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INTEGRATING SOFTWARE AND HARDWARE TO ENHANCE CLASSROOM BIM INSTRUCTION

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Abstract

University based construction management programs typically instruct students in the use of Building Information Modeling "BIM." The students' interactions with BIM require them to perform exercises using computer software related to modeling, estimating and scheduling. Most of the students' BIM interactions are confined to software environments and do not make connection with the construction environment. Some students may be more focused on the built environment and may be less comfortable behind the computer. They may not as eagerly adopt BIM or see the benefits of using this tool in the field. To bridge this gap, a program has been developed that combines BIM modeling with advanced robotic surveying equipment and unmanned aerial systems (drones).

Auburn University Building Science students complete a project prior to graduation which combines all skills learned throughout the curriculum. Students select different buildings for their project and one requirement is to model the foundation and superstructure of the building from 2d construction drawings. With the 3d model complete, the students learn how to export the necessary data and utilize robotic surveying equipment to outline their foundation in an outdoor grassy area. Photographic data is obtained using a drone, processed, and is then brought back into the BIM model to verify the accuracy of the physical layout. This paper details this program and looks at the software, equipment and techniques used to demonstrate the value of integrating BIM with work performed in the field.

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1. Introduction

Teaching in project management and technology courses over the years, it has been observed that a certain demographic of construction management students do not engage in BIM exercises and BIM centered classroom discussions. That type of student is typically more focused on the field supervision/tactile side of construction management rather than project management. In an effort to persuade that type of student of the advantages and possibilities of BIM and other advanced technologies, an attempt is being made to connect the software with hands-on construction related tasks. It is believed that seeing the usefulness of BIM for practical tactile tasks will inspire students to engage more fully in BIM. BIM software has a steep learning curve and can be discouraging for students who have just begun to use the tools. [1] In addition to the requisite computer skills, one of the challenges with BIM software is that it is akin to virtual building, therefore to be proficient in BIM the user needs to have a lot of technical knowledge and experience. The same type of technical knowledge and experience that is desired by those inclined to engage in field supervision is extremely useful for BIM user proficiency. [1] Therefore, engaging this demographic with BIM is a more natural marriage then it may seem at first.

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In addition to the increased use of BIM in the construction industry, it is important for construction related programs to prepare their students with BIM-related skills and knowledge that they will be expected to possess once they enter the workforce. [2] Adequate BIM knowledge, skills and abilities is essential to advancing the construction industry into the BIM age. In parallel with industry, construction management programs need to integrate BIM within their curricula ensuring that students enter the workforce with the requisite BIM knowledge and skills they will need in their future careers. Therefore, both industry and academia need to focus on BIM training and education to maximize the values and benefits from the use of BIM. [2] Construction Management programs can play a vital role in BIM education and training thereby lowering the internal training burden of construction companies. Without a doubt, the demand for more individuals with experience and knowledge of BIM technology and VDC practices exists. [2] BIM use has grown from a design tool into a near necessity for delivering major construction projects. [3] It is no longer a viable excuse for a student to claim that they desire to become a field supervisor therefore it is not necessary that they develop BIM skills. BIM skills will be required and utilized by all the onsite management staff at a construction site. It is therefore critically important that we as educators use extra efforts to reach out to those students who remain comfortable being unengaged with BIM.

1.1 BIM Layout

Seniors in Auburn University's Building Science program have to pass a course titled "Senior Thesis." This course tends to be very rigorous and requires a tremendous amount of effort from the students. It is a whole project simulation requiring students to submit a number of deliverables including; a BIM model of the structure, estimate, schedule, pay applications, and many other project documents. This is an intensive process for students and requires them to display a wide range of knowledge skills and abilities. Students are also required to produce some work which is of their own choosing. This section of their thesis is referred to as "student selected" work and is required to involve approximately 40 hours of work with a direct relation to their project. Other than that, students have flexibility in what they choose to do and is an opportunity for the students to pursue their own interests and passions. To help students fulfill this requirement various suggestions are provided, along with various previously approved deliverables from which they can choose. If none of these options interest the students, they are allowed to develop ideas of their own.

One of those a la carte electives for student selected work has been a layout exercise where the students take their structural model and physically lay out the foundations. By design, this exercise is intended to reach those students who are not engaged in BIM by connecting a hands-on practical construction activity with BIM software. In order to complete this exercise, students must model the foundations of their building and attach points to those modeled elements to allow them to complete the layout. These points correlate with an X, Y, Z coordinate system which is recognized by the surveying equipment.

All students use Autodesk Revit to create their structural model. After creating their structural model in Revit students utilize Autodesk Point Layout (Revit Plugin) to generate a list of points to be loaded into the total station. In addition to Autodesk Point Layout, points can be generated natively inside Revit. When using this advanced type of surveying equipment, the students simply export a .dwg file and import that into the surveying tablet where the points are easily generated. All the methods described above can be used to arrive at the same place which is to have points generated from your BIM model loaded into your total station ready for physical layout.

At Auburn, with a limitation on the number of hardware devices and space to complete the layout exercise, typically only one group can be accommodated at a time. To complete the layout exercise, students use the following two pieces of surveying equipment which have different capabilities. When the program was started, students used a traditional two-person total station, the Leica model TS06. As the program grew in popularity, an advanced robotic total station was purchased allowing students to complete the exercise on their own.

It appeared that the student's interest in the exercise grew once the robotic total station was acquired. The two types of total stations are shown below in figure 1.

Figure 1: (a) Two-man Total Station (b) Robotic Total Station

Total stations are inherently complex and faculty members can spend an inordinate amount of time instructing students on how to efficiently use the hardware. The robotic total station it a little more user friendly but still requires a significant amount of one on one time with the students to show them how to complete the exercise. To correct this problem, a series of short instructional videos were produced on how to operate the hardware and software. The videos can be found via the attached link.

https://www.youtube.com/channel/UCGEExyLdGoDSbqWjxfuCNWw?view_as=subscriber

In addition to the surveying hardware that the students use to mark out their layout in the field, an unmanned aerial vehicle (UAV), or drone is used to photograph the layout from above. The photographs are currently being acquired using DJI's Inspire 1 Pro with the Zenmuse X5 camera equipped with a 15mm lens. These aerial photos allow students to get a bird's eye view of their layout work and really get an appreciation for precision achieved by the surveying equipment. This UAV technology is another type of technology that is well suited to the field and those individuals inclined toward field operations. See a picture of the UAV utilized in figure 2 below.

Figure 2

2. Methodology

This a la carte exercise has been offered to senior thesis students over the past three years. In that time period there have been over nine sections of the thesis class averaging between 30-45 students per semester. Each semester in which the exercise has been offered as a student selected work activity, more than half of the students in the thesis class have elected to participate in it. A conservative estimate of approximately 150 students have elected to perform the exercise over the past three years and it has been consistently well received.

Students have been required to complete this exercise in groups no larger than three. Student groups collaborate on

one of the group member's models and utilize it for field layout. The software integration between Revit and the survey instrument typically takes about an hour. Depending on the number of points to layout, the field work can take the student groups between 4-8 hours. After the points are identified students use flower to mark the dig lines for their footings. After all this is complete the students are required to write up a single page reflective piece about the exercise that becomes part of their deliverable for thesis. The images included below in figure 3 show the Revit model used to establish the points and on the left side and aerial photographs of the completed field layout on the right.

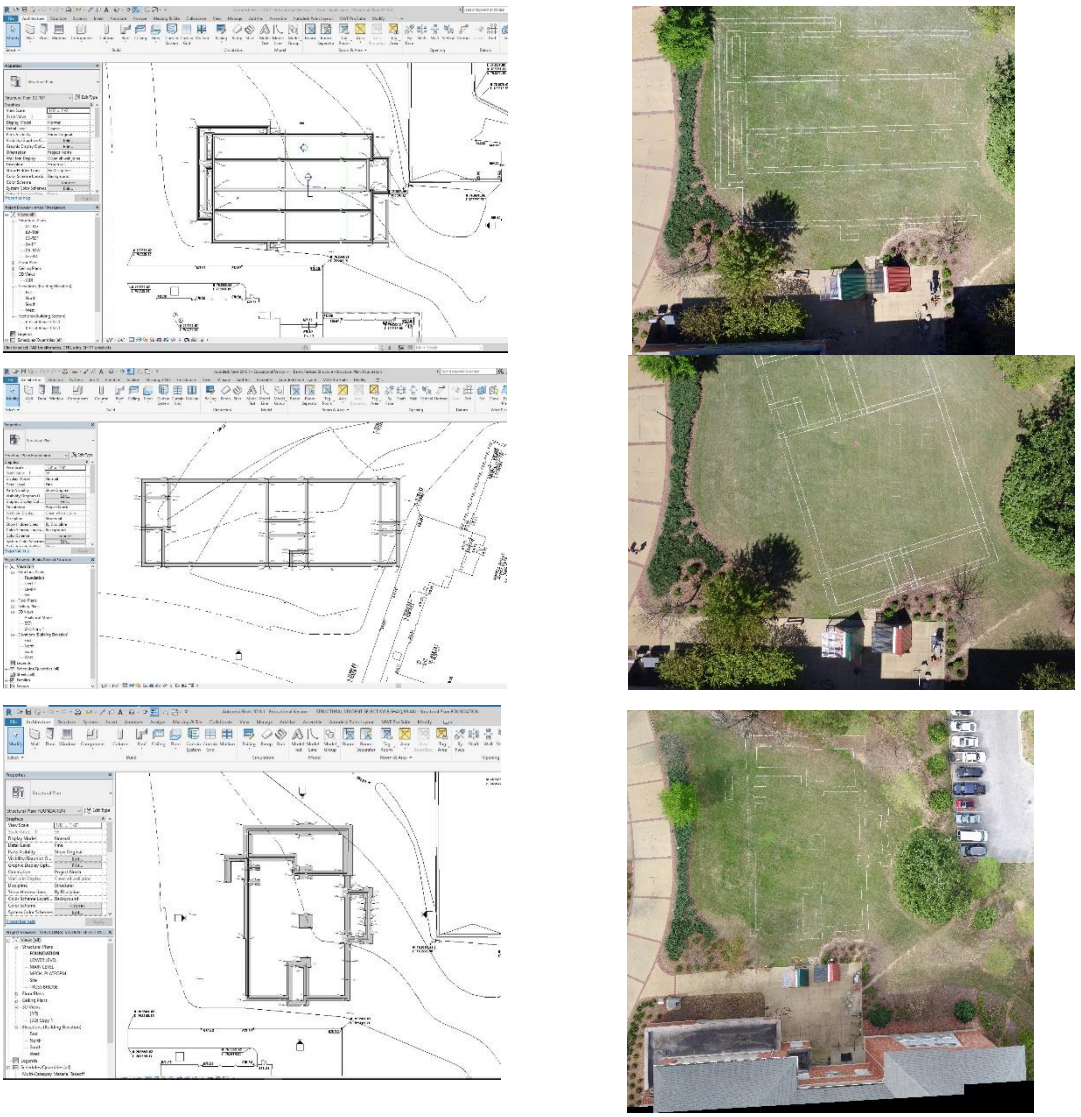

Figure 3

Of the multiple students who have completed the exercise, seven have been interviewed concerning their perception of this exercises' utility as a teaching tool and bridge to engage non-technical students. The interview questions were structured to discovered whether or not an exercise of this type could inspire tactile personality types to engage with BIM and other advanced technologies such as UAVs.

The first question was a demographic question about the participants. The first questions asked the students, "Do you consider yourself a "BIM Person", (i.e. do you feel that this is a primary part of your expertise and/or skillset?)" Figure 4 summarizes these results.

-Not really but I do appreciate it and see the value of it.

-Yes

-No I do not consider myself a “BIM Person”, but I do fell proficient w/ the program.

-I believe I am competent, but not highly skilled at it.

-Yes, I do consider myself a BIM Person.

-I would not consider myself as proficient as some w/BIM but I am very capable of using it.

I do value it and see how it can make some activities run more efficiently.

-No, I see the value in BIM but it is not something I would consider as a primary part of my

expertise

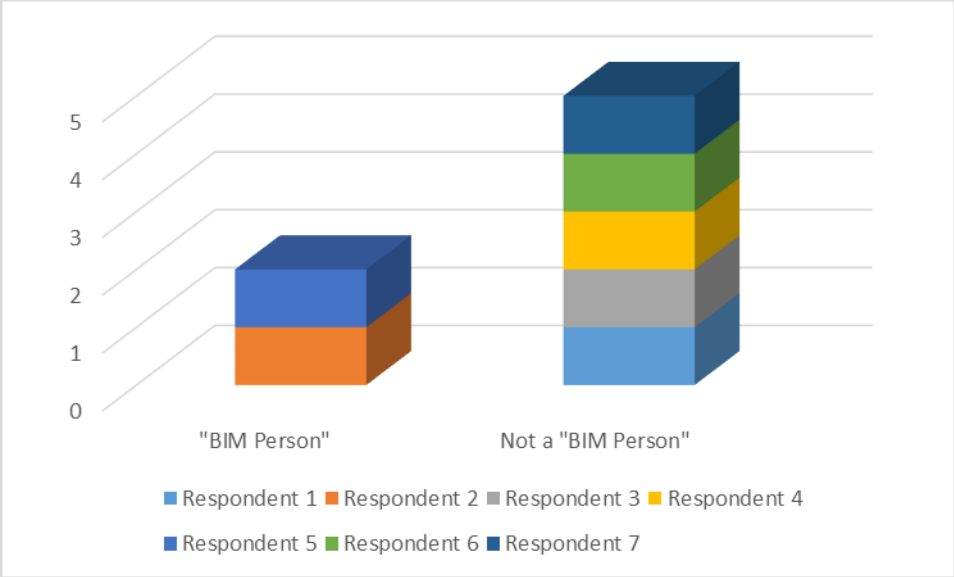

Figure 4

The second question was also a demographic type question “Do you consider yourself a “Superintendent Type” employee, (i.e. do you feel that this is a primary part of your expertise and/or skillset?)” Figure 5 summarizes the responses below.

-I consider myself more of a pm guy.

-I enjoy being onsite but don’t envision being a superintendent

-Yes, I am going into the field side post college

-No. I consider myself more skilled for the management side of construction.

-I am a superintendent type employee

-Yes, I do consider myself a “superintendent type” person. I like getting my hands dirty, being onsite & solving problems as well as interacting w/workers. I am a lot better at hands on than using software or doing “PM” work.

-Yes, I enjoy being out on the site interacting with the trades.

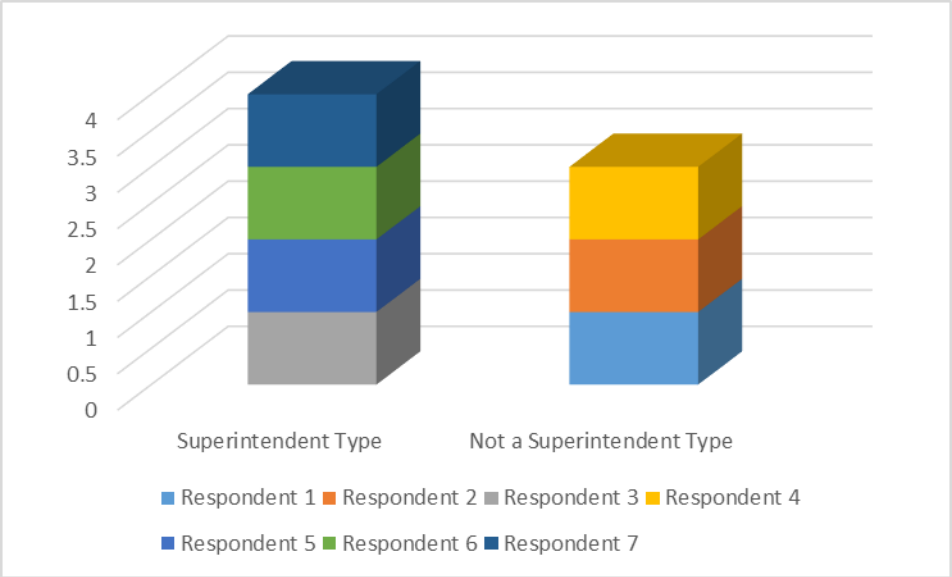

Figure 5

The third question asked about their perception of field type personalities "Is it your opinion that "Superintendent Type" personalities don't value BIM, and in general are less likely to use it as a tool to improve the efficiency of their everyday workflows?" Figure 6 summarizes the responses below.

-Yes, I agree with this.

-Yes

-Yes old school superintendents are hesitant w/ using new tools.

-I believe that the younger ones have come to appreciate it more, but the older superintendents enjoy doing things the old fashioned way.

-The past tells us that Superintendent type personalities do not value BIM or any tool that makes things easier and more efficient for that matter. However, I feel that younger employees are helping change that.

-Yes, typically "Superintendent Type" people do not value BIM. "Superintendent Types" tend to be more technologically inept so it is not common or practical for them to use it to improve efficiency.

-Depending on the size company, larger companies have the resources to train superintendents on new BIM technology. Smaller companies don't value BIM in the same way because of cost.

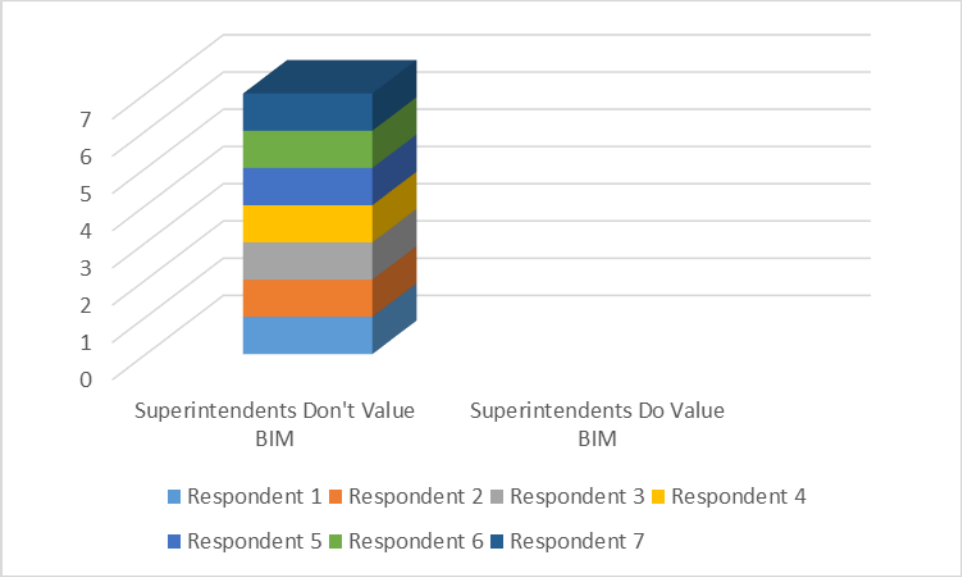

Figure 6

The last question I asked had to do with whether or not the respondents felt that a hands-on activity like using the model for foundation layout could potentially inspire "Superintendent Type" personalities to engage with BIM software more readily. Figure 7 summarizes the responses below.

-Yes, I do believe that it would, even knowing and being familiar with my BIM foundation model made it easy to layout the foundations.

-I think it will be tough to move from the old way of layout due to difficulty with the technology

-Yes, new people, like myself, will be willing to use the new technology

-Yes.

-Yes, I believe it would inspire. After doing that exercise, people would be crazy not to be a fan of BIM.

-Yes. I will say that it has already made me more interested in BIM. Definitely after seeing its efficiency on interior slab layout.

-Yes, assuming they get the proper training I believe that the "Superintendent Type" personalities would engage more with BIM.

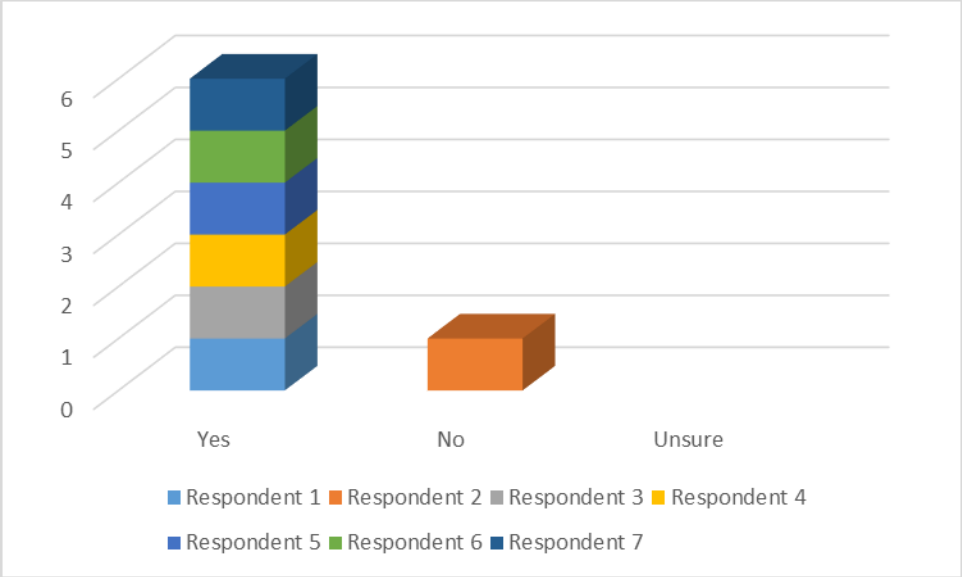

Figure 7

3. Conclusions

Prior to conducting the formal interviews cited in this research, informal feedback was received from all the students participating in the program. From this feedback the program is believed to be successful in engaging and drawing tactile non-technical students toward BIM and other advanced technologies. After seeing the results of these interviews this ad hoc opinion was confirmed and the exercise appears to accomplish its intended purpose. The research certainly is preliminary in its results and invites additional work and follow-up research. As was stated in the introduction advanced technologies such as BIM and UAVs will continue to grow in importance in the construction industry and it is imperative that our graduates are skilled in how to efficiently utilize these tools on their construction projects. Specifically, we as a faculty have a particular concern about engaging the type of student that considers themselves to be in the superintendent mold to both utilize and implement these advanced technologies.

4. References

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