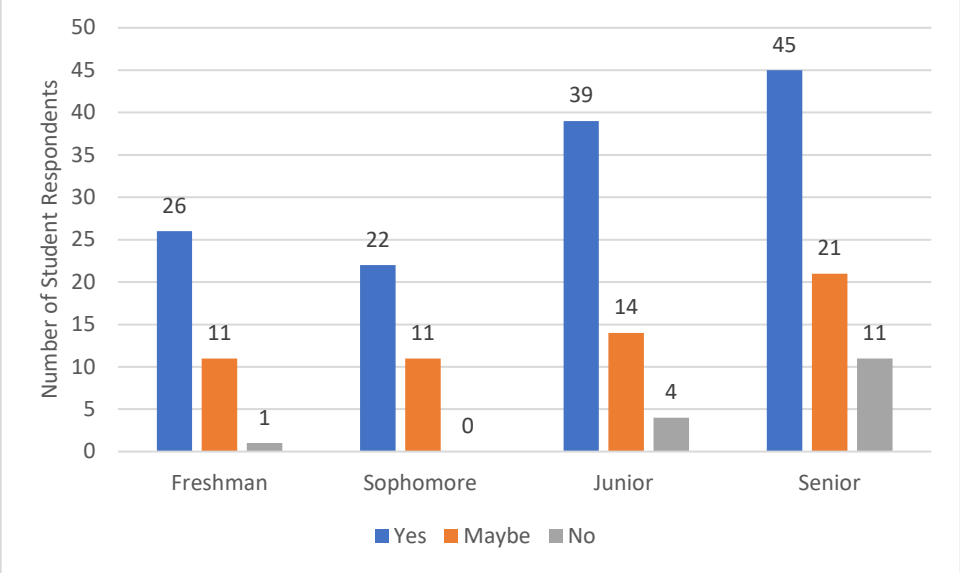


Figure 6: Usage of BIM application along with Competency level

To investigate the level of the students' awareness of BIM across the construction profession, the students were asked to answer the following questions, "Do you think that you will be a BIM user in the coming years?" and "Do you think that it is important to learn BIM to get job in the construction industry?". The results of the level of the students' awareness of BIM with the different levels of students (i.e., freshman, sophomore, junior, and senior levels) are presented in Figure 7 (A). The students in the junior and senior levels showed a more positive outlook on BIM users in the coming years than the students in the freshman and sophomore levels. As shown in Figure 7 (B), the result indicated that the students in the junior and senior levels have a higher awareness level of the BIM education in getting a job in the construction industry, compared to the awareness level of the students in the freshman and sophomore levels. It can be concluded that the students in the junior and senior levels have a higher level of competency and familiarity with BIM and a higher level of understanding of the BIM application than the students in the freshman and sophomore levels.



A. Do you think that you will be a BIM user in the coming years?



B. Do you think that it is important to learn BIM to get job in the construction industry?

Figure 7: Importance of learning BIM during Undergraduate Years

This study also investigated the students' perception of BIM-related jobs. The students were asked to answer the following question, "Most relevant BIM related job positions". As shown in Figure 8, respondents reported BIM relevant job positions are a) Architecture, b) Construction Manager, c) Pre-construction Engineer d) BIM Specialist/ BIM Manager e) BIM Modeler /CADD Drafter, f) Structure Engineer, and g) Virtual Designer. It is indicated that the students in the junior and senior levels have a higher level of familiarity and understanding of BIM related job positions than Freshman and Sophomore. The results of the students' perception of BIM-related jobs showed that the foremost known job position is a construction manager and the least known job position is a virtual designer. Moreover, it can be concluded that the students have higher formality with architecture job and construction manager positions with BIM related jobs.

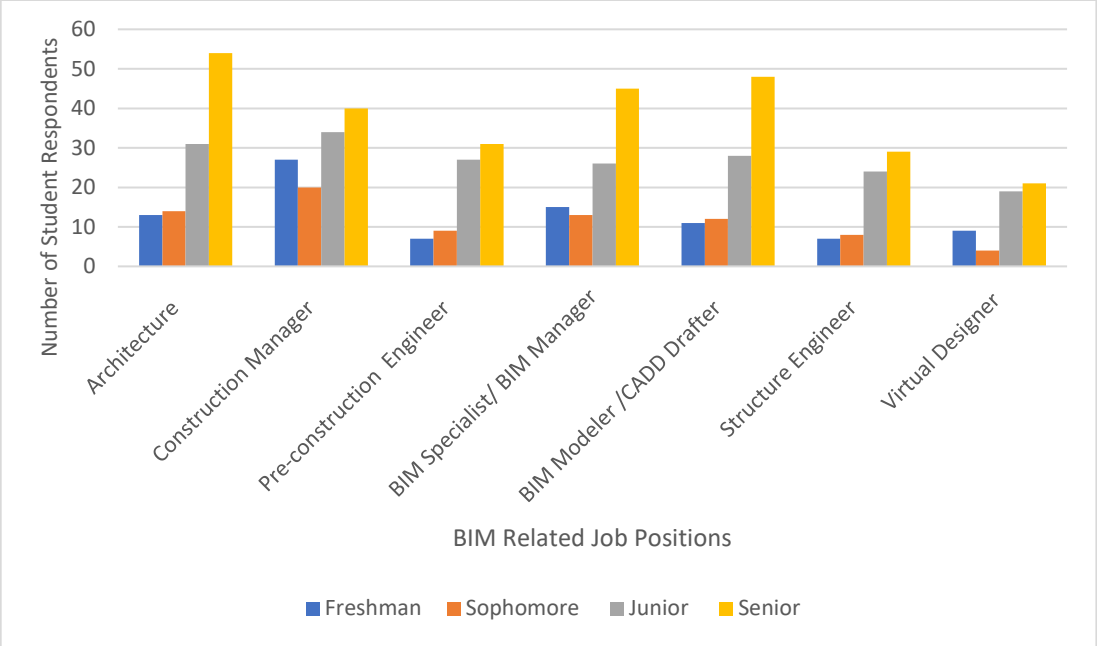


Figure 8: BIM relevant job positions respondent along Undergraduate Years

Conclusion

The research analyzed the students' perceptions of the BIM application in the construction management program in a university. This study investigates five major aspects of students' perceptions toward a BIM application including, (1) the source of knowledge of BIM; (2) the perception of the BIM software applications with a level of competency; (3) the awareness level of BIM to get a job in the construction industry; (4) the perception of BIM-related jobs; the perception of the future of BIM in the construction industry; and (5) the importance of BIM education within the CM degree program and CM undergraduate capstone projects. The result indicated that a) 90% of the respondents heard BIM and 71% of the respondents who knew BIM, heard it at University and b) most of the responded students had the average and low levels of the BIM familiarity and competency. The level of the students' familiarity and competency with BIM increased as the students progressed from Freshman to Senior level. The results indicated that the majority of the students (107 respondents and 52 respondents out of 224 students) strongly agreed for the incorporation of BIM in CM degree program and a capstone project.

Most respondents rated their BIM usage competency as average on architecture and structural model. As the BIM competency level increases, the students can apply to use more applications of BIM. The students in the junior and senior levels have a higher awareness level of the BIM education in getting a job in the construction industry, compared to the awareness level of the students in the freshman and sophomore levels. It can be concluded that the students in the junior and senior levels have the higher level of competency and familiarity with BIM and the higher level of understanding of the BIM application than the students in the freshman and sophomore level. Most respondents (about 78%) rated their forecast future usage in the construction industry would be increased. Based on the student response, the BIM curriculum should be improved and expanded because that would be more demand from the industry. Overall, the research from the student perspective would address perceptions of BIM implementation, especially construction management students' opinions related to BIM implementation and help to get feedback from industry opinion to implement into the curriculum.

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