Implementation of Building Information Modeling for Show-Me Solar Decathlon 2011 and ArchSt 4815 Studio V

Faculty Project Leaders:
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   Resident Instruction Assistant Professor and State Housing and Environmental Design Specialist
   Studio V Instructor
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   Department of Architectural Studies
   Project Evaluation

Student Project Leader:
Jacqueline McDermott Kelty, University of Missouri
   Department of Architectural Studies, senior

Brief Description
Building Information Modeling (BIM) is the process of generating and managing building data in the design through construction of a building project. It uses three-dimensional, real-time, dynamic modeling software to increase knowledge of building structure, systems, and components in buildings. In the architecture and engineering professions, two-dimensional, paper-based project information (construction drawings and specifications) is quickly giving way to 3D interactive Building Information Modeling. In order to provide students with applicable knowledge and hands-on training in this emerging technology, it is necessary to incorporate special training of BIM in an advanced design studio (Studio V) and in the design and construction of the Show-Me Solar Team entry in the 2011 Solar Decathlon.

Goals and Objectives Realized
Implementation of Building Information Modeling (BIM) knowledge advanced the proficiency of students in design and better prepared them for professional practice in architecture and interior design firms that routinely incorporate BIM in large projects.

- Students who are proficient in BIM achieved a greater understanding and appreciation of the integration and complexity of building structure, systems, and components.
- Students now have hands-on BIM experience which makes them more marketable to large design and construction firms.
- Students incorporating BIM in the Show-Me Solar entry in the 2011 Solar Decathlon better understand the complex relationship between design and construction of buildings.
Project Description

Summary
The IIF funds from MUITC were used for student and faculty training and support in order to implement BIM technology and software in the Show-Me Solar 2011 Solar Decathlon entry and in ArchSt 4815 Studio V. The training was provided by Mid-West CAD of St Louis and comprised two separate, three-day workshops for a total of 27 students and two faculty members (one training each in the FS2010 and SP2011). The training was only be necessary for the two sessions as future teaching of the software and program could be administered by faculty and students who have completed the training under this grant. The training was for the software Autodesk Navisworks, which is the compatible BIM program to Revit and AutoCAD, which are currently available to students and supported by MU, DoIT, and ET@MO.

Use of BIM in the Show-Me Solar entry in the 2011 Solar Decathlon
After successfully placing 11th of 20 in the 2009 Solar Decathlon, students from the University of Missouri (MU) and the Missouri University of Science & Technology (S&T) have once again composed the “Show-Me Solar Team” in order to compete in the 2011 and 2013 competitions. This team is composed of undergraduate and graduate students with a goal to design and build the most attractive, effective, and energy-efficient solar-powered house for the next available Solar Decathlon. The Solar Decathlon, an international design competition, exists to educate the public on solar energy, energy efficiency, and the best in home design. The Show-Me Solar house is built on campus and then is temporarily moved to Washington, DC, for a month for the actual competition. The team has faculty and adjunct advising, but the project is specifically organized and led by students. Students ultimately make all of the design decisions and then are responsible for the construction of the house with labor from the students of both campuses.

In the rules and regulations for the Solar Decathlon, the construction documentation (drawings, specifications, cost estimate) and the construction of the house must include use of a fully integrated, three-dimensional, Building Information Model. This model will allow any student, competition judge, or interested consumer, via website, to click on a portion of the model and obtain information about that component or assembly. (For example, clicking on a particular door in the model would return the size of the door, manufacturer and product, door material and finish, open the manufacturer’s website for the door, provide the cost, delivery time, and installation instructions for the door, etc.)

Although the Missouri team was not one of the teams selected for competition in 2011, the design proposal will be resubmitted for the 2013 competition. The use of BIM in the Studio V and among the Solar Decathlon team greatly increases the chances of an accepted submission for the 2013 competition.

Use of BIM in ArchSt 4815 Studio V
Studio V is the design studio that is the semester before the capstone project (also called Thesis project) in the Department of Architectural Studies curriculum. Students in Studio V are expected to integrate structure, building materials and assemblies, building codes, accessibility, and building systems (lighting, plumbing, ventilation) into their design projects as an example of the synthesis of their knowledge in these areas. It is a challenging course, yet critical to seniors who are going to soon be in professional practice and use this knowledge on a daily basis on real projects for clients. Currently, the class uses software by Autodesk (AutoCAD, Revit) for the construction documents in the class (drawings, specifications), but the information is not considered as advanced as true Building Information
Modeling. Since most large design firms and many medium sized firms are using BIM for their projects, it is imperative that students begin to learn and master BIM software prior to graduating from MU.

The Navisworks training was fully integrated into the Studio V class which was taught in the Fall Semester of 2010, Spring and Summer Semester of 2011. It is now a permanent, integral part of the class requirements and learning. An interesting note is that after the software training was implemented into the Studio V class, the Architectural Studies department received word from CIDA (Council for Interior Design Accreditation - our accreditation board), that BIM will be a future requirement for all interior design programs in the near future. Implementation of BIM in the curriculum this year has allowed the program to be ahead of most similar design programs in the United States.

Management Plan and Revised Project Schedule

The time line (and responsible personnel) for the project was as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 2010</td>
<td>Pre- Evaluation of Solar Decathlon Students in BIM knowledge (Phillips)</td>
</tr>
<tr>
<td></td>
<td>Three-day BIM training workshop for Solar Decathlon students at MU and in Studio V</td>
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<tr>
<td></td>
<td>(Goldschmidt, McDermott-Kelty)</td>
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<tr>
<td>November 2010</td>
<td>Submission of BIM Model to Solar Decathlon for judging and evaluation (Goldschmidt, McDermott-Kelty). <em>Was not selected as one of the teams to compete.</em></td>
</tr>
<tr>
<td>December 2010</td>
<td>Post-Evaluation of Solar Decathlon and Studio V Students in BIM Knowledge (Phillips)</td>
</tr>
<tr>
<td>January 2011</td>
<td>Pre- Evaluation of Studio V Students in BIM knowledge (Phillips)</td>
</tr>
<tr>
<td></td>
<td>Three-day BIM training workshop for Studio V students at MU (Goldschmidt, Phillips, McDermott-Kelty)</td>
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<td>Date</td>
<td>Event</td>
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</tr>
<tr>
<td>May 2011</td>
<td>Submission of BIM Model as part of course requirements for Studio V (Goldschmidt, McDermott-Kelty)</td>
</tr>
<tr>
<td>May 2011</td>
<td>Post-Evaluation of Studio V Students in BIM Knowledge (Phillips)</td>
</tr>
<tr>
<td>June 2011</td>
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<td></td>
<td>Three-day BIM training workshop for Studio V students at MU (Goldschmidt, Phillips, McDermott-Kelty)</td>
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<td>Submission of BIM Model as part of course requirements for Studio V (Goldschmidt, McDermott-Kelty)</td>
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<tr>
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<td>Post-Evaluation of Studio V Students in BIM Knowledge (Phillips)</td>
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**Evaluation Criteria**

Evaluation of the success of the project was administered independently by Dr. Ronn Phillips, ArchD., of the Department of Architectural Studies. Dr. Phillips created and administered a pre- and post-training test to the students. Dr. Phillips also interviewed department faculty for their evaluation of the training as it is reflected in student studio work. This information is attached to this report to be shared with the MUITC faculty and committee. Evaluation and feedback of the Show-Me Solar BIM model by the Solar Decathlon judges was not possible after the team was not selected for competition.

Summary of the Evaluation from Dr. Phillips:

**PreTest Results**
The number of correctly answered responses for all students participating in the PreTest evaluation was (mean = 2.18, n=17), with a minimum number of correct responses of zero and a maximum number of correct responses of five. The standard deviation for the PreTest scores was 1.47, with a median score of
5.9, and a mode of 0.0. The percentage of correct responses for all students participating in the PreTest was 19.8 percent (n=17).

**PostTest Results**
The number of correctly answered responses for all students participating in the PostTest evaluation was (mean = 4.75, n=16), with a minimum number of correct responses of zero and a maximum number of correct responses of eight. The standard deviation for the PostTest scores was 2.38, with a median score of 25.0, and a bi-mode of 6.3 and 25.0. The percentage of correct responses for all students participating in the PostTest was 43.2 percent (n=17).

**Comparative Results**
An examination of each of the 11 items shows an overall increase in number of correct responses for all but one of the items. The mean increase across all 11 items from PreTest to PostTest was 25.4 percent, adjusted for the one item that did not record an improvement.

**Expenditure of Funds**

- **Navisworks Training**  
  August 2010 – July 2011  
  1950 x 3 days  
  1050 Food and Lodging (Trainer and MST students)  
  700 Travel (Trainer and students)  
  7600.00

- **Software Materials and Support**  
  6725.00  
  - Navisworks Reference Materials  
  - Navisworks Software for Students and Faculty for ITV lab

- **Evaluation (Phillips)**  
  1050.00

**Total Grant Expenditure**  
$15,375.00

*Note that workshop training expenses have been provided by Mid-West CAD which is a licensed provider and trainer of Navisworks, located in St. Louis, MO.*
An Evaluation of the NAVISWORKS Curriculum  
Department of Architectural Studies  
University of Missouri  

Dr. Ronald Phillips, ArchD  
21 July 2011  

An 11-item evaluation instrument with open-ended responses was administered to 17 undergraduate students prior to (PreTest) and subsequent to (PostTest) the NAVISWORKS curriculum presentations by Michael Goldschmidt of the Department of Architectural Studies at the University of Missouri during the month of June, 2011. The PreTest and PostTest 11-item evaluation instruments are presented in the appendix of this evaluation.  

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Appendix A: PreTest Evaluation Instrument

NAVISWORKS EVALUATION: Pre-Test

Name:

Respondent ID Number:

Please fill in the blanks for the following 10 questions. Be as specific with your responses as you can.

1) BIM is an acronym for what?

_______________________________________________________________________________

2) A designer notices that the Construction Documents for a project show a beam on the structural drawings that runs through a window on the architectural drawings. This is an example of what?

_______________________________________________________________________________

3) A 3D model of a design that shows the progression of the construction on a timeline is called what?

_______________________________________________________________________________

4) In a BIM project, what two items from the Construction Documents are typically combined into the same computer file?
   (a)____________________________________ (b)_____________________________________

5) A designer adds overlay notes to a BIM that shows required changes to be made to the project. These are referred to as what?

_______________________________________________________________________________

6) Interactivity with a BIM and an external file or program is done through what?

_______________________________________________________________________________

7) Clicking on an object in a BIM brings up the object’s properties. This is known as a what?

_______________________________________________________________________________

8) Clicking on an object in a BIM brings up a website. This is known as a what?

_______________________________________________________________________________

9) Moving through a BIM at the eye-level of a typical person is known as a what?

_______________________________________________________________________________

10) Combining design and construction information from different software programs into a single BIM simplifies the project’s what?

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