Implementing Collaborative Learning Platforms in Construction Management Education

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Abstract –

Over the last few decades, the investments in more complicated construction projects, involving multiple disciplines and different teams, have increased the need for more complex communication means. The purpose of communication methods is to ensure higher levels of coordination between project participants (owners, architects, engineers, contractors, suppliers, etc.). Adequate communication brings many benefits to a project, such as improved team performance due to information exchange, increased knowledge of other participants' skills or their availability. Building Information Modelling (BIM) has the ability to aggregate information on construction projects and facilitate the design, construction, and facility management processes. Therefore, including BIM classes in construction management education is of utmost importance for the success of students. Moreover, introducing cloud collaboration to these classes helps students better understand the collaborative aspect of the construction industry. The purpose of this paper is to study the benefits of Autodesk Next Gen BIM 360 brought to a graduate BIM class. Students of this class were divided into groups and asked to model the different disciplines of a project using Autodesk Revit© while collaborating the project on Next Gen BIM 360. At the end of the semester, students reported the benefits and drawbacks of Next Gen BIM 360. The benefits included the ease of use of the platform, better communication of ideas and concerns using Next Gen BIM 360 cloud services, real-time collaboration opportunities, and model coordination on the cloud.

Keywords –

BIM; Next Gen BIM 360; Collaboration; Construction; Education

1 Introduction

The construction industry is very dependent on information exchange between project stakeholders, as communication is imperative for the success of construction projects. The structure of the industry is very much fragmented, and it involves numerous data-intensive processes through the lifespan of projects [1]. Typically, massive amounts of data which need to be continuously updated and synchronized are generated across the entire lifecycle to achieve better project outcomes [2]. Seeing as construction projects comprise complex activities interconnected with these vast amounts of data, collaboration between team members is highly essential to ensure successful completion of these projects. However, seamless collaboration and information exchange continue to be a challenge for the industry despite great efforts dedicated to understanding and improving these processes [3]. With the advancements in information technology, the construction industry has gradually shifted towards more collaborative working practices based on BIM. Collaboration is a process of teamwork and information dispersion through communicating, coordinating, networking, and exchanging in order to maximize the group effort of the project stakeholders [4].

In recent years, collaboration technologies have evolved through research efforts to increase the efficiency of information communication. The utilization of cloud-based technologies to realize the integration of all project phases has increasingly grown to be a widespread practice in project management, making the communication of more cumbersome information probable [4]. Through the use of these collaborative technologies, long-distance communication is made possible, and project stakeholders are not confined to an actual workstation next to each other. Consequently, collaboration, communication, and teamwork skills are ever more crucial in the construction workforce today [5]. Thus, there is an opportunity for institutions of higher learning

to incorporate collaborative learning into their curricula in order to equip students with essential employability skills and to also enhance their engagement in the classroom. This paper explores the use of Autodesk Next Gen BIM 360 as a collaborative learning platform in construction management education to enhance the learning experience of students.

2 Literature Review

2.1 BIM in Education

BIM is an intelligent three-dimensional model-based process capable of combining the dispersed information shared between project stakeholders [6]. For this reason, BIM has been customarily implemented on construction projects to address several of the problems confronting the industry such as budget overruns, contingencies in schedule forecasts, safety, and overall quality of the project [7]. In the last few years, BIM has been used as a collaborative platform in projects to magnify the quota of data shared between the various parties involved in construction. Taking into account the high potentials of BIM and the several advantages to its implementation on construction projects, the technology can be employed as an educational tool in institutions of higher learning. For instance, construction jobsites can be virtually incorporated into classrooms with computer-generated models hosted in virtual environments that simulate design and construction processes. With BIM-based instructional techniques, educators are capable of equipping students in the architecture, engineering, construction, and operations (AECO) fields with the required skills and abilities necessary to complete construction tasks successfully, by eliminating inadequacies from the lack of practical exposure to real-time jobsite situations [8]. Computer and information technologies significantly impact the skills and educational successes of students as they foster collaboration between instructors and students, ultimately enhancing problem-solving and inquiry skills in the students [9].

Additionally, some government protocols require that public construction projects are commissioned with BIM, leading to a rise in demand of BIM specialists in the construction workforce. As a result, several approaches to encourage institutions of higher learning to integrate BIM into the curricula of both undergraduate and graduate courses [10, 11, 12]. Research has shown that BIM can be implemented as an instructional tool for a variety of construction activities such as the operation of construction machinery, occupational health and safety, logistics planning, jobsite training, and project coordination and visualization [13, 1, 14, 15, 9].

2.2 Collaborative Learning

As established, BIM processes are multidisciplinary and require seamless collaboration and information exchange between all project stakeholders. In the construction, context collaboration can be defined as a harmonious team-based setting in which every member understands and values the contribution of others, as well as their role and responsibilities [16]. However, there is often the problem of ensuring the various disciplines, trades and companies collaborate amicably which poses an obstacle to channeling the full potentials of BIM [17]. Several researchers have tackled the issues facing BIM-enabled projects in maintaining collaboration through the lens of technology, while others consider the issue to be that of human behavior [17, 18]. Following the human behavior school of thought, the integration of collaboration philosophies into BIM courses in institutions of higher learning has been suggested as a practical solution to hostile teamwork situations in the industry [18, 19]. In the context of construction management education, collaboration can be defined as a shared, interactive process that requires the involvement of two or more participants, working collectively to attain results not easily achievable individualistically [20]. This process is commonly referred to as collaborative learning.

Collaborative learning often incorporates team-based, project-based, and problem-based learning methods in which students work together in small teams to achieve a common objective [15]. Collaborative projects characteristically simulate actual construction projects and processes with the goal of solving problems more efficiently in order to ensure better outcomes [21]. During the process, students are trained to be good listeners to their team members, as well as to regard the ideas of others with respect and uphold equivalent decision-making authority [22]. Several collaborative learning platforms can be utilized in classrooms to make the learning, designing and executing process easier [5]. Three-dimensional modeling platforms and information communication technologies can be employed to impart a clearer understanding and visualization of designs and models, and to improve communication among the students [18]. For the purpose of this study, Autodesk Next Gen BIM 360 was the platform used to facilitate collaborative learning in a construction management program.

2.3 Autodesk Next Gen BIM 360

Autodesk BIM 360 is as a cloud service that aims to connect the construction project lifecycle. BIM 360 improves construction project delivery processes by providing the tools required to evoke informed-decision making as the platform emphasizes the importance of

well-structured data that is continuously kept up-to-date [23]. BIM 360 is an inclusive project management program intended for the construction industry. Since its introduction into the industry in 2010, the portfolio expanded as a group of products designed to support construction workflows from pre-construction through handover and operations through the BIM 360 Docs, BIM 360 Glue, BIM 360 Field, and BIM 360 Plan services [24]. However, each of these services fundamentally functions as isolated products, creating a non-unified platform for communicating and sharing information.

However, at present, the BIM 360 platform has evolved from a set of separate solutions to a construction management platform that offers a more integrated, workflow-focused, "one-product" experience, called the Next Gen BIM 360. The Next Gen BIM 360 platform features a single, common data platform that allows easy access to all project information from anywhere in BIM 360 [24]. Drawings, models, and files uploaded during the design phase can be carried into the construction phase to support requests for information (RFIs), submittals, inspections and more. The platform also features a powerful insight and analytics layer that includes interactive dashboards and reporting, for informed decision making and predictive analysis. The services included in the Next Gen BIM 360 portfolio are Document Management, Design Collaboration, Model Coordination, Field Management, Project Management, and Cost Management [24].

The cloud-based platform endeavors to optimize project delivery schedules and budget while ensuring that industry standards, safety regulations, and project specifications are adhered to. The software empowers managers by allowing them to coordinate staff actions, implement workable schedules, improve communication between teams and companies, resolve issues and non-conformities; all of these in a digitalized environment with real-time information. One of the significant advantages of Next Gen BIM 360 is the fact that the software is flexible enough to accommodate different sizes and scopes of construction projects, which is one of the prime reasons for choosing the platform as a collaborative learning platform for this study.

3 Methodology

3.1 Use of Autodesk Next Gen BIM 360 in the Classroom

For the purpose of this study, the data collected is based on a sampling of students enrolled in the M.E. Rinker, Sr. School of Construction Management at the University of Florida (UF). The Construction Information Systems class offered by the Center for Advanced Construction Information Modeling (CACIM) was the class selected for the implementation of this study, which is a graduate level class covering virtual design and construction (VDC) technologies. The first eight sessions of the class demonstrate modeling concepts in Autodesk Revit®, where students are asked to complete architectural, structural, and mechanical models of a medium-scale commercial building. The remaining eight sessions of the class expound on the use of BIM for scheduling, estimating, point layouts, and visualization. In addition to the class assignments, students are expected to complete a team project which entails developing BIM models using original blueprints of educational buildings.

Since the Fall 2016 semester, the Autodesk BIM 360 has been incorporated in the class for collaboration; however, in the Fall 2018 semester, the class transitioned to the Next Gen BIM 360 platform. The study was conducted over two semesters, with participants from the Fall 2018 and Spring 2019 semesters. The breakdown of the sample size is shown in Table 1 with 47 students participating in this study. Using the Next Gen 360 platform, specifically the Document Management, Design Collaboration, Model Coordination, and Project Management modules, students had the chance to explore the multi-disciplinary coordination, clash detection, BIM data, and document management functionalities of the platform. Most importantly, the different team members were able to co-author BIM models on a single Revit® file. At the end of the semester, students were asked to evaluate the usefulness of the Next Gen BIM 360 platform, and rate their experience using the tools to collaborate and communicate.

Table 1. Study sample size

Semester	Number of Study Participants
Fall 2018	18
Spring 2019	29

3.2 Workflow

One of the class deliverables is a final project in which the class is divided into groups of four or five. Each group was given a set of two-dimensional drawings and asked to model the architectural, structural, and mechanical components of the building.

The first task for the students was to upload the drawings to Next Gen BIM 360 Document Management. In Document Management, students were able to organize the drawings into folders, and create templates that can automatically detect the sheets' numbers and names. Moreover, Document Management can

automatically detect sections and callouts on the drawings, and create hyperlinks to facilitate the navigation of large sets of drawings.

The next task required of the team project was to initiate the project on the cloud using Next Gen BIM 360 Design Collaboration. Students also created worksets to control the level of permission and the ownership of elements in the model. This facilitated the modeling process as students had the ability to grant or deny editing requests placed by other team members, which guaranteed the correct placement of the elements in the model.

During the modeling process, students also used Next Gen BIM 360 Project Management to communicate issues and RFIs. Students were able to place pushpins on the drawings and submit RFIs to the class instructor related to the drawings. Once the RFI is reviewed by the instructor, all team members were able to see the response. The Issues functionality was also used for communication among team members themselves.

Finally, before the final submission of the model, students used Next Gen BIM 360 Model Coordination. Model Coordination automatically creates clash detection tests from the models saved on the cloud. Moreover, similar clashes are grouped to facilitate the review process. Students used these clash groups to coordinate the model better and resolve clashes between the different disciplines of the project.

During the semester, a questionnaire was developed and distributed to the class. The questionnaire was a short survey that asked the following questions:

1. What did you like best about the Autodesk Next Gen BIM 360 tools?
2. What did you dislike about the Autodesk Next Gen BIM 360 tools?
3. How would you rate your experience using the Autodesk Next Gen BIM 360 tools on a scale of 1 to 5, 5 being best?

4 Results and Discussion

4.1 Benefits of Autodesk Next Gen BIM 360

At the end of the semester, students were asked to evaluate the usefulness of Next Gen BIM 360, and discuss how it enhanced their construction management education. Based on the responses of the study participants, the benefits of the Autodesk Next Gen BIM 360 tools can be categorized into six as shown in Table 2, all of which center on enhanced collaboration and communication.

Table 2. Responses of students to the benefits of Autodesk Next Gen BIM 360

Benefits	Frequency n = 47	Percentage of total
Ease of use	40	85%
Real-time collaboration	45	96%
Single data repository	38	81%
Central project collaboration	47	100%
Design review	41	87%
Model coordination	40	85%

The percentages of the responses of the participants in summarized in Figure 1.

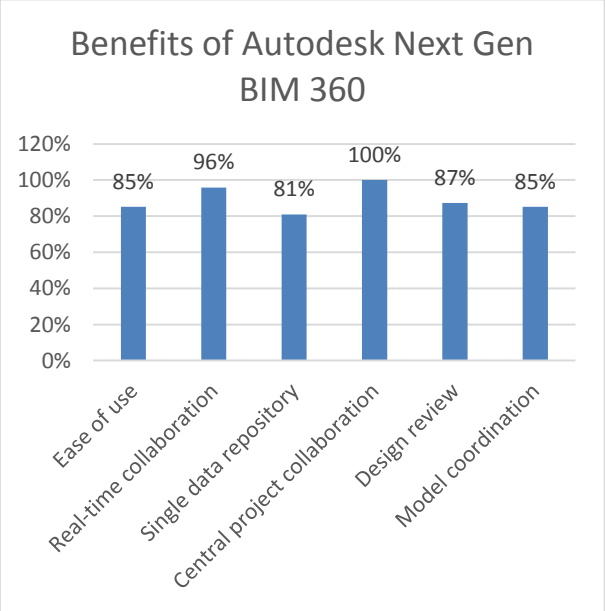

Figure 1. Benefits of Autodesk Next Gen BIM 360

4.1.1 Ease of Use

The Next Gen BIM 360 platform is a user-friendly platform that did not require any extensive knowledge of cloud-based services. Some of the feedback from the students regarding the ease of use of the platform include:

- The platform is relatively easy to use and is getting more and more integrated as a coordination tool.
- The simplicity of use for people with little or no computer knowledge.
- The easy access to the website and ease of use was a big benefit.

4.1.2 Real-Time Collaboration

With the Next Gen BIM 360 platform, students were able to work remotely and still collaborate with their team members from their different locations. Some of the feedback from the students regarding the benefit of long-distance collaboration include:

- It is perfect for working remotely from home.
- It fostered a connection with team members even though we worked mostly from different locations.
- Next Gen BIM 360 enabled real-time updating of models and documents.

4.1.3 Single Data Repository

The Next Gen BIM 360 platform now centralizes all project data in a single data repository connecting all workflows from design to construction to operations. Some of the feedback from the students regarding the single data repository feature of the platform include:

- It is an excellent depository to compile all the project information in one place.
- Having relevant project information readily accessible in the cloud was helpful.
- A significant benefit is having information available in the cloud and having the ability to collaborate with others in the cloud.
- The concept of a single bank of all the project information and to have a well-structured process in place for checking, reviewing and approving the information is appreciated.
- Autodesk Next Gen BIM 360 improves sharing and storing of documented files.
- One centralized location where all project information is kept was essential.

4.1.4 Central Project Communication

With the Next Gen BIM 360 platform, communication with other team members can be easily achieved in the BIM 360 environment without the need for email. Some of the feedback from the students regarding the benefit of central project communication include:

- Communication was improved by BIM 360.
- BIM 360 solved countless communication errors between all the members of the team.

4.1.5 Design Review

Using the Document Management Module, students could create markups on design sheets, make comments as well as publish both the mark-ups and comments for other team members to see and respond accordingly. Also, Document Management made it easy to publish design sets by converting models into individual two-dimensional sheets that could be measured and calibrated. Some of the feedback from the students regarding the benefit of design review include:

- Being able to make markups and issues and share them with team members, as well as keep a record of them.
- Creating mark-ups and issues on the sheets is a significant benefit.
- Easy to upload 3D models with sheet generated files easily extracted sheets.
- Title block data is automatically scanned and extracted when uploading pdf files and also comes with an automatic zoom of sheet title, sheet numbers, and sheet names.
- Having the ability to review and analyze the information is a powerful tool.

4.1.6 Model Coordination

With the Model Coordination module, students were able to automate the BIM coordination process, making it quicker to identify and resolve problems between the different disciplines. Some of the feedback from the students regarding the model coordination feature include:

- It is a great collaboration tool that makes problem-solving much easier through model coordination processes.
- The ability to coordinate and solve problems much sooner than usual without using BIM 360.
- It is excellent for viewing models as it quickly highlights any problems or clashes.
- The comparison tool is useful for visualizing model changes.
- It sped up the review process by almost half the time.

4.2 Drawbacks of Autodesk Next Gen BIM 360

As with all emerging software, the Autodesk Next Gen BIM 360 is not without a few technical difficulties that can be improved. The students were also asked to evaluate the limitations of the Next Gen BIM 360 platform. Based on the responses of the study participants, the top five drawbacks of the Autodesk Next Gen BIM 360 tools is shown in Table 3.

Table 3. Responses of students to the limitations of Autodesk Next Gen BIM 360

Benefits	Frequency n = 47	Percentage of total
Slow speed	47	100%
Time consuming to sort documents	30	64%
Issues cannot be assigned to more than one person	40	85%
Problematic issues tracking	25	53%
Working with worksets is delicate	40	85%

The analysis of the responses indicated that:

- Out of the 47 respondents, 100% mentioned the slow upload and download speed to and from the cloud platform as a significant limitation.
- In the Document Management module, 64% of the respondents indicated the lack of a feature that highlights the most recently updated documents as a limitation, as it makes it time-consuming to sort through several sheets.
- The inability of users to assign an issue to more than one person at a time was indicated by 85% of the respondents as a limitation.
- Of the 47 respondents, 53% stated that the issues tracking functionality in the Model Coordination module is problematic.
- Of the 47 respondents, 85% stated that working with worksets in the Design Collaboration module is delicate as a team member can change the properties of elements assigned to worksets of other team members without permission.

4.3 Experience using the Autodesk Next Gen BIM 360 Platform

The last question of the questionnaire was designed to evaluate the experience the students had with using the Autodesk Next Gen BIM 360 Platform. The experience of the students were rated on a Likert scale ranging from poor to excellent. The results of the responses to this question are summarized in Table 4. Out of the 47 respondents, 4% indicated that they had a moderate experience using the Autodesk Next Gen BIM 360 tools, 21% indicated that they had a good experience using the platform, while 75% of the students stated that they had an excellent experience using the Autodesk Next Gen BIM 360 platform.

Table 4. Frequency and percentages of the experience of participants

Experience using Autodesk Next Gen BIM 360	Frequency n = 47	Percentage of total
Very poor	0	0%
Poor	0	0%
Moderate	2	4%
Good	10	21%
Excellent	35	75%

5 Conclusion

With construction projects becoming more complex and multidisciplinary, the amount of information exchanged between project stakeholders has increased the need for more advanced collaboration and communication technologies. BIM and cloud-based collaborative platforms can aggregate the dispersed information and enhance communication between project stakeholders. In addition to their use in the construction industry, collaborative platforms can also be employed in education to improve the learning experience of construction management students.

This paper explored the use of Autodesk Next Gen BIM 360 as a collaborative learning platform in a Construction Information Systems graduate class. In Fall 2018, 18 students reported the benefits of Next Gen BIM 360 and how it helped them collaborate and communicate with their team members for successful completion of their final project. The students highlighted the ease of use, real-time collaboration opportunities, single data repository, central project communication, design review capabilities, and model coordination as significant benefits of Next Gen BIM 360. However, the platform is not without a few technical difficulties that must be improved upon for a better experience.

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