

# When Lego Meets BIM: A Hands-on Session of a Construction Management Course

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This paper presents an innovative approach of introducing building information modeling (BIM) to construction management students who are new to the concept. The approach uses an existing Lego house in an introductory BIM course and demonstrates the benefits of BIM in construction management through a hands-on session. A Lego house was selected from the Lego digital gallery and then adjusted and converted into a BIM model. Next, a typical set of 2D construction drawings of the Lego house was generated from the BIM model for a comparison between the traditional 2D approach and the BIM process. During the hands-on session, students were divided into groups to build the Lego house, but only with the 2D drawing set instead of Lego instructions. Students were allowed to submit requests for information after 15 minutes and were provided with the BIM model. Students were then guided to navigate and inspect the model in Navisworks and completed the Lego house with the help of BIM. Through the hands-on session, students easily recognized the benefits of using BIM in construction management compared with the traditional 2D approach. This hands-on session was highly valued by students and served as a catalyst for the introductory BIM course.

**Key Words:** BIM, Construction Management, Introductory Course, Hands-on, Lego

## Introduction

While the construction industry has been transitioning from 2D drawings to building information modeling (BIM), construction management programs have also adopted various methods to introduce the BIM process in their curriculum. This paper presents an innovative approach of introducing BIM to construction management students who are new to the concept. The approach uses an existing Lego house in an introductory BIM course and demonstrates the benefits of BIM in construction management through a hands-on session of building the Lego house with BIM.

The approach was inspired by a hands-on session of the Associated General Contractors (AGC) BIM Education Program where participants built a Lego house together based on a 2D drawing set and a BIM model. The hands-on session in the introductory BIM course used a more complicated Lego house and adopted most steps from the AGC's program. The literature has shown that in addition to helping students recognized the benefits of using BIM in construction management, the hands-on sessions will also prepare students for subsequent coursework and promote team building skills and teamwork environment (McIntyre, 2013).

## Background

### *Inspiration*

The idea of using a Lego house in a hands-on BIM session was inspired by the AGC's BIM Education Program. The program is designed to prepare construction professionals at all experience levels to successfully implement BIM on a construction project and is required to obtain the AGC Certificate of Management-Building Information Modeling (CM-BIM). In one session of the program, participants were provided with Lego blocks from a house model (model number: 40154, 174 pieces), which serves as pencil pot, as shown in Figure 1. Participants were then assigned individual roles, including a mason, a carpenter, a door and window installer, a roofer, a landscaper, etc., with exclusive access to specific colored block types, as well as a project manager for overall supervision. Participants

must either refer to the provided 2D drawing set or request a BIM model to complete the Lego house within the allocated time frame. Participants must also meet specific milestones to complete different components of the Lego house, such as walls and the roof, and adhere to specified safety regulations. The author participated in this session and much enjoyed the hands-on experience, and had since believed that a similar session could be developed for a BIM course to benefit construction management students.



*Figure 1: A Lego House as a Pen Pot Used in AGC’s BIM Education Program (Adapted from Lego.com)*

### *Objectives*

The hands-on session of building a Lego house serves several purposes in the BIM course:

- 1) The session concludes the BIM fundamentals module as an “icebreaker”. The BIM fundamentals module is the first module in the course and is all about the basic theories, including the BIM workflow, federated model, level of development, project delivery methods, BIM contracts, and BIM execution plan, which is relatively dry to students.
- 2) The session serves as a “spoiler” to introduce the BIM application module. The BIM application module is the second module in the course that immediately follows the BIM fundamentals module. During the hands-on session, Autodesk Navisworks is introduced for the first time in the course and some basic navigation features are instructed in the session.
- 3) The session compares the traditional 2D drawing approach with the BIM process in building an actual project, which allows students to personally recognize the benefits of using BIM in construction management through the hands-on experience.
- 4) The session serves as a catalyst for the BIM course to connect the theoretical BIM knowledge to the hands-on practice of various BIM tools, and at the same time promotes this course to other interested construction management and architecture students.

### *Literature Review*

Due to decade uses of paper plans in the construction industry, 2D drawings have always been adopted in construction management education as a pedagogical tool (Zolfagharian et al., 2013). While being widely used, it often requires some degree of students’ prior experience to interpret 2D drawings since students must perceptually visualize the components of a structure from lines and symbols in a drawing set and mentally combine them into a virtual structure. Students with little or no previous experience often face challenges and must spend more time interpreting 2D drawings (Irizarry et al., 2012). Using BIM as a pedagogical tool in construction management education can assist students in understanding the complexity of construction projects in both the process and product (Boon and Prigg, 2011; Pikas et al., 2013). In addition, many students are aware of BIM as the emerging

technology used in the industry and have the expectations of learning the latest and most essential paradigm in a construction management program (Nawari et al., 2014).

A construction kit offers innovative ways to provide students with hands-on sessions that simulate the actual construction management experience. McIntyre (2013) used the Tektōn Hotel Plaza Set, a girder and panel building kit, in a first-year introductory construction management course to mimic an array of construction management functions and responsibilities that are required for a typical construction project. Other hands-on sessions in construction management courses primarily focused on senior capstone design projects (Scalza, 2007; Lee et al., 2011). These hands-on sessions with construction kits have proven to be able to prepare students for subsequent coursework and promote team building skills and teamwork environment (McIntyre, 2013).

## Model Preparation

### *Lego Model Selection*

Before selecting a Lego house for the BIM course, it must be commercially available, and its digital model must also be accessible. The Lego Digital Designer (LDD) Gallery provided free access to a variety of digital Lego models, most of which were user designed and a small amount were official Lego products. Through a complete search within the gallery, the Lakeside Lodge (model number: 31048, 368 pieces) was selected for the course. It is a 3-in-1 model and the main model was used in the course, which opens in the middle to show its interiors and furniture, as shown in Figure 2. The LDD Gallery no longer provides digital Lego models after February 2018, but this model can be alternatively found at Eurobricks at <https://www.eurobricks.com/forum/index.php?showtopic=41226&view=findpost&p=2432275> and downloaded at [http://www.brickshelf.com/gallery/Gnac/Creator/\\_31048a.lxf](http://www.brickshelf.com/gallery/Gnac/Creator/_31048a.lxf).



Figure 2: A Lego House as a Lakeside Lodge Used in the BIM Course (Adapted from Lego.com)

### *BIM Model Conversion*

Downloaded digital Lego models are in lxf file format, which can be opened by LDD, its native editor. The program, however, cannot export a file that can be read directly by a BIM tool, and the following steps are needed to convert a digital Lego model into a BIM model:

- 1) Open the downloaded lxf file with LDD and export it to ldr format.
- 2) Open the ldr file with LeoCAD, an open-source digital Lego model creator, and export it to 3ds format. Before exporting, it is necessary to examine the model in LeoCAD as certain objects showed up incorrectly, as shown in Figure 3, and reorientation and movement are therefore needed for these objects.



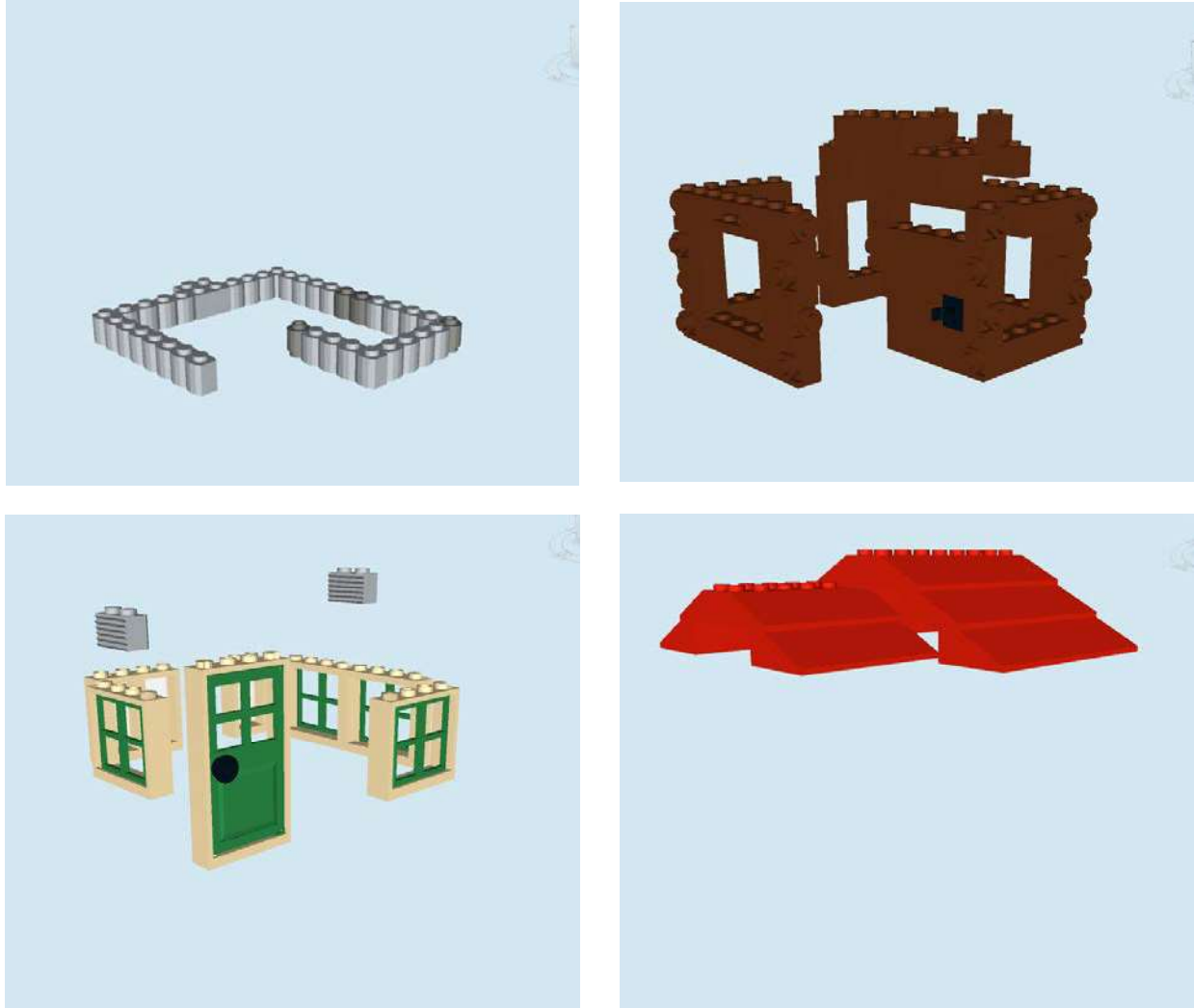
*Figure 3: The Lakeside Lodge in Lego Digital Designer and in LeoCAD*

- 3) Open the 3ds file with Autodesk 3ds Max, a professional 3D modeling tool, delete unneeded objects, such as the Lego person, moose, campfire, tree, etc., then save and export it to fbx format.
- 4) Open the fbx file with Autodesk Navisworks, a popular BIM design review tool, and save it as nwd format. The digital Lego model has now been adjusted and converted into a BIM model, as shown in Figure 4.



*Figure 4: The Lakeside Lodge BIM Model in Navisworks after Editing with 3ds Max*

- 5) Create sets for the BIM model to group objects of the same building component. The process is time-consuming because unlike other native BIM models, all objects in the Lego model are unorganized as separate pieces, and as a result, each building component needs to be sorted out manually and individually. The sets created for the Lakeside Lodge included appliance, beams, ceiling, chimney, door and window, floor, foundation, furniture, ground, roof, walkway, walls, as well as other accessories. Figure 5 demonstrates some examples of the building component sets.



*Figure 5: Navisworks Sets for Foundation, Walls, Door and Window, and Roof*

### *Drawing Set Generation*

In order for students to compare the traditional 2D approach and the BIM process when building the Lego house, a typical 2D drawing set needs to be generated from the BIM model. Autodesk Navisworks as a design review tool does not have the capability of generating 2D drawings from BIM models, and therefore it has to go back to the modeling tool Autodesk 3ds Max, as follows:

- 1) Open the 3ds file with Autodesk 3ds Max saved from step 3) above and export it to dwg format that contains 3D CAD information.
- 2) Start Autodesk Revit, a popular BIM modeling tool, with an architectural template and import the dwg file in black and white colors. The Lakeside Lodge BIM model shows the outline of each Lego block when the visual style is set to hidden line, which allows four exterior elevation views as well as the roof plan to be easily generated, as shown in Figure 6.



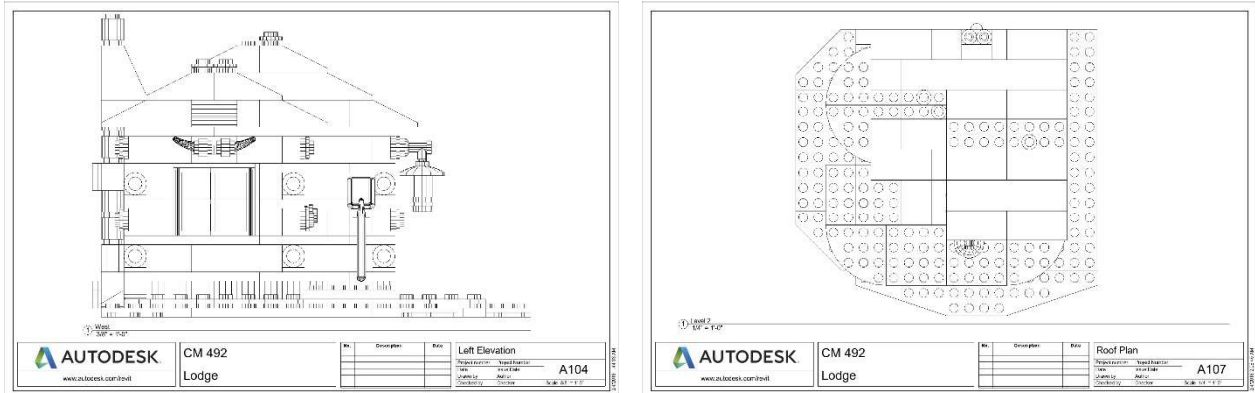


Figure 6: Left Elevation and Roof Plan of the Lakeside Lodge from Revit

- 3) Other typical 2D drawings can be generated using the same method, but require prior editing in 3ds Max, including section views and various plan views at different heights. This is because Revit does not support section or elevation cuts through 3D dwg information. A workaround is to delete all objects that block the desired section view or plan view, export the edited model to different dwg files based on the view, and then import the dwg file in Revit to generate the respective 2D drawing for section views and plan views. For example, to generate a foundation view drawing, all objects above the foundation blocks need to be deleted in the 3ds file before exporting into a dwg file. 2D drawings generated with this method included site plan, foundation plan, floor plan, ceiling plan, framing plan, left section, and right section, as shown in Figure 7.

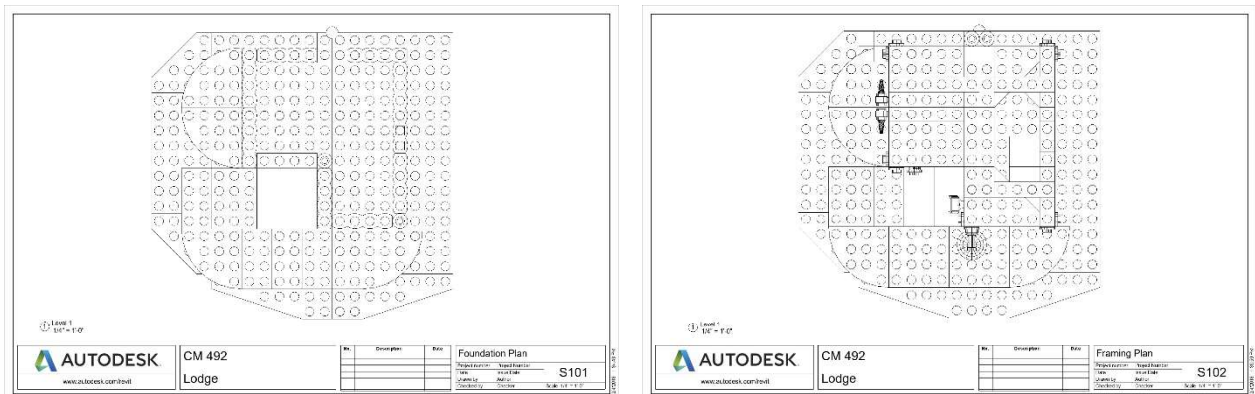


Figure 7: Foundation Plan and Framing Plan of the Lakeside Lodge from Revit

- 4) Finally, a cover sheet was created with Revit that included the two 3D rendering images of the Lakeside Lodge, as demonstrated in Figure 4. The complete 2D drawing set contains a total of 13 sheets including:
- Cover Sheet
  - C101 - Site Plan
  - A101 - Floor Plan
  - A102 - Front Elevation
  - A103 - Rear Elevation
  - A104 - Left Elevation
  - A105 - Right Elevation
  - A106 - Ceiling Plan
  - A107 - Roof Plan
  - A108 - Left Section
  - A109 - Right Section
  - S101 - Foundation Plan
  - S102 - Framing Plan

### Hands-On Session

The hands-on session was given in a modular introductory BIM course after the BIM fundamentals module was completed and before the various BIM computer programs were introduced. As a result, students only had basic

modeling skills of Revit from other courses and had not been exposed to the actual use of Navisworks or other BIM tools. The hands-on session serves as a catalyst for the BIM course to connect the theoretical BIM knowledge to the hands-on practice of various BIM tools.

### *Building with Drawings*

Students were divided into groups of three to four and were provided with Lego blocks and the 2D drawing set instead of its official instruction, without knowing the existence of the BIM model. Students were then instructed to work together to build the Lego house based on the 2D drawings, starting from the site plan. Since the drawings were generated in black and white, students could refer to the rendering images to determine the color of individual blocks.

Students were first allocated 15 minutes to work on building the Lego house. During this time, all groups were able to complete the site and foundation based on the drawings, although with possible mistakes. Students began to work on the walls and chimney and started to struggle with the 2D drawings. They were then allowed to submit requests for information (RFIs) and some started to complain about the difficulty with the 2D drawings. In response to the RFIs, students were instructed to locate the BIM model on the course page in the online learning system.

### *Introducing BIM Tools*

Once students had downloaded and opened the BIM model of the Lego house, they were instructed to pause building the house and focus on learning the basic features of Navisworks, which they were told to use for the rest of the Lego house. Students were then instructed to practice the navigation features of pan, rotate, zoom, select, hide, isolate (hide unselected), as well as browse through the different sets already available in the nwd file. Once familiar with these basic operations with Navisworks, students were instructed to continue building the Lego house.

### *Building with BIM*

With the BIM model now available, students were able to understand the locations of different objects much easier by hiding other building components or isolating the desired blocks. While continuing with the walls, several groups quickly identified that their site was not installed correctly according to the BIM model due to overlapping objects shown in the 2D drawings. These groups had to take several blocks apart and rework on the site to correct the mistakes before continuing with the walls. Most groups assigned a dedicated member to manipulate the BIM model while other members focused on building the house and requested information from the BIM person. All groups successfully completed building the Lego house within the regular class period of one hour 15 minutes.

## **Student Feedback**

Although formal written feedback was not collected from students for this single session of the BIM course, students were asked about their opinions about building the Lego house with BIM. Students highly recognized the help of BIM in putting the Lego house together and strongly valued this hands-on session in the BIM course. Students were able to easily identify the benefits of using BIM in construction management from building the Lego house, which include:

- 1) A BIM model can reveal a lot of details of a project that are simply hidden in a 2D drawing set due to the limitations of plan, elevation, and section views. These details often require references to various detail sheets in a drawing set if properly identified, otherwise they can be easily overlooked. With the rotate and hide tool in a BIM program, these details can be located and understood easier.
- 2) Objects in a BIM model can be either hidden or isolated so that the desired building components can be inspected without the obstruction of other objects in front of them. These features are particularly beneficial to students who are used to 2D drawings since they have now seen a new way to examine the relative position of building components. With the ability to isolate objects, there is no need to refer to various 2D views in a drawing set to determine their spatial location.
- 3) A BIM model helps to reduce the number of errors tremendously in building the project due to the ability of better understanding the project, and as a result, less amount of rework is needed.

- 4) Because of the above advantages of BIM over 2D drawings, it consequently reduces the time needed to complete the project. In actual construction projects, shorter project duration translates to less project cost, which benefits both the owner and the contractor.

Overall, students highly valued this hands-on session of building a Lego house with BIM. They believed it was a class session with lots of fun and at the same time they really learned and remembered the knowledge through the hands-on experience. Students appreciated the instructor's efforts in making it happen and wished to be able to do it again and also in other courses.

## Conclusions

Many construction management programs have employed different strategies to introduce BIM contents in their curriculum as the construction industry has been transitioning into the new BIM era. This paper presents an innovative approach of introducing BIM to construction management students who are new to the concept. The approach uses an existing Lego house in an introductory BIM course and demonstrates the benefits of BIM in construction management through a hands-on session of building the Lego house with BIM. The hands-on session has proven to prepare students for subsequent coursework and promote team building skills and teamwork environment, in addition to helping students recognized the benefits of using BIM in construction management. This hands-on session was highly valued by students and serves as a catalyst for the introductory BIM course.

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