<table>
<thead>
<tr>
<th>Presentation ID</th>
<th>Presentation Title</th>
<th>Presenter</th>
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<tr>
<td>101</td>
<td>Project Based Learning for Enhanced BIM Implementation in the Sustainability Domain</td>
<td>Wei Wu</td>
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<td>103</td>
<td>BIM Course Development and Its Future Integration at University of Indonesia and Institute of Technology Bandung, Indonesia</td>
<td>Gregorius Gegana</td>
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<td>BIM in Pedagogy: Fundamentals and Exploration</td>
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<td>Process and Structure: Performance Impacts on Collaborative Interdisciplinary Team Experiences</td>
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<td>Toward Adoption Of BIM In The Nigerian AEC Industry: Context Framing, Data Collecting and Paradigm For Interpretation</td>
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<td>Michael Gonzalez</td>
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<td>David Batie</td>
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<td>An example class on Building Information Modeling for Construction Project Management</td>
<td>Fernanda Leite</td>
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<td>Tutorials at Home, Vignette Exercises in Lab: A new model for BIM Education</td>
<td>Anne Anderson</td>
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<td>117</td>
<td>Industry-Academic BIM Alliance: A Pragmatic Approach to Enhance Students’ BIM Knowledge</td>
<td>Tony Graham</td>
</tr>
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<td>119</td>
<td>How should we teach BIM? A case study from the UK</td>
<td>Zulfikar Adamu</td>
</tr>
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<td>120</td>
<td>Developing BIM Laboratory Exercises for a MEP Systems Course in a Construction Science and Management Program</td>
<td>Rogelio Palomera-Arias</td>
</tr>
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<td>121</td>
<td>Real Life Examples For Student Project To Better Students’ Understanding BIM Implementation</td>
<td>Rui Liu</td>
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<td>122</td>
<td>Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at Two Universities</td>
<td>Maria Gomez</td>
</tr>
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<td>123</td>
<td>An Interdisciplinary Approach to Integrate BIM in the Construction Management and Engineering Curriculum</td>
<td>Julide Demirdoven</td>
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<td>125</td>
<td>BIM Educational Framework for the Quantity Surveying Students: The Malaysian Perspective</td>
<td>Kherun Nita Ali</td>
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<td>126</td>
<td>Framework for expanding BIM adoption within the taught curriculum</td>
<td>Marcel Maghier</td>
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<td>127</td>
<td>Integration of Building Information Modeling (BIM) Course into Design Curriculum Case Study</td>
<td>Tony Widjarnarso</td>
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<td>131</td>
<td>BIM in the Intro to Construction and Facilities Management course</td>
<td>Kevin Miller</td>
</tr>
<tr>
<td>133</td>
<td>Two Year Graduate Transdisciplinary Building Core Program</td>
<td>Lamar Henderson</td>
</tr>
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<td>134</td>
<td>Enhanced Collaboration between Construction Management and Architecture Students utilizing a Building Information Modeling (BIM) Environment</td>
<td>John Cribbs</td>
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<tr>
<td>135</td>
<td>Best practices and lessons learned in BIM project execution planning in construction education</td>
<td>Steven K. Ayer</td>
</tr>
<tr>
<td>136</td>
<td>Design Disassembled: Understanding Building Systems through BIM</td>
<td>Tracy Stone</td>
</tr>
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<td>137</td>
<td>Introducing Laser Scanning Technology In A Graduate BIM Class</td>
<td>Raymond Issa</td>
</tr>
<tr>
<td>138</td>
<td>BIM Education in ASIA</td>
<td>Han Hoang</td>
</tr>
</tbody>
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Project-based learning for enhanced implementation of BIM in the sustainability domain

Wei Wu & Yupeng (Vivien) Luo
Construction Management, Fresno State
Agenda

- Motivation and objectives
- Project-based learning
- Joint-course project design
- Assessment plan
- Project execution
- Results and findings
- Discussion
Motivation of study

- Both sustainability and BIM are important industry trends
- Because of the synergies, Green BIM is now a common practice
- Program assessment (SOAP, ACCE) revealed weaknesses of our students in communication (oral, written, and graphical) and problem-solving
- Project-based learning can significantly enhance student learning outcomes
Project objectives

- Explore alternative pedagogical approach in BIM and sustainability education
- Assess and improve critical program student learning outcomes (SLOs)
  - SLO 1*: Communication
  - SLO 3: Teamwork and Team Relations
  - SLO 4**: Problem Solving and Critical Thinking
  - SLO 11: Sustainability

*, **: SLOs 1 and 4 are used as placeholders for assessment pertaining to BIM competencies
Project-based learning

- New skill sets requirements for CM graduates urge pedagogical innovation:
  - specialization vs. integration
  - passive vs. proactive

- Project-based learning (PBL) is a proven effective student-centered pedagogical approach:
  - build knowledge
  - develop critical thinking and creativity
  - cultivate soft skills: leadership and communication

- Transformation of instructors’ roles
Joint course project overview

- **Two courses:**
  - CM132 - Advanced Architectural Design (BIM)
  - CM177 - Green building and sustainable construction

- **Project:**
  - Jordan Research Center: ~32,000 SF, 3-story undergoing laboratory building
  - Sustainability goals: LEED certification at “Certified” and a higher level (decided by students)

- **Project team composition: student role-play**
  - 1 LEED consultant (CM177)
  - 1 BIM coordinator/project manager
  - 1 Design professional
  - 1 Owner’s rep
  - 1 project engineer (optional) (CM132)
Joint course project delivery

Tasks Summary:

- LEED design charrette reports and meeting minutes
- LEED credit analysis and documentation
- BIM Execution Planning documentation
- Architectural and structural design models
- Performance simulation models and simulation result reports
- Model-based quantity takeoff and estimating for LEED materials and products
- Spatial coordination and constructability review report
- Team meeting minutes and communication notes
## Technology selection

<table>
<thead>
<tr>
<th>Project activity/task</th>
<th>Recommended technology</th>
<th>Optional technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site selection/analysis</td>
<td>Google Earth</td>
<td>—</td>
</tr>
<tr>
<td>Model authoring</td>
<td>Autodesk Revit 2014</td>
<td>Sketchup</td>
</tr>
<tr>
<td>Energy simulation</td>
<td>Autodesk Green Building Studio</td>
<td>Sefaira</td>
</tr>
<tr>
<td>Water efficiency calculation</td>
<td>Autodesk Green Building Studio</td>
<td>—</td>
</tr>
<tr>
<td>Daylighting simulation</td>
<td>Autodesk Green Building Studio</td>
<td>Sefaira; Autodesk Daylighting Analysis plug-in*</td>
</tr>
<tr>
<td>Materials takeoff</td>
<td>Autodesk Revit 2014</td>
<td>On Screen Takeoff</td>
</tr>
<tr>
<td>Design documentation communication &amp; management</td>
<td>Google Apps; Dropbox; PlanGrid</td>
<td>Autodesk A360</td>
</tr>
<tr>
<td>LEED certification management</td>
<td>Google Apps</td>
<td>Autodesk Revit Credit Manager for LEED**</td>
</tr>
</tbody>
</table>

* **: Both are Autodesk Labs products.
Project management

CM132+CM177_Joint_Course_Project

Week 10/13 ~ 10/19

CM132: tasks to complete:
- BIM Execution Planning Goals/Uses Worksheet
- Jordan Research Center Architectural Massing for Conceptual Energy Simulation
  - Conceptual Energy Simulation Analysis Report
- Jordan Research Center Structural Model Part I
  - Datum
  - Foundation Plan
  - Framing Plan

CM177: tasks to complete (due by the end of Sun, Oct 19):
- Rework on your meeting minutes from the first design charrette, OR have your first design charrette for those who haven't had one yet.

Please be sure to address the following in your minutes:
- Group member roles - LEED consultant, owner's rep, architect/engineer, BIM facilitator, contractor, etc.
- LEED process intro by the appointed LEED consultant. Provide a brief summary.
- BIM implementation intro by the appointed BIM facilitator. Provide a brief summary.
- LEED scorecard review - Identify "Yes" credits and "No" credits. Attach the LEED scorecard as a separate file. In the minutes, provide narratives regarding how the "Yes" & "No" decisions were made on these credits. Identify credits that will have an impact on the BIM facilitator's work.
- Action items for the next design charrette as well as meeting time and location.

Dr. Luo will visit Team 1's meeting this week. Please send her a meeting request.

- Create a new page on your site dedicated to RFI's. Compile separate lists of questions for owner, architect, and builder related to LEED LT, LS, and WR credits.
# Project assess plan

<table>
<thead>
<tr>
<th>Program SLOs</th>
<th>Model &amp; Design Documentaion</th>
<th>Team Presentation</th>
<th>Team Final Report</th>
<th>Team Google Site</th>
<th>Autodes k BPAC</th>
<th>Entry Survey</th>
<th>Exit survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLO 1</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
</tr>
<tr>
<td>SLO 3</td>
<td></td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td></td>
<td></td>
<td>☒</td>
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<tr>
<td>SLO 4</td>
<td>☒</td>
<td>☒</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>SLO 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Autodesk Building Performance Analysis Certificate Program

**Rahul S., (rahulswami) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 16 2014
- **Enrolled on**: Nov 06 2014
- **Score**: 91.00%

**Maciel Torres A., (salvaro700) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Nov 26 2014
- **Enrolled on**: Dec 05 2014
- **Score**: 89.00%

**Crepin E., (BrianCrepin) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Nov 15 2014
- **Enrolled on**: Dec 18 2014
- **Score**: 90.00%

**Garcia C., (carlosfer1) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 09 2014
- **Enrolled on**: Dec 19 2014
- **Score**: 90.00%

**Yang C., (yang62) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Nov 02 2014
- **Enrolled on**: Dec 19 2014
- **Score**: 91.00%

**Rudolph E., (rudolph) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Oct 15 2014
- **Enrolled on**: Dec 17 2014
- **Score**: 91.00%

**Navarro M., (mnavarro209) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 02 2014
- **Enrolled on**: Dec 21 2014
- **Score**: 90.00%

**Quillen C., (quillenc56) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Dec 09 2014
- **Enrolled on**: Dec 19 2014
- **Score**: 90.00%

**Heng J., (hunger@mail.fullerton.edu) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Oct 16 2014
- **Enrolled on**: Dec 03 2014
- **Score**: 88.00%

**Godoy J., (Godboy58) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 26 2014
- **Enrolled on**: Dec 17 2014
- **Score**: 90.00%

**Gonzalez J., (jgomez408) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 27 2014
- **Enrolled on**: Dec 17 2014
- **Score**: 88.00%

**Carillo J., (jcarillo1415) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Dec 18 2014
- **Enrolled on**: Dec 19 2014
- **Score**: 90.00%

**Reff J., (jref) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 15 2014
- **Enrolled on**: Oct 16 2014
- **Score**: 85.00%

**Sanchez J., (joseyanche) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Dec 03 2014
- **Enrolled on**: Dec 03 2014
- **Score**: 89.00%

**Sheffield L., (LSheffield21) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Nov 26 2014
- **Enrolled on**: Dec 09 2014
- **Score**: 90.00%

**Lee M., (mlmeket@mail.fullerton.edu) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 09 2014
- **Enrolled on**: Dec 14 2014
- **Score**: 86.00%

**Jansen N., (nicky@mail.fullerton.edu) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 19 2014
- **Enrolled on**: Dec 10 2014
- **Score**: 92.00%

**Gonzalez N., (Wicenc) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 03 2014
- **Enrolled on**: Dec 11 2014
- **Score**: 89.00%

**Palomera N., (Palomera) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 04 2014
- **Enrolled on**: Dec 10 2014
- **Score**: 88.00%

**Ruiz R., (ruizjfr) - BPA Student**
- **Percentage**: 100.00%
- **Completed**: Sep 27 2014
- **Enrolled on**: Dec 17 2014
- **Score**: 89.00%
1. Introduction

This document will elaborate on the contents and formatting requirements of the final project manual of this joint course project to facilitate your group’s preparation and production of the manual. Please be aware that compliance with this specification is mandatory and will be integrated into the grading rubric.

As a restatement, the goal of this joint course project is to evaluate the synergies between BIM implementation in green building design and LEED certification requirements. Important student learning outcomes, including communication (oral, written and graphical), teamwork/team relations, problem solving and critical thinking, and sustainability will be assessed.

2. Project Manual Specifications: Contents

The contents of the project manual will be a comprehensive coverage of all project activities that your group has been conducting during the last 2 months. You were advised at the beginning of the project that detailed documentation would be required to demonstrate your efforts. The following list serves as the minimum requirements of the contents that should be included in your manual. You are encouraged to submit extra documentation that would showcase your innovation and commitment to accomplishing the goal of this project.

- **Introduction of the project, the group, and the logistics of the project:** The first section of the project manual should include a concise project summary, the group members/roles, and the overall logistics of the project, e.g., debriefing on the documentation management, time management, website maintenance and meetings/meeting minutes (~2 pages).

- **LEED design charrette reports/meeting minutes:** Every group is required to conduct multiple meetings to discuss the overall strategy of achieving LEED certification with BIM facilitation. These meetings set the tone for the group collaboration and provide a roadmap of the tasks to be performed by the group (~2 pages).

- **A CD including all LEED documentation for TWO levels of LEED certification:** LEED certified and a second one of your choice. For EACH SET of documentation, please provide the following:
  - a. The final LEED checklist.
  - b. Completed LEED form for each credit pursued.
  - c. Required supporting documents for each credit pursued.

  NOTE: Please also include a printout of item a (the two LEED checklists) in your binder.

- **BIM execution planning:** In conjunction with the LEED design charrette, the groups are also supposed to conduct planning for BIM execution, specifically, how the BIM functionalities will be leveraged to achieve the proposed LEED credits. Please print out the worksheets you created using the templates provided by the Penn State BIM Project Execution Planning Guide, and provide a short summary of your group’s discussion on the process, especially how your group understand the fundamentals of synergies between sustainability and BIM (~4
Table 1: Grading Rubric for Joint Course Project Group Presentation (Max: 25 Points)

<table>
<thead>
<tr>
<th>Grading Criteria</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Appearance</strong></td>
<td>Poor</td>
<td>Below</td>
<td>Meet</td>
<td>Confident</td>
<td>Advanced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>expectation</td>
<td>expectation</td>
<td>expectation</td>
<td>expectation</td>
<td>expectation</td>
<td></td>
</tr>
<tr>
<td>Presentation Organization</td>
<td>Presenters are not prepared and poor organization of content.</td>
<td>Presentation is very confused and unclear. No objectives identified.</td>
<td>Attention required by listeners to follow the presentation. Objectives are inconsistent.</td>
<td>Presentation is clear and logical. Opening included clearly stated objectives.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery</td>
<td>Speakers cannot be heard. Presentation was too short or long. Key points not summarized.</td>
<td>Information is read from a script of directly from the screen. Poor posture and no eye contact.</td>
<td>An annoying number of “Ahs and Ums”. Pace is too fast or too slow. Key points are touched upon without adequate articulation.</td>
<td>Reasonable pace and from style. Some rough understanding. Articulate &amp; enjoyable to listen to. Good layout.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of Visual Aids</td>
<td>No aids are used or they are so poorly prepared that they disturbed the presentation.</td>
<td>Aids are difficult to read. Poor images or inappropriate animations.</td>
<td>Aids are marginal. Font is large enough to read. Some distracting backgrounds.</td>
<td>Aids are reasonably good. Graphics and animation usage are appropriate.</td>
<td>Aids presented are professional and polished. Font is large enough. Images are relevant and help address the issue.</td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td>No clear role defined and no bonding between group members.</td>
<td>Minimal participation from one or more members.</td>
<td>All group members participate but one or more members dominant.</td>
<td>Almost balanced participation</td>
<td>Balanced participation. Clear and appropriate role allocation.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Grading Rubric for Joint Course Project Binder (Max: 75 Points)

<table>
<thead>
<tr>
<th>Grading Criteria</th>
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<th>6</th>
<th>9</th>
<th>12</th>
<th>15</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Professional documentation</strong></td>
<td>Poor</td>
<td>Below expectation</td>
<td>Meet expectation</td>
<td>Confident</td>
<td>Advanced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Binder is poorly prepared, no efforts in professional documentation.</td>
<td>Some efforts in professional documentation; substandard physical binder appearance</td>
<td>Satisfactory professional documentation; acceptable binder physical appearance</td>
<td>Good professional documentation; good binder physical appearance</td>
<td>Excellent professional documentation; great binder physical appearance</td>
<td></td>
</tr>
<tr>
<td>Contents - Completion</td>
<td>Binder contains 50% or less of required project deliverables.</td>
<td>Binder contains 51%–69% of required project deliverables.</td>
<td>Binder contains 70%–79% of required project deliverables.</td>
<td>Binder contains 80%–89% of required project deliverables.</td>
<td>Binder contains 90%–100% of required project deliverables.</td>
<td></td>
</tr>
<tr>
<td>Contents - Accuracy</td>
<td>Little information is provided in the deliverables with poor accuracy.</td>
<td>Some information is provided in the deliverables with low accuracy.</td>
<td>Solid information is provided in the deliverables with acceptable accuracy.</td>
<td>Great amount of information is provided in the deliverables with good accuracy.</td>
<td>Excellent coverage of information in the deliverables with impeccable accuracy.</td>
<td></td>
</tr>
<tr>
<td>Formatting</td>
<td>No obvious efforts in compliance with formatting requirements.</td>
<td>Some efforts in compliance with formatting requirements.</td>
<td>Acceptable formatting, quite a few mistakes and inconsistencies.</td>
<td>Good and consistent formatting, very few mistakes.</td>
<td>Excellent formatting, almost impeccable consistency.</td>
<td></td>
</tr>
</tbody>
</table>
Assessment results: direct measures

![Bar chart showing student performance distribution across different assessment categories: Model & Design Documentation, Team Presentation, Team Final Report, Team Google Site. The chart indicates the percentage of students falling into high, medium, and low performance categories for each category.]
Assessment results: direct measures

![Bar chart showing student performance distribution for Team Presentation, Team Final Report, and Team Google Site, with percentages for each category: High (>=90%), Medium (71% ~ <90%), and Low (<=70%).]
Assessment results: direct measures

- Model & Design Documentation: 27.30% High, 47.70% Medium, 0.00% Low
- Team Presentation: 100.00% High, 0.00% Medium, 0.00% Low
- Team Final Report: 0.00% High, 13.80% Medium, 30.30% Low
- Autodesk BPAC: 69.70% High, 86.20% Medium, 0.00% Low
Assessment results: direct measures

The bar graph shows the student performance distribution across different categories such as Team Final Report and Autodesk BPAC. The graph uses color coding to differentiate between High (≥90%), Medium (71% ~ <90%), and Low (≤70%) performance levels.

- **Team Final Report**:
  - High: 13.80%
  - Medium: 86.20%
  - Low: 0.00%

- **Autodesk BPAC**:
  - High: 24.20%
  - Medium: 75.80%
  - Low: 0.00%
Assessment results: indirect measures
Assessment results: indirect measures

<table>
<thead>
<tr>
<th>Project performance indicators</th>
<th>Survey results in mean Likert scales (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The rest of the team</td>
</tr>
<tr>
<td>Planning &amp; Execution</td>
<td>3.46</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>3.67</td>
</tr>
<tr>
<td>Time Commitment &amp; Contribution</td>
<td>3.67</td>
</tr>
<tr>
<td>Collaboration &amp; Communication</td>
<td>3.54</td>
</tr>
<tr>
<td>Overall Accomplishment</td>
<td>3.58</td>
</tr>
</tbody>
</table>
Reflection on assessment

- Adequate direct measures are critical: if one fails, you’ve got a backup
- Assessment data gathering is challenging if students don’t know what to expect: clear instruction on deliverables is absolutely necessary
- External measures such as Autodesk BPAC is helpful, although there are some technical difficulties
- Project-based learning does not come naturally, but necessitates consistent coaching and mentoring
Reflection on joint course project

- Be realistic about the scope of work: students will be intimidated and need constant motivation
- Bring real experts into classroom is a must: advantage of using projects on campus
- Cultivate the synergistic thinking is more important than the actual technical skills
- Instructors need planning out at meticulous level to ensure smooth learning experience
BIM Course Development and Its Future Integration at University of Indonesia and Institute of Technology Bandung, Indonesia

Gregorius A Gegana A1, Tony H Widjarasaro2

1 Department of Architecture, Faculty of Engineering, University of Indonesia
E-mail: lonelanrete@gmail.com

2 Department of Architecture, School of Architecture, Planning and Policy Development, Institute of Technology Bandung
E-mail: tonyhwidjarasaro@gmail.com
INTRODUCTION

- BIM movement in Indonesia has not been as enthusiastic as in developed countries
- globalization in construction teamwork is unavoidable: ASEAN Economic Community 2015
- Neighboring ASEAN countries also has started to adopt BIM to their AEC practice: Singapore BIM Guide 2013
- steady increase in the demands of BIM skilled personnel as well as competition pressure in Southeast Asia market
- educational institutions contribute in the education of future graduates who understand and able to operate within a BIM defined framework
Study objective

- to look and compare at 2 different BIM curricula from University of Indonesia (UI) and Institute of Technology Bandung (ITB), their learning outcomes, assessment criteria, and samples of student’s work
Method

- BIM course from each university is reviewed and student’s works samples are presented
- the overall courses and work samples are tabulated for integrated examination
- Discuss the future integration for BIM study with other courses, its direction, and future improvements
BIM COURSE AT UNIVERSITY OF INDONESIA
Course Description

- Computer Aided Design (CAD) Presentation
  - Elective- 3 credits (3rd semester and up)
  - Prerequisites: Architectural Communication Technique (mandatory/ 1st semester)

- BIM integration since 2007
- Related CAD course: -
Course’s objectives

students to be able to explore CAD and BIM application to generate comprehensive, pre-professional architectural documentation and digitally visualize their architectural idea, both individually and in teamwork

- 2D drafting
- 3D Modelling
- Project documentation/ quantification
- Rendering/ visualization
Learning method

workshop in computer lab once a week and assignment

- **Week 1-4**: 2D project documentation using CAD application
- **Week 5-7**: individual model in BIM application: ArchiCad
- **Week 8-14**: groupwork to make integrated 2D project documentation with 3D visualization and quantification in BIM

- **PROJECT**: 3-4 stories public building from their senior’s Final Studio project
<table>
<thead>
<tr>
<th>WEEK</th>
<th>TOPIC</th>
<th>SUB-TOPIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAD Introduction</td>
<td>AutoCAD user interface and features: layers and units 2D drawing/ modification tools</td>
</tr>
<tr>
<td>2</td>
<td>Documentation standards and furnishing</td>
<td>Symbols, annotating, and dimensioning tools Blocks and library</td>
</tr>
<tr>
<td>3</td>
<td>Orthographic projection</td>
<td>Project exercise: floor plan</td>
</tr>
<tr>
<td>4</td>
<td>Layout and printing</td>
<td>Viewport, layout, and plotting</td>
</tr>
<tr>
<td>5</td>
<td>Introduction to BIM: ArchiCad</td>
<td>User interface and features: layers/ objects, stories, units Integrating CAD drawing (floor plan) to ArchiCad Structural elements: grids, vertical columns, and wall</td>
</tr>
<tr>
<td>6</td>
<td>Structural elements</td>
<td>Beam, floor, and vertical openings; structural plan</td>
</tr>
<tr>
<td>7</td>
<td>MID-TERM submission (individually)</td>
<td>Floor plans of 3-4 stories public building BIM structure model: structural plan and isometric</td>
</tr>
<tr>
<td>8</td>
<td>Collaboration Introduction Basic elements I</td>
<td>Splitting works and combining files Exterior and Interior walls, curtain walls Wall openings: doors and windows</td>
</tr>
<tr>
<td>9</td>
<td>Basic elements II</td>
<td>Floor/ slab, roof, ceiling plan</td>
</tr>
<tr>
<td>10</td>
<td>Circulation and furnishing</td>
<td>Stairs, ramp, furnishing, and landscape</td>
</tr>
<tr>
<td>11</td>
<td>Detailing and annotation</td>
<td>Dimensioning, text, and space elements</td>
</tr>
<tr>
<td>12</td>
<td>Project documentation</td>
<td>Doors and windows schedule, layout and printing</td>
</tr>
<tr>
<td>13</td>
<td>3D visualization</td>
<td>Daylight, artificial lighting, and rendering</td>
</tr>
<tr>
<td>14</td>
<td>FINAL project submission (teamwork)</td>
<td>Project documentations of 3-4 stories public building: Plans, elevations, sections, and elements quantification 3D visualization: interior and exterior renderings</td>
</tr>
</tbody>
</table>
Learning Outcome 1: 2D CAD Documentation

Evaluation is based on architectural/construction drafting codes and order:

- Precision
- Dimensions and scales
- Symbols and annotations
- Layout
Learning Outcome 2: Individual Basic BIM Model

Evaluation is based on:
- model accuracy
- cleanliness
Learning Outcome 3: Teamwork BIM Model and Documentation

Evaluation of 2D documentation:

- Precision
- Dimensions and scales
- Symbols and annotations
- Layout
Learning Outcome 3: Teamwork BIM Model and Documentation

Evaluation of 3D visualizations:
- Rendering and lighting quality
- Communicative images
- Creativity in taking camera angle
- Objects order

<table>
<thead>
<tr>
<th>Zone Categories</th>
<th>Story</th>
<th>Room</th>
<th>Floor Type</th>
<th>Room height</th>
<th>Perimeter</th>
<th>Wall surf.</th>
<th>Measured Area</th>
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</thead>
<tbody>
<tr>
<td>2.0 STUDENT ZONE</td>
<td>3rd FLOOR total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4th FLOOR</td>
<td>WAHANA OLAH...</td>
<td></td>
<td>3,050.00 mm</td>
<td>50,103.32 mm</td>
<td>112.69 m²</td>
<td>124.85 m²</td>
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<tr>
<td></td>
<td>4th FLOOR</td>
<td>WAHANA OLAH...</td>
<td></td>
<td>3,050.00 mm</td>
<td>56,616.22 mm</td>
<td>38.04 m²</td>
<td>147.07 m²</td>
</tr>
<tr>
<td>2.0 STUDENT ZONE</td>
<td>4th FLOOR total</td>
<td></td>
<td></td>
<td></td>
<td>106,719.5 mm</td>
<td>150.73 m²</td>
<td>271.93 m²</td>
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<tr>
<td>2.0 STUDENT ZONE</td>
<td>total</td>
<td></td>
<td></td>
<td></td>
<td>704,990.4 mm</td>
<td>1,513.93 m²</td>
<td>1,430.87 m²</td>
</tr>
</tbody>
</table>
# Grading Criteria

<table>
<thead>
<tr>
<th>Grade</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>demonstrated the ability to fully-explore the applications to result excellent professional quality of documentation and 3D renderings</td>
</tr>
<tr>
<td>A-</td>
<td>shows professional quality with few minor drawbacks in either 2D drafting or 3D images</td>
</tr>
<tr>
<td>B+</td>
<td>shows extra efforts to result either better quality of 2D drafting or 3D renderings</td>
</tr>
<tr>
<td>B</td>
<td>have clear and comprehended drafting order and 3D rendering</td>
</tr>
<tr>
<td>B-</td>
<td>ability to result pre-professional documentation with few minor drawbacks</td>
</tr>
<tr>
<td>C+</td>
<td>shows extra efforts to communicate project documentation</td>
</tr>
<tr>
<td>C</td>
<td>sufficient effort to fulfill all task requirements</td>
</tr>
</tbody>
</table>
Course Evaluation and Future Development

- 2007 CAD (7 weeks) : BIM (7 weeks)
- 2010 CAD (3 weeks) : BIM (11 weeks)

Plan of Imparting BIM into Building Physics course:
- to enable design exploration based on building performance analysis
BIM COURSE AT INSTITUTE OF TECHNOLOGY BANDUNG
Course Description

- **Introduction to BIM**
  - Elective - 3 credits (4th semester and up)
  - Prerequisites: Computational Studio (mandatory/ 3rd semester)

- Established in 2014
- Related CAD course: Computational Studio, Parametric Design
Course’s objectives

introduce students to the basics of BIM operation, as well as its main benefits in comparison to the conventional CAD method

- Provision of accurate and integrated documentation of drawings and other information within a project
- Facilitation of cooperation across teams of different disciplines by use of its work-sharing feature
Learning method

workshop in computer lab once a week and individual/team work practice

- **Week 1-8**: individual learning of basic element modeling in Revit
  - **PROJECT**: 2 stories house

- **Week 9-14**: BIM’s collaborative aspects
  - **PROJECT**: high-rise apartment
<table>
<thead>
<tr>
<th>WEEK</th>
<th>TOPIC</th>
<th>SUB-TOpic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to BIM in the construction industry Revit Architecture</td>
<td>Evolution of information technology in architectural design Design method using BIM technology BIM principles and workflow, user interface and key features of Revit Architecture</td>
</tr>
<tr>
<td>2</td>
<td>Setting up project</td>
<td>Topography modeling, Image references Datum: project location, grid, elevation</td>
</tr>
<tr>
<td>3</td>
<td>Basic component modelling</td>
<td>Column, Walls, Openings: window, doors</td>
</tr>
<tr>
<td>4</td>
<td>Circulation and roof</td>
<td>Circulation: Stairs, ramp, Roof types</td>
</tr>
<tr>
<td>5</td>
<td>Revit Content Creation</td>
<td>Revit Family creation and editing: System, Loadable, and In-place</td>
</tr>
<tr>
<td>6</td>
<td>Curtain Wall</td>
<td>Curtain wall system</td>
</tr>
<tr>
<td>7</td>
<td>Mass modelling and editing</td>
<td>Mass modeling and editing</td>
</tr>
<tr>
<td>8</td>
<td>MID-TERM Presentation (individually)</td>
<td>BIM model &amp; documentations of 2-stories house: Floor plans, elevations, sections, room schedule, and 3D</td>
</tr>
<tr>
<td>9</td>
<td>Intro to Collaboration</td>
<td>Introduction to Collaboration, principle of worksheet Project workshop with PT. Intiland Development, Tbk.</td>
</tr>
<tr>
<td>10</td>
<td>Project Workshop</td>
<td>Project workshop</td>
</tr>
<tr>
<td>11</td>
<td>Project Workshop</td>
<td>Project workshop</td>
</tr>
<tr>
<td>12</td>
<td>Collaborative Management</td>
<td>Clash detection with Naviswork Exercise on project and rectification</td>
</tr>
<tr>
<td>13</td>
<td>Collaborative Management</td>
<td>Project modification and elaboration</td>
</tr>
<tr>
<td>14</td>
<td>FINAL project submission (teamwork)</td>
<td>Project final: BIM model of high-rise apartment Course feedback</td>
</tr>
</tbody>
</table>
Learning Outcome 1: Understanding BIM and Individual Project

Evaluation is based on the accuracy of their building information as compared to the information of the original BIM model.
Learning Outcome 2: Collaborative Project

- PT. Intiland Development Tbk to lecture on the collaborative aspects of BIM and explain the current application of BIM in their organization.
Learning Outcome 2: Collaborative Project

- Evaluation is based on each teams’ appropriate alignment to the central file of the apartment.
# Grading Criteria

<table>
<thead>
<tr>
<th>Grade</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>able to produce professional quality, well-documented set of comprehensive drawings, with only minor inconsistencies, or incomplete elements</td>
</tr>
<tr>
<td>A-</td>
<td>shows minimum comprehensive set of drawings with additional explanatory drawings to express better understanding of the modeled building design</td>
</tr>
<tr>
<td>B</td>
<td>fulfill the minimum comprehensive set of drawings with notable improvements</td>
</tr>
<tr>
<td>B-</td>
<td>shows minimum comprehensive set of drawings, as is required in the project terms of reference</td>
</tr>
<tr>
<td>C</td>
<td>shows minor inconsistencies to the drawing standards, and/or incomplete components in their projects</td>
</tr>
<tr>
<td>C-</td>
<td>submit their project with a few notable inconsistencies to the drawing standards, and/or incomplete components in their projects</td>
</tr>
</tbody>
</table>
Course Evaluation and Future Development

- Computational Studio: basic BIM element modeling
- Intro to BIM: content creation and collaboration

Plan of joint class with Department of Applied Physics:
- to enhance comprehensive performance analysis of the final design
- material usage efficiency of the final design
- multi-discipline collaboration
<table>
<thead>
<tr>
<th>Course Name</th>
<th>University of Indonesia</th>
<th>Institute of Technology Bandung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related CAD</td>
<td>1. Computational Studio (prerequisite)</td>
<td>1. Computational Studio (prerequisite)</td>
</tr>
<tr>
<td>Emphasis</td>
<td>Design exploration</td>
<td>Building technology</td>
</tr>
<tr>
<td>Course Objective</td>
<td>1. 2D drafting, 3D modeling</td>
<td>1. Accurate, integrated documentation and information within BIM model</td>
</tr>
<tr>
<td></td>
<td>2. Documentation/ quantification</td>
<td>2. Project collaboration</td>
</tr>
<tr>
<td></td>
<td>3. Rendering/ visualization</td>
<td></td>
</tr>
<tr>
<td>BIM app</td>
<td>ArchiCad</td>
<td>Revit Architecture</td>
</tr>
<tr>
<td>Method</td>
<td>Workshops/ projects</td>
<td>Workshops/ projects, Guest lecture/ case study</td>
</tr>
<tr>
<td>Duration</td>
<td>14 weeks (including exams)</td>
<td>14 weeks (including exams)</td>
</tr>
<tr>
<td>Learning Outcome</td>
<td>Individual drafting</td>
<td>Individual accurate modeling</td>
</tr>
<tr>
<td></td>
<td>Floor plans of 3-4 stories building</td>
<td>Model with integrated documentation and quantification of 2-stories house</td>
</tr>
<tr>
<td></td>
<td>Individual simple modeling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Structural model and plan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teamwork modeling</td>
<td>Teamwork modeling</td>
</tr>
<tr>
<td></td>
<td>Documentation of low-rise building</td>
<td>Combined BIM model of high-rise apartment</td>
</tr>
<tr>
<td></td>
<td>Floor plans of low-rise building</td>
<td></td>
</tr>
<tr>
<td>Future Development Plans</td>
<td>Sustainable design</td>
<td>Sustainable design</td>
</tr>
<tr>
<td></td>
<td>Integration with Building Physics course to explore high performance building design</td>
<td>Joint class with Dept. of Applied Physics to analyze performance and material of final design</td>
</tr>
</tbody>
</table>
Analysis & Result

Differences can be caused by the differences in department’s curriculum emphasis

- UI encourages design exploration
- to integrate BIM knowledge into related existing course to enhance the exploration

- ITB has emphasis on technology and real world practice based
- more to expand outside, based on real practice case and multi-discipline collaboration
CONCLUSION

BIM can be integrated on school curriculum by expanding it inwards or outwards:

- Integrating to existing courses or establishing new courses
- To do inner design exploration or open multi-discipline collaboration
BIM PEDAGOGY

Fundamentals and Exploration

Presented by Geoffrey Becker for the 9th BIM Academic Symposium | Washington, DC | 7-8 April 2015
The Authors

Karen Kensek

Assistant Professor at the University of Southern California

Professor Kensek specializes in computer applications for architecture. Her research has focused on BIM and its role in sustainability, simulation, virtual reconstruction, as well as solar envelopes an digital design. She has hosted seven BIM symposia at USC covering topics such as sustainable design, construction and fabrication, and cutting edge technology and practices.

Geoffrey Becker

Master of Building Science Student at USC

Geoffrey is a second-year MBS student. His primary research interest is exploring strategies for effective energy retrofits to historic buildings. He has served as Kensek’s ARCH 507 class assistant since beginning his master’s at USC in the fall of 2012. He is expected to graduate in May 2015 with a certificate in Sustainable Design.
Outline

- BIM at USC: ARCH 507
- Homework
- Final Projects
  - Viewpoints on BIM
  - Sustainable Design
  - Customization (plug-ins)
  - Visual Scripting with Dynamo
BIM at USC: ARCH 507

- Upper division course in the School of Architecture
- Goals:
  - Teach what BIM is (3D parametric modeling)
  - Provide useful (employable) skillset
  - Impart understanding of future potentials for BIM
- Focus: Teaching software
  - Primarily Autodesk Revit, but also Navisworks, Green Building Studio, Vasari, Solibri, ArchiCAD, and others
- Course consists of 8 skill-building homework assignments and 1 exploratory project
### Grading and schedule

<table>
<thead>
<tr>
<th>Homework</th>
<th>Percentage of Grade</th>
<th>Assignments</th>
<th>Number of points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework 1</td>
<td>20%</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Homework 2</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Homework 3</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homework 4</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homework 5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homework 6</td>
<td>10</td>
<td></td>
<td></td>
</tr>
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<td>Homework 7</td>
<td>10</td>
<td></td>
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</tr>
<tr>
<td>Homework 8</td>
<td>10</td>
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<tr>
<td>Part 1</td>
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<td>Part 2</td>
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<tr>
<td>Part 3</td>
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<tr>
<td>Pop-quizzes</td>
<td>varies</td>
<td></td>
<td></td>
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<tr>
<td>Questions on readings</td>
<td>varies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>varies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Lecture, Homework, Required Readings (see other software references online)

<table>
<thead>
<tr>
<th>Week 1</th>
<th>January 16</th>
<th>Introduction to BIM</th>
<th>Routledge - Application - one of the professional firm case studies (designLAB, ZGF, CASE, or Mortenson Construction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 2</td>
<td>January 23</td>
<td>Understanding Families</td>
<td>Routledge - Introduction and Chapter 1: BIM overview</td>
</tr>
<tr>
<td>Week 3</td>
<td>January 30</td>
<td>Creating Parametric Components</td>
<td>HWK 1 due Routledge - Chapter 2: Stakeholders and BIM’s many roles</td>
</tr>
<tr>
<td>Week 4</td>
<td>February 6</td>
<td>Advanced Parametric Components</td>
<td>HWK 2 due Routledge - Chapter 3: Data exchange and interoperability</td>
</tr>
<tr>
<td>Week 5</td>
<td>February 13</td>
<td>BIM as a Database, Interoperability</td>
<td>HWK 3 due Routledge - Chapter 4: BIM as a Database, Interoperability</td>
</tr>
<tr>
<td>Week 6</td>
<td>February 20</td>
<td>BIM in the Profession: Construction</td>
<td>HWK 4 due Routledge - Chapter 5: Beyond basic BIM (read the subsection on Computational design) and Conclusion</td>
</tr>
<tr>
<td>Week 7</td>
<td>February 27</td>
<td>Rendering and Animation</td>
<td>HWK 5 due Wiley - Forward and Chapter 12: Analytical BIM: BIM Fragments, Domain Gaps, and Other Impediments</td>
</tr>
<tr>
<td>Week 8</td>
<td>March 6</td>
<td>Conceptual Modeler and Parametric Pattern Based Curtain Walls</td>
<td>HWK 6 due Wiley - Chapter 13: One BIM to Rule Them All and Chapter 14: Component-Based BIM</td>
</tr>
<tr>
<td>Week 9</td>
<td>March 13</td>
<td>Introduction to Parametric Adaptive Components</td>
<td>HWK 7 due Wiley - Chapter 13: One BIM to Rule Them All and Chapter 14: Component-Based BIM</td>
</tr>
</tbody>
</table>

#### Lecture, Homework, Required Readings (see other software references online)

| Week 10, March 20, Spring Break | | | |
| Week 11 | March 27 | Introduction to Visual Scripting | HWK 7 due Wiley - BIM Analytics (read one of the following chapters: 5, 6, 7, 8, 10, 11) |
| Week 12 | April 3 | Visual Scripting - attractors | HWK 8 due http://bimcurriculum.autodesk.com/unit/unit-8-computational-design (especially 8.3.1 about attractors) http://autodesk.typepad.com/bpa/2013/08/more-fun-with-dynamo-for-bpa-automatic-shading-design.html |
| Week 13 | April 10 | Visual Scripting – solar control | FP, part 1 due Wiley - Chapter 16: BIM, Materials, and Fabrication |
| Week 15 | April 24 | BIM in the Profession: Architecture | Optional: Routledge - Chapter 4: BIM implementation |
| Week 16 | May 1 | Course Synthesis | Optional: aiaio95712 - AIA BIM contract documents.pdf National Building Information Modeling Standard (NBIMSv1_p1.pdf) |

**FINAL, May 8, 8 – 10 am. Final Project, part 3 due**
Course Textbooks

Karen M. Kensek, LEED AP BD+C, Assoc. AIA

Technical Design Series: Building Information Modeling (Routledge 2014 http://www.routledge.com/books/details/9780415717748/) is an overview of BIM in the profession at an introductory, but comprehensive level. This book addresses many key roles that BIM is playing in shaping professional offices and project delivery processes. The book is divided into two parts: Fundamentals (BIM overview, stakeholders and BIM’s many roles, data exchange and interoperability, BIM implementation, and beyond basic BIM) and Application (four case studies: designLAB Architects, ZGF, CASE, and Mortenson Construction).

Karen M. Kensek, LEED AP BD+C, Assoc. AIA
Douglas E. Noble, PhD, FAIA

Building Information Modeling: BIM in Current and Future Practice (Wiley 2014 http://www.wiley.com/WileyCDA/WileyTitle/productCd-111876630X.html) is an edited compilation of provocative essays providing a forum for these leadership voices in the marketplace of ideas about building information modeling in architecture. They provide clarity and direction for thinking about the current practice and the future directions of BIM, instigating commentary by foremost thinkers about both research about BIM and speculation into the future of BIM. The 26 chapters are grouped together thematically in six sections that present both complementary and sometimes incompatible positions: Design Thinking and BIM, BIM Analytics, Comprehensive BIM, Reasoning with BIM, Professional BIM, and BIM Speculations.

In addition, full-color digital material (PDFs, PowerPoint slides, animations) is available for professors to augment the use of this book in their classes, including case studies by architecture firms an engineering firm, and contractors; two faculty bonus papers; and sample teaching material.

These books are available free of charge for faculty considering them for their class.
Homework

- 8 assignments cover more-or-less set progression
- Goal is to give a good overview of BIM fundamentals
- **Homework 1: BIM Overview: Introduction to Revit Architecture**
  - **Homework 2: Understanding Families**
  - **Homework 3: Your Building: 2D / 3D Coordination**
  - **Homework 4: BIM Scheduling and Detailing**
  - **Homework 5: Rendering and Animation**
  - **Homework 6: Intro. to the Conceptual Modeler and Pattern Based Curtain Walls**
  - **Homework 7: Parametric Modeling: Adaptive Components**
  - **Homework 8: Varies**
Final Project: BIM Viewpoints

- Students interviewed a key BIM coordinator at an architecture firm for project near completion.
- Then interviewed someone with the firm that constructed the project.
- Analyzed how the model was made and passed along throughout its development, what problems occurred, how to improve the process.
- Note: some firms insisted on keep their interviews confidential.
Final Project: BIM & Sustainable Design

- This project has had a few versions, some with Revit, some with Vasari
- Has included completion of Autodesk Building Performance Analysis Certificate
  - *Adjusted now to include only select modules*
Final Project: Customization (plug-ins)

- Students created plug-ins to improve productivity
- Used Revit API (application program interface) to create plug-in
- Learned some C#, how to use Visual Studio, and how to create an add-in file
Final Project: Visual Scripting with Dynamo

- Learned to use powerful form-generating algorithms
- Part 1: Create an attractor script and manipulate instance parameter
- Part 2: Create shading devices to respond to sun’s location
- Part 3: Create parametric geometry based on Zach Kron’s bridge
Karen’s Conclusions

- The structure of ARCH 507 provides students opportunities to develop marketable skills in building information modeling, while also exploring the cutting edge potential of various software platforms.
- The question remains, what other courses should accompany classes like ARCH 507?
- Will BIM be subsumed in the architecture curriculum, much like CAD and 3D modeling?
Geoffrey’s Opinions

- ARCH 507 is a valuable class for students from across all of the AEC disciplines.
- The course is time-intensive, but students are ultimately very happy that they have taken the class and done the work.
THANK YOU
Process and Structure: Performance Impacts on Collaborative Interdisciplinary Team Experiences

Tamera McCuen, Associate Professor, tammymccuen@ou.edu
Haskell & Irene Lemon Construction Science Division, University of Oklahoma

Elizabeth Pober, Associate Professor, epober@ou.edu
Interior Design Division, University of Oklahoma
Team Structure & Process

- Team Structure: arrangement among people based on roles and responsibilities

- Team Process: defines specific modes of interaction between two points of activity in time
Purpose

• Focus on three research questions:
  – Is there a difference in student perceptions about the importance of team process compared to team structure?
  – Which individual team process components do interdisciplinary teams identify as impacting collaboration?
  – Does a team’s process or structure have a greater impact on its performance?
Study Design & Context

- Interdisciplinary design-build project organized for 38 students in their final semester
- Interdisciplinary faculty team
- Study participants included
  - 11 Construction Science
  - 12 Interior Design
  - 7 Architecture
- Local elementary school RFP for addition and renovations
Materials & Procedures

- Team building exercises
- RFP
- BIM utilized by all team members to facilitate communication and decision making
- LOD 200 to 300 model with additional deliverables included in a proposal book and digital presentation
<table>
<thead>
<tr>
<th>Construct</th>
<th>Component</th>
<th>Aggregate Mean and Standard Deviation (by component item)</th>
<th>Aggregate Mean and Standard Deviation (by construct)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Aggregate Mean and Standard Deviation (by component item)</td>
<td>Aggregate Mean and Standard Deviation (by construct)</td>
</tr>
<tr>
<td>Team process</td>
<td>Information exchange</td>
<td>3.76 (.963)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Protocol</td>
<td>4.05 (.609)</td>
<td>4.0 (.698)</td>
</tr>
<tr>
<td></td>
<td>Information sharing</td>
<td>4.18 (.637)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standards</td>
<td>4.03 (.585)</td>
<td></td>
</tr>
<tr>
<td>Team structure</td>
<td>Roles</td>
<td>4.12 (.863)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Responsibilities</td>
<td>4.19 (.809)</td>
<td>3.93 (.842)</td>
</tr>
<tr>
<td></td>
<td>Project knowledge</td>
<td>3.61 (.905)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical expertise</td>
<td>3.79 (.791)</td>
<td></td>
</tr>
</tbody>
</table>
Results

Collaboration

Info

Sharing

Info

Exchange

Industry Standards
Discussion & Implications

• Distinction between the importance of team process and team structure are slight based on the current study results.

• Results led to further questions about the quantity and quality of student experiences compared to the type of experience, whether industry or academic.
Discussion & Implications

• Anecdotal evidence indicates gaps between the students’ perceptions about team process and their utilization of the process.

• The faculty believe there are opportunities to improve student team performance with similar projects in the future.
Thank you!

Questions?
TOWARD ADOPTION OF BIM IN THE NIGERIAN AEC INDUSTRY; CONTEXT FRAMING, DATA COLLECTING AND PARADIGM FOR INTERPRETATION

Sa’id Alkali Kori, Ph.D. Candidate, s.a.kori@liverpool.ac.uk.

Dr. Arto Kiviniemi, Professor of Digital Architectural design, A.kiviniemi@liverpool.ac.uk.

School of Architecture, University of Liverpool, Liverpool, UK.
METHODOLOGY

THE ICT REVOLUTION AND THE AEC INDUSTRY

The industry facing a paradigm shift in use of Building Information Modelling (BIM) and Integrated Design and Delivery Systems (IDDS) (Owen et al., 2009) in an effort to increasing productivity, efficiency, infrastructure value, quality and sustainability; and reduce lifecycle costs (Arayici et al., 2011)..........needs a corresponding shift in focus and processes........

Finland, USA, UK, Australia, Netherlands, Singapore, Hong Kong Finland, Norway, Denmark, Hong Kong among others have adopted BIM technologies and have experienced significant growth in construction project delivery.

In an effort toward aligning the Nigerian AEC industry, a ‘sleeping giant’ (Little has been reported on the ICT in the industry ) to the international benchmark of practice....survey of state of art of the industry on its prospect of BIM.
AIM AND OBJECTIVES OF THE RESEARCH

To examine the prospect of the Nigeria Architectural firms market on its state of art and their openness to the information and digital technology toward adoption of Building information modelling (BIM) in the AEC sector.

A review of literature was done focusing on the understanding of the BIM, some case studies regarding BIM in the AEC market among others.

The study opted for a three steps analysis:

I. to classify the firms into a 3-dimensional scale based on staff employed;

II. (ii) to assess data by analysing the response of each category against the BIM maturity models using cross tabulation;

III. (iii) to define the level of the willingness and implementation of each category using a descriptive analysis.
METHODOLOGY

STUDY SAMPLE
Architectural firms that are registered with the Architects Registration Council of Nigeria and however some that are design consultancy firms within four (4) selected cities of, Lagos, Abuja, Kano and Kaduna.

METHOD
An online survey questionnaire using an online application Fluid survey was used as a tool of data collection distributed via email.

100 surveys administered, 40 surveys which amount to at least 40.00% were retrieved and used for analysis

“...the result of a survey could be considered significant if the response rate not lower than 30-40% is obtained.” (Moser and Kalton ,1971),

CLASSIFICATION
That firms with staffs:
1. Between 1 to 10 into Small scale Architectural firm
2. Between 11 to 20 into Medium scale Architectural firm
3. Beyond 20 into Large scale Architectural firm.
THE RESEARCH DESIGN

MAINLY BASED ON THE SUCCAR 2009 BIM MATURITY MATRIX

Specific Attainable Applicable Flexible Gradual Cumulative Current Informative Measurable Granular Neutral Relevant

A FRAMEWORK FOR BIM PROSECT IN NIGERIA ARCH FIRMS

BIM COMPETENCY SET

TECHNOLOGY SETS:
- Software Application and used
- Hardware and networks (along disciplines)
- Hardware and networks (across disciplines)

PROCESS SETS:
- Leadership,
- human Resources
- products/services.

POLICY SETS:
- Contracts.
- Regulations.
- Preparatory.

BIM CAPABILITY STAGE

- Object-based Modelling
- Model-base collaboration
- Network-base integration
The chi-square table revealed that the “Asyp. Sig. is $p < .001$, and being less than 0.05, there is a very strong statistical relationship between the number of the computer literates workforce and that of the entire firm staff.

Table 1: Cross tabulation of Size of firms by digital design staffs in the firms

<table>
<thead>
<tr>
<th>SIZE OF FIRMS</th>
<th>Number of Digital design workforce</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 to 10</td>
<td>11 to 20</td>
</tr>
<tr>
<td>Small firms</td>
<td>% within size of the firm</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within digital design workforce</td>
<td>45.8%</td>
</tr>
<tr>
<td>Medium firms</td>
<td>% within size of the firm</td>
<td>71.4%</td>
</tr>
<tr>
<td></td>
<td>% within digital design workforce</td>
<td>41.7%</td>
</tr>
<tr>
<td>Large firms</td>
<td>% within size of the firm</td>
<td>20.0%</td>
</tr>
<tr>
<td></td>
<td>% within digital design workforce</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>25.197</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>30.511</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 6 cells (66.7%) have expected count less than 5. The minimum expected count is 1.93.
THE ASSESSMENTS

Assessing the current state of the art of the architectural firms base on the designed conceptual framework

descriptive but qualitative in analysis as it would relate to the Succar’s BIM matrix framework

in the analysis cross tabulation with the size of the firms was done in each case then followed by a descriptive analysis in each case
digital tools are mainly used for Sketching, modelling and mostly only print copy were shared for visualization and presentation

BIM is regarded as a technology stream without much consideration to the business process and it lacks performance and improvement strategy with lack of leadership and motivation

lack of any policy rules, guidelines or standard in use of the digital tools

<table>
<thead>
<tr>
<th>BIM Maturity Matrix</th>
<th>Competency set</th>
<th>0 point</th>
<th>10 point Initial/hoc</th>
<th>20 point Defined</th>
<th>30 point Managed</th>
<th>40 point Integrated</th>
<th>50 point Optimised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Software</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Hardware % Network 1</td>
<td>0</td>
<td>18.2</td>
<td>63.6</td>
<td>18.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Hardware &amp; Network 2</td>
<td>9.1</td>
<td>45.5</td>
<td>36.4</td>
<td>9.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Process</td>
<td>Leadership</td>
<td>36.4</td>
<td>9.1</td>
<td>9.1</td>
<td>9.1</td>
<td>27.3</td>
<td>9.1</td>
</tr>
<tr>
<td></td>
<td>Human Resources</td>
<td>45.5</td>
<td>9.1</td>
<td>27.3</td>
<td>9.1</td>
<td>9.1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Product and services</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Contractual</td>
<td>36.4</td>
<td>9.1</td>
<td>9.1</td>
<td>9.1</td>
<td>27.3</td>
<td>9.1</td>
</tr>
<tr>
<td>Policy</td>
<td>Regualtory</td>
<td>45.5</td>
<td>9.1</td>
<td>18.2</td>
<td>9.1</td>
<td>0</td>
<td>18.2</td>
</tr>
<tr>
<td></td>
<td>Preparatory</td>
<td>9.1</td>
<td>0</td>
<td>18.2</td>
<td>0</td>
<td>36.4</td>
<td>36.4</td>
</tr>
<tr>
<td></td>
<td>Sub total</td>
<td>182</td>
<td>300.1</td>
<td>181.9</td>
<td>63.7</td>
<td>100.1</td>
<td>72.8</td>
</tr>
<tr>
<td></td>
<td>Percentage %</td>
<td>20.22</td>
<td>33.33</td>
<td>20.22</td>
<td>7</td>
<td>11.11</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BIM Stage</th>
<th>capability</th>
<th>Capability stage</th>
<th>Pre BIM</th>
<th>Object Base Modelling</th>
<th>Model base Collaboration</th>
<th>Network base integration</th>
</tr>
</thead>
</table>

Table 2: The summary table of the assessment in the small architectural firms.
### MEDIUM FIRMS

<table>
<thead>
<tr>
<th>BIM Maturity Matrix</th>
<th>0 point</th>
<th>10 point</th>
<th>20 point</th>
<th>30 point</th>
<th>40 point</th>
<th>50 point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competency set</td>
<td></td>
<td>Initial/ Ad-hoc</td>
<td>Defined</td>
<td>Managed</td>
<td>Integrated</td>
<td>Optimised</td>
</tr>
<tr>
<td>Technology</td>
<td>Software</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Hardware</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>35.7</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>Network 1 %</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Network 2 &amp;</td>
<td>7.1</td>
<td>35.7</td>
<td>28.6</td>
<td>7.1</td>
<td>14.3</td>
</tr>
<tr>
<td>Process</td>
<td>Leadership</td>
<td>21.4</td>
<td>14.3</td>
<td>0</td>
<td>42.9</td>
<td>14.3</td>
</tr>
<tr>
<td></td>
<td>Human Resources</td>
<td>21.5</td>
<td>0</td>
<td>14.3</td>
<td>14.3</td>
<td>14.3</td>
</tr>
<tr>
<td></td>
<td>Product and services</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Contractual</td>
<td>21.4</td>
<td>14.3</td>
<td>0</td>
<td>35.7</td>
<td>21.4</td>
</tr>
<tr>
<td>Policy</td>
<td>Regualtory</td>
<td>21.4</td>
<td>14.3</td>
<td>0</td>
<td>42.9</td>
<td>14.3</td>
</tr>
<tr>
<td></td>
<td>Preparatory</td>
<td>7.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Sub total</td>
<td>99.9</td>
<td>78.6</td>
<td>92.9</td>
<td>378.6</td>
<td>135.7</td>
<td>114.1</td>
</tr>
<tr>
<td></td>
<td>11.11%</td>
<td>8%</td>
<td>10%</td>
<td>42%</td>
<td>15%</td>
<td>12%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BIM capability Stage</th>
<th>Capability stage</th>
<th>Object Base Modelling</th>
<th>Model base Collaboration</th>
<th>Network base integration</th>
</tr>
</thead>
</table>

Table 3: The summary table of the assessment in the Medium architectural firms.

- Significant collaboration using digital model within the firm.
- Mainly regarded the technology stream but with some ideas about the process but reluctantly adhered to with less motivation and lack of leadership
- Significant detail level robust for potentially improving collaboration on a digital platform as BIM but not used by the firms
LARGE FIRMS

Table 4: The summary table of the assessment in the small architectural firms.

<table>
<thead>
<tr>
<th>BIM Competency set</th>
<th>0 point</th>
<th>10 point Initial/ Ad-hoc</th>
<th>20 point Defined</th>
<th>30 point Managed</th>
<th>40 point Integrated</th>
<th>50 point Optimised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Software</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hardware &amp; Network 1</td>
<td>0</td>
<td>20</td>
<td>26.7</td>
<td>6.7</td>
<td>33.3</td>
<td>13.3</td>
</tr>
<tr>
<td>Hardware &amp; Network 2</td>
<td>6.7</td>
<td>40</td>
<td>6.7</td>
<td>6.7</td>
<td>13.3</td>
<td>26.7</td>
</tr>
<tr>
<td>Process</td>
<td>13.4</td>
<td>6.7</td>
<td>0</td>
<td>13.3</td>
<td>33.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Leadership</td>
<td>13.4</td>
<td>6.7</td>
<td>53.3</td>
<td>0</td>
<td>26.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Human Resources</td>
<td>6.7</td>
<td>6.7</td>
<td>53.3</td>
<td>0</td>
<td>26.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Product and services</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Contractual</td>
<td>13.4</td>
<td>6.7</td>
<td>6.7</td>
<td>0</td>
<td>46.7</td>
<td>26.7</td>
</tr>
<tr>
<td>Policy</td>
<td>13.4</td>
<td>6.7</td>
<td>0</td>
<td>13.3</td>
<td>33.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Regulatory</td>
<td>13.4</td>
<td>6.7</td>
<td>0</td>
<td>13.3</td>
<td>33.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Preparatory</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6.7</td>
<td>40</td>
<td>53.3</td>
</tr>
<tr>
<td>Sub total</td>
<td>53.6</td>
<td>86.8</td>
<td>93.4</td>
<td>246.7</td>
<td>226.6</td>
<td>193.3</td>
</tr>
<tr>
<td>Percentage</td>
<td>6%</td>
<td>10%</td>
<td>10%</td>
<td>27%</td>
<td>25%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Table 4: The summary table of the assessment in the small architectural firms.

- Model Base collaboration.
- Significantly adhering to a set process, there is lack of effective leadership and facilities to support the process.
- This in turns affect the effective implementation of the available policy elements such as guidelines, contracts and effective training.
CONCLUSION

- BIM could potentially help standardization across the industry in Nigeria.
- Adoption of BIM in the industry is an entire shift in the practice.
- Cultural transformation has always been a greater challenge than technological transformation when adopting BIM.
- With effective process adherence, the medium and the large firms in the Nigeria AEC industry could easily curb with the known challenges of the BIM adoption.
- The process set could lead to proper setting of the policy set effective to the context.
- Major issues lie in the small firms regarding the whole shift as just a technological stream and disregarding its accompanying effects on their business settings.
- However, all the firms affirms an enthusiasm for a technological innovation with some resistance to changing cultural practice.
RECOMMENDATION AND FURTHER STUDIES

• Education and Training.
• Software Licences and interoperability.
• Acknowledging the evolution of the shift to a new business process by BIM in the AEC industry.
• Developing a BIM adoption strategies and establish guidelines for integration
• Professional institutes and government to take the lead.

Further research is recommended to understand how the BIM adoption does change the practice in the industry what approach to adopt in other to reconcile the issues arising.

BASIS FOR THE PhD RESEARCH

This research is based on the theory that BIM requires new business models and modes of practice. Effective use of BIM will force small firms to adopt new business models and methods of not only design, but also production (Eastman 2008).

ACKNOWLEDGMENTS
This paper is based on the first authors’ MSc thesis in the University of Salford, Manchester in 2013 and this research has been the motivation toward his PhD research, which is currently ongoing in the University of Liverpool.
BIM COURSE - 2014

Michael Angel Gonzalez
Department of Civil Engineering
University of New Mexico
“BEGIN WITH THE END IN MIND”

7 Habits of Highly Effective People
by Stephen Covey

1. Be Proactive
2. Begin with end in mind
3. Put first things first
4. Think Win-Win
5. Seek first to understand, then to be understood
6. Synergize
7. Sharpen the Saw
WHY ADOPT BIM THEORIES?

Credit: Paul Teicholz, Ph.D. Professor (Research) Emeritus, Dept. of Civil and Environmental Engineering, Stanford University
BIM HISTORY; HOW CAN YOU KNOW WHERE YOU ARE GOING IF YOU DON’T KNOW WHERE YOU HAVE BEEN? AND MORE IMPORTANTLY WHERE YOU WANT TO GO. “HAVING VISION”
BIM’S EVOLUTION; MAIN-STREAM

Cave Drawings ~ 40K years

Hand Drawings (Sketch to Proportion) 1100s – 1900s

Leonardo’s Designs 1452 - 1519

Architectural Drafting 1920 --> 1930 (AGS)

Board Drafting to Scale 1940s – 1990s

Computer Aided Drafting & Design 2-D 1980 - Current

3 Dimensional Computer Aided Design 2000 – Current
TELEPHONE’S EVOLUTION;

Smoke Signals
Telegons 1830
Alexander Bell 1892
Common Phones 1900 - 1980

Common Analog Phones 1980 - 1990
Common Digital Phones 1990 - 2000
Common Smart Phones 2000 - 2015 ->>
WHY NOT?
TELEPHONE’S EVOLUTION:

- Smoke Signals
- Morse Telegraph Key (circa 1844)
- Telegraph 1830
- Alexander Bell 1892
- Common Phones 1900 - 1980
- Common Analog Phones 1980 - 1990
- Common Digital Phones 1990 - 2000
- Common Smart Phones 2000 - 2014
- BIM Stage 2014
BIM’S EVOLUTION;

BIM on Laptops, Tablets, and Smart Phones, Why Not ...?

BIM design in Cloud

BIM and 3-D Scanning Verification

http://www.youtube.com/watch?v=BEoivAGQYJ8

4-D Scheduling Dynamic & Parametric
The use of Building Information Modeling (BIM) technology in design practice has grown dramatically. Once considered applicable only to the largest and most sophisticated projects, design firms of all sizes now use BIM in their work in a variety of settings (Structural Engineering Institute, 2010).
CURRENT/ FUTURE PROCESSES

**Building Information Modeling**
- Conceptual Design
- Programming
- Renovation
- Demolition

**Building Information Management**
- Detailed Design
- Analysis
- Documentation
- Fabrication
- Construction 4D/5D
- Operation and Maintenance
- Construction Logistics

**Facilities Information Management**
- BIM Building Life-Cycle
“BIM’S PROCESS EVOLUTION”
CURRENT/ FUTURE PROCESSES

Architecture
- Conceptual Design
- Modeling & Design
- Sustainability Analysis
- Custom Fabrication
- Visualize and Simulate
- Multidiscipline Coordination
- Construction Documentation

 MEP Engineering
- Well-Balanced Coordination
- Model & Drawings
- Building Information Modeling
- Sustainable Design & Building Performance Analysis
- MEP Engineers & Designers
- Fabrication Documentation
- HVAC Commissioning

Example: Early Sustainable Design Decisions
- Could I power my building with photovoltaics and wind power?
- How much would adding insulation help reduce energy?
- How sensitive is my portfolio to changes in weather?
- How much energy should my building use per year?
- How could I optimize occupancy?
- How can I utilize the surrounding land to reduce energy waste?
- Which envelope material will reduce energy the most?
- To achieve net zero, should I go for a multi-story tower or a larger floorplate?
- How could I minimize embodied carbon and construction waste?
CURRENT/FUTURE PROCESSES

Construction

- Structure
- Documentation
- Quantification
- Estimating
- 4D Sequencing
- Scheduling
- MEP
- Civil
- Visualization
- Clash Detection/Coordination
- ERP/SCM/O&M
INNOVATIVE CHANGE IN EDUCATION?

Innovation Continuum identifies innovation is continuous, everywhere, in three broad areas of innovation:
1) “Sustaining” or incremental innovation
2) “Transformational” or significant innovation
3) “Disruptive” or game-changing innovation

Many variables may impact the level of innovation in educational institutions; from financial & spatial resources to faculty buy-in, and available instructors with appropriate KSAs’
What is the stage and investment of training and technology in design at your University?
BIM IN EDUCATION – PRIMARY STAKEHOLDERS

- Administration
- Students
- Faculty
History, Principles, Theories, and Techniques of computer building information modeling applications in the construction industry are used extensively.

Use AutoDesk - Revit Architecture ®, and Revit Structure ® Modeling software and supplementary.

Architectural, Construction Management, Civil and Construction Engineering students develop and apply current database technologies, and explore future possibilities and use.

Mid-term exam, 2 minor & 1 major research papers, individual models, 1 team project with structural design & FEM analysis; or 4-D & 5-D with MS Project and Navis Manage and optional timeline are included in the course.
First Individual Project Modeling and Layout – “sympathy for the devil”
Team Project Modeling and Layout Structurally Designed at Specified US Location
Team Project Modeling and Layout Structurally Designed at Specified US Location (Rendering)
Team Project Analyzing Clinic Model 4-D & 5-D with Navis Manage; Source: http://www.nibs.org/?page=bsa_commonbimfiles&hhSearchTerms=%22clinic+and+models%22
UNM DEPARTMENT OF CIVIL ENGINEEERING - BUILDING SMART FOUNDATION BIM SUMMIT 2014

Collaboration with industry professionals, academia and students – win-win!
UNM DEPARTMENT OF CIVIL ENGINEERING
CE130L-002 FALL SEMESTER 2014

- Construction Detailing
- Civil Site, Traffic Phasing & Structural Plans
- Reading Drawings & submitting requests for information (RFIs)
- Modeling building from Rubric
- Receive Models and use NavisWork & Manage project and cost analysis
- 2 Exams, and Final Exam

Construction Detailing project modeling and 4-D & 5-D Integrated into freshman level course
VERY SPECIAL THANK YOU TO:

Birgitta Foster ME MBA bSa bSf
Chuck Mies LEED AP AIA AutoDesk ACE
Dana “Deke” Smith FAIA NIBS bSa
Mahmoud Reda-Taha PhD Civil Engineering Chair – UNM
John C. Stormont PhD former chair for having vision and confidence
Arup Maji PhD former chair for starting me with my first course

A Super Special Thank You to my Wife who gave me the skills to teach
with Love and Patients. - Wanda Leyba-Gonzalez USAF MSgt Ret MSPd
Introductory BIM Class
Design/Builder Project

Dr. David L. Batie
Associate Professor
Department of Construction Management
East Carolina University
Points of Discussion

• Course Explanation
• Student Role
• Course Exercises
• Term Project Design
• Future Opportunities
Course Explanation

• Introductory BIM Class
  • SketchUp / AutoCAD / Revit
• Exposure to Design-Build
• Intended to enhance the BIM learning applications
• Student responsibilities for design
• Small Office Building design-build assignment
Student Role

• Initial work on Teams
• Develop design information for Five building system needs. Team Presentations to class.
  • Building Designs
  • Building Structural Systems
  • Interior Finishes & Furnishings
  • Storefronts, Doors, and Windows
  • Handicap and Building Code Requirements
• Develop Individual Small Office Building design
• Complete documentation of Final Project
Course Exercises

- Preliminary 3D modeling exercises in SketchUp
- Floor Plan Sketches
- AutoCAD Floor Plan / Site Plan
- Revit “Getting Started”
- Revit Term Project
- BIM Tricks
Term Project Design

• Small Commercial Office Building
• Program Requirements
  • 2000 GSF
  • Offices / Conference Room
  • 1+ Acre property
  • Parking Requirements
• All project design decisions by individual students based upon research
• Maintain on-going Project Notebook
Term Project Design

- Specific Final Documents from Model
  - Renderings / Interior & Exterior
  - Site Plan
  - Floor Plan
  - Furnishings Plan
  - Reflected Ceiling Plan / Preliminary HVAC layout
  - Elevations
  - Schedules (Door/Window/Finishes/Furnishings/Wall/Roof)
  - Sections
Student Examples
Student Examples
Student Examples
Future Opportunities

- Student encouragement to explore program capabilities
- Solar Studies
- Enhanced capabilities in estimating, scheduling, MEP, Quality Control and Project Management classes.
- Advanced graphics Luminous software
- Advanced BIM course
QUESTIONS?
An Example Project-based Course on BIM for Construction Management

Fernanda Leite, PhD
Assistant Professor

Department of Civil, Architectural and Environmental Engineering
The University of Texas at Austin

http://www.caee.utexas.edu/prof/leite/
CEPM Program Overview

- Graduate-level program within CAEE Department
- 3 tenured & 1 tenure-track faculty members
  - Jim O’Connor
  - Carlos Caldas
  - Bill O’Brien
  - Fernanda Leite
- ~300 graduates since 1970’s
- Link with CII
CEPM Alumni Around the World (1970-2013)

Updated 5/31/2013
Speaker Intro

• PhD in Civil and Environmental Engineering (2009), Carnegie Mellon University
• Assistant Professor at UT since January 2010
• Courses taught:
  – Project Management & Economics (Undergrad)
  – Building Information Modeling (Grad/Undergrad)
  – Project Controls (Grad)
  – Construction Safety (Grad)
• Graduated 19 MS and 4 PhD students
• Currently advise 6 MS and 3 PhD students
CE 395 R7 & ARE 376: BIM

- Cross-listed Grad and Undergrad course: Building Information Modeling for Capital Projects
- 7 offerings since Fall 2010
- Enrollment between 12 and 23 students
- Attracts students from multiple areas within the CAEE department and other departments:
  - CEPM, ARE, Structures, Materials
  - Mechanical Engineering, School of Architecture
Learning Objectives

• Define BIM;
• Describe workflow in using BIM in the building lifecycle;

• Perform **model-based cost estimating**;
• Perform **4D simulations**;
• Perform **MEP design coordination**;
• Evaluate the use of **3D point clouds** to support construction and asset management;

• Evaluate and communicate your ideas related to the use of BIM in the building life cycle.
Format of Instructional Units

• **Introductory class**
  - Lecture format
  - Discussion of relevant literature
  - Previous research
  - Industry applications (Case Studies)

• **Two lab-based classes**
  - Lab 1: Introduction to software system(s) used in unit & hands-on application with examples
  - Lab 2: “time for questions”

• **Group presentations of homework results**
  - Class discussion of learning outcomes
## Lab-related Assignments

### Spring 2015

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW 1 - Model-based Cost Estimating</td>
<td>Assemble Systems &amp; RS Means Online</td>
</tr>
<tr>
<td>HW 2 - Scheduling and 4D Simulation</td>
<td>MS Project, Autodesk Navisworks Manage &amp; Synchro 4D</td>
</tr>
<tr>
<td>HW 3 - MEP Clash Detection</td>
<td>Autodesk Navisworks Manage</td>
</tr>
<tr>
<td>HW 4 - Point Cloud</td>
<td>Autodesk 123D Catch</td>
</tr>
</tbody>
</table>
Additional Course Activities

• **Group Case Study**
  – Written report and class presentation on real-world BIM application; industry mentored

• **Quizzes (3-4 per semester)**
  – Covering topics from each module

• **Individual Synthesis Report** *(grad students only)*
  – Conference paper format; BIM-related topic of choice
  – Mid-semester deliverables and continuous feedback

• **Guest Lectures (3-4 per semester)**
  – General Contractors, Subcontractors, Design Firms, Technology companies, Academics
Example Instructional Unit

Design Coordination
Traditional Design Coordination

Distance from top surface of finished floor to bottom surface of pipe

7'11” with ½” insulation
BIM-based Design Coordination
Data Analysis

• Analyzed precision and recall of clashes identified in both processes
  – Kept track of objects that were and were not modeled, which had impact in precision and recall

\[
\text{precision} = \frac{\text{relevantClashes} \cap \text{retrievedClashes}}{\text{retrievedClashes}} = \frac{TP}{TP+FP}
\]

\[
\text{recall} = \frac{\text{relevantClashes} \cap \text{retrievedClashes}}{\text{relevantClashes}} = \frac{TP}{TP+FN}
\]
Results

Counts of clashes in both processes – **Floor 1**

<table>
<thead>
<tr>
<th></th>
<th>Electrical</th>
<th>Heating</th>
<th>Plumbing</th>
<th>Fire Protection</th>
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<tr>
<td></td>
<td>CM</td>
<td>AT</td>
<td>CM</td>
<td>AT</td>
</tr>
<tr>
<td>Ductwork</td>
<td>4</td>
<td>29</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Electrical</td>
<td></td>
<td></td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
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</tbody>
</table>

Higher recall in automatic process!

CM = Coordination meeting/manual (2D)
AT = Automatic/BIM-based (3D)
Results

• Precision and Recall

Lower precision in automatic process!
Design Coordination Meeting in Jobsite

UT Belo Center for New Media
General Contractor: Flintco

Spring, 2010
Design Coordination Meeting at UT’s Vis Lab

UT Liberal Arts Building
General Contractor: SpawGlass

Meeting date: October 6, 2011
UT-Austin’s Vis Lab: tour and Case Study presentations

- Multi-touch display
- Demo of design coordination research
- High-resolution model visualizations
- Industry-mentored Case Studies
Mock Design Coordination Meeting led by GC
Industry Involvement

• Case study
• Guest lectures
• Jobsite visits
• Mock-design coordination meeting
Jobsite Visits
Lessons Learned

• Process-oriented teaching and learning
  – Focus on process rather than product
  – Active learning

• Modular structure of the course design
  – Standard format
  – Flexible content

• Industry involvement

• Constant tracking of learning outcomes
Thank you! Questions?

Explore UT – CEPM Booth
Exploring Flip for BIM: Tutorials at Home, Exercises in Lab

Carrie Sturts Dossick
University of Washington

Anne Anderson
Washington State University

Hoda Homayouni and Chris Monson
University of Washington
University of Washington
Seniors (3 cr)
Lecture/Lab
10 weeks

Washington State University
Sophomores (2 cr)
Lecture/Lab
14 weeks
Flip the Classroom

Watch lectures at home –
do “homework” in class
(Baker 2000; Lage at al. 2001)

Peer-to-peer learning
(Mazur 2009)

For BIM:

Tutorials at home

Exercises in class
Learning Objectives

Emphasis on Concepts (vs tool training)
(Hietanen and Drogenumller, 2008)

Basic software skills introduced in university, mastered in on-the-job training.
(Kymell, 2008)
<table>
<thead>
<tr>
<th>Software</th>
<th>Lectured concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>SketchUp</td>
<td>Introduction to BIM</td>
</tr>
<tr>
<td>Revit I - Basic Modeling Skills</td>
<td>Surface modeling; Groups vs Components</td>
</tr>
<tr>
<td>Revit II - Quantity Take Off (QTO) and Layout Settings</td>
<td>3D Parametric Modeling</td>
</tr>
<tr>
<td>Navisworks I - Quantity Take Off</td>
<td>Parametric modeling in the context of QTO</td>
</tr>
<tr>
<td>Navisworks II - Clash Detection</td>
<td>Creating sets</td>
</tr>
<tr>
<td>Navisworks III - 4D Modeling</td>
<td>3D visualization</td>
</tr>
<tr>
<td>BIM 360 Glue - Clash Detection</td>
<td>4D visualization</td>
</tr>
<tr>
<td>REVIT TOPIC (FALL 2014)</td>
<td>LAB ASSIGNMENT</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Revit interface; Importing images</td>
<td>Import the 2D floor plan image; create levels and reference planes</td>
</tr>
<tr>
<td>Walls and Curtain Walls</td>
<td>Create grids; Add walls; Add doors and windows</td>
</tr>
<tr>
<td>Floors, Roofs, and Ceilings</td>
<td>Create the floors, roofs and ceilings</td>
</tr>
<tr>
<td>Adding Families</td>
<td>Create a custom stacked wall; Space windows as shown on the plans</td>
</tr>
<tr>
<td>Stairs, Ramps, and Railings</td>
<td>Create stairs; Add mechanical components; Add site components</td>
</tr>
<tr>
<td>Site Modeling; Modifying Families</td>
<td>Create a toposurface; Adjust and array site fencing</td>
</tr>
<tr>
<td>Masses and Rendering</td>
<td>Create a conceptual estimate; Create a conceptual model using a mass; Render the model</td>
</tr>
<tr>
<td>Modifying Families; Rendering</td>
<td>Model the main entry canopy structure; Render the entry view</td>
</tr>
<tr>
<td>Details; Section Boxes; Walkthroughs</td>
<td>Create and annotate details; Create new 3D views using the section box; Create a walkthrough of their building</td>
</tr>
<tr>
<td>Drawing Sets; Workflow</td>
<td>Create a sheet layout with elevations and sections; Create worksets</td>
</tr>
<tr>
<td>&quot;Something Cool&quot;</td>
<td>Each student was asked to independently find and demonstrate &quot;something cool&quot; about Revit to the class. Students chose any three of those items to incorporate into their final model.</td>
</tr>
</tbody>
</table>
Conclusions

Drawbacks:
- **Getting students to prepare for class**
  - Missed tutorials = missed software introduction
  - Lost and frustrated
  - At home tutorials require Assignments and monitoring

Benefits:
- **Faculty have direct contact with students**
  - Able to get students unstuck

- **Self-paced (strength and weakness)**
  - More advanced students would leave or not attend
    - missing peer-to-peer opportunity
  - Others felt rushed and focused only on software skill
Thank you to our co-authors Chris Monson and Hoda Homayouni

Thank you to our students with whom we explore these alternative education delivery methods!
INDUSTRY-ACADEMIC BIM ALLIANCE: A PRAGMATIC APPROACH TO ENHANCE STUDENTS’ BIM KNOWLEDGE

Department of Built Environment
Tony E. Graham, Associate Professor
Musibau A. Shofoluwe, Professor
Robert B. Pyle, Professor & Department Head

North Carolina Agricultural and Technical State University
ABSTRACT

It was projected that by 2014, over 70% of architects, over 40% of engineers, and over 50% of contractors would adopt BIM (McGraw Hill Construction, 2012).

In response to this trend, North Carolina A&T State University (NCA&T) has integrated BIM as part of its ACCE-accredited construction management curriculum.

In addition to a dedicated stand-alone BIM course, the faculty has also experimented with teaching a BIM-integrated senior capstone course in alliance with an industry partner. This paper discusses the alliance formation process and the issues and challenges faced.
INTEGRATION OF BIM INTO CONSTRUCTION CURRICULUM

Driven by industry and government requirements for cost-efficient building delivery systems and improved operational efficiency, construction educators can no longer afford to ignore the need to educate construction graduates in the applications of BIM.

Taylor, Liu, and Hein (2008) argued that “If education is to prepare students for the coming BIM revolution, its integrative potential among the related disciplines must be explored at educational institutions” (p. 1).
Joannides, Issa, and Olbina (2011) reported that:

- 78% of members of the Association of Collegiate Schools of Architecture (ACSA) and American Council for Construction Education (ACCE) schools stated that BIM was part of their curriculum.
- 67% of ACSA member schools reported that their programs have a stand-alone BIM course.
- 53% of ACCE member schools reported that their programs have a stand-alone BIM course.
INTEGRATION OF BIM INTO CONSTRUCTION CURRICULUM, con’t

Similarly, Becerik-Gerber, Gerber, and Ku (2011) as cited in Lee and Dossick (2012) found:

- BIM courses were integrated into 57% of the engineering programs
- 36% of the construction management programs

Furthermore many programs lack of strategies and capabilities to introduce and leverage BIM into existing coursework (Clevenger, Ozbek, Glick & Porter, (n.d).

Additionally, many programs lack qualified faculty in BIM technology.
INTEGRATION OF BIM INTO CONSTRUCTION CURRICULUM, con’t

For those schools that have integrated BIM into their construction curriculum, the popular modes of delivery include offering it as part of subject matters in some of their existing courses, and as a required stand-alone course. Only a handful of schools co-teach BIM practices with industry partners.

In order to maximize the students’ mastery of BIM practices as seamless as possible, the following advice was offered by Taylor et. al (2008):
Introduce students to BIM early in the curriculum as part of the subject matter topics. Thus, by the time students get to the required BIM course, they would have been familiarized with most of the terms and select applications” (p. 9)

The authors argued that BIM should not be limited to one dedicated course but rather diffused throughout the construction curriculum.
BIM IN NCA&T CONSTRUCTION CURRICULUM

BIM is currently a requirement in the ACCE-accredited baccalaureate construction management (CM) curriculum at NCA&T State University:

- In 2009, the construction faculty in the Department of Built Environment began to deliberate on the need for BIM integration.
- A curriculum committee was formed to review the existing curriculum, with the input of the Construction Management Advisory Board.
- In 2010, the course, dubbed CM 256 – Introduction to Building Information Modeling was developed and approval by the University Senate Curriculum Committee.
BIM IN NCA&T CONSTRUCTION CURRICULUM

The course is offered as a sophomore level course.

- This would allow students to understand BIM basic principles and applications by the time they begin to take upper level courses.
- The course introduces BIM technology with emphasis on applications to construction industry.

Students Learning Outcomes (SLOs) are:

- Ability to define BIM and explain the difference between BIM and Computer-Aided Drafting (CAD).
- Ability to explain and discuss the various applications of BIM.
- Ability to apply BIM principles to develop simple building models and specifications.
- Ability to manipulate a building model to produce different views.
- Proficiency in the use of BIM tools to produce basic quantity take-off from a building model.
BIM IN NCA&T CONSTRUCTION CURRICULUM

Because students lack knowledge of how contractors and/or sub-contractors can utilize BIM technology for project delivery, the faculty decided to divide the BIM course:

- Week 1 through 9, students are placed in groups to focus on:
  - current project delivery methods such as 2-D paper-based specifications and documents
  - BIM-integrated project delivery approach (IPD)
  - BIM for Contractors
  - BIM tools and parametric modeling
  - Interoperability
  - BIM for Subcontractors
  - and BIM for Fabricators are also introduced
BIM IN NCA&T CONSTRUCTION CURRICULUM

During Week 10 through Week 16, students are required to demonstrate BIM competency in the weekly Revit modules that include:

- conceptual design
- industry practices
- creation of floor systems
- documentation
- wall and roof systems
- windows, doors
- schedules, quantity take-off, structural components and renderings.
Tools & Ribbons

Learning the different ribbons

- Wall
- Door
- Modify

Using the different tools

- Home
- Insert
Roofs

- “Creating a Roof by Footprint”-is to create a roof by using the outline of the building in plan view. Within this project we used the following roof types:
  - Flat roof-(East Wing)
  - Gable roof- (Corridor)
  - Hip roof-all sides sloped-(West Wing)
Structural Framing

- Structure Tab, Beam Button, Framing, Steel, Hollow Structural Section
Structural Slabs

Foundation slabs do not require support from other structural elements. Use foundation slabs to model slabs on a grade or complex foundation shapes.
Chapter 10: Stairs, Ramps, and Railings

- Creating Stairs by using the Rise/Run Function
Chapter 12: Detail
By Antwan Lock
Creating a wall section from a blank view
Before and after changing line weight
Adding notes
Creating Schedules

- Instantly schedule items based on database
- Sequential numbers assigned to components
- Common Schedules: Doors, Windows and Finishes
- Save hours of time and maintain 100% accuracy
Room Schedules

• Click on the schedules button on the view tab
• New schedule
• Give it the fields: number, name, base finish, wall finish, floor finish, ceiling finish, comments, and level
• Sort by number
• Modify fields by clicking into them
Creating Compound Walls

- Click Wall Button
- Type Selector in Properties, Choose basic Wall
- Duplicate/Edit in Structure row
- Material Cell
- Preview
Adding Layers to the Compound Wall

• Click Layer 1/Insert
• Change Function
• Select Material
• Layers below Wrap
Adding a Curtain Wall

- Wall button/Curtain Wall: Store Front
- Edit type/Duplicate
- Select Automatically Embed/Vertical Grid Pattern Spacing 4'/Adjust for Mullion Size
- Instance properties offset to 3'-7"
- Set top constraints to Roof/offset to -1'
- Pick Radial wall Center Line
The Solar Study gives a time-elapsed visual of shadowing within a given timeframe and location.
THE SENIOR CAPSTONE PROJECT

The senior capstone course was designed to encapsulate all CM courses that have been offered in the curriculum. Seniors are assigned construction project with some of the leading construction firms in the region.

- Required portfolio:
- Review sets of construction documents
- Review production drawings and specifications
- Review and discuss contracts
- Discuss Ethics
- Discuss construction administration and management as they relate to the project.

The course culminates with the submission of a detailed portfolio by each student.
THE SENIOR CAPSTONE PROJECT

As BIM continues to gain popularity in the AEC industry, the CM faculty began to discuss a paradigm shift for the capstone course.

The outcome was to integrate BIM into the course for a semester and assess its success. Its success would determine whether to incorporate it permanently into the course.

Seven senior students were enrolled in the class, including four who had completed the introductory BIM course. The BIM’s SLOs were the same as used in CM 256.
FORMATION OF ACADEMIC-INDUSTRY ALLIANCE

To enhance the students’ learning experience, a collaborative academic-industry alliance was initiated with Lend Lease (US) Construction Inc.

- The objective was to expose students and faculty to a real-world application of BIM technology
- Lend Lease (US) Construction Inc. specializes in Health Care facilities and the company uses BIM extensively in all its projects.
- After meeting with the company officials, the company agreed to work with the faculty to team-teach BIM applications to our Spring 2013 Senior Capstone students.
To enhance the students’ learning experience, a collaborative academic-industry alliance was initiated with Lend Lease (US) Construction Inc.
Issues and Concerns

There were technical challenges faced during the delivery of the course. Some of them are listed below:

- The computer lab used to facilitate live webinar sessions failed to work as expected.
- Issues were found with the computer RAM and file storage, hardware capacity, and speed.
- There were problems with computer software compatibility.
- Technical challenges of accessing several gigabits of BIM-based model data through the university and Lend Lease file transfer protocol (ftp) became apparent very quickly when Lend Lease BIM Integration Manager “went live”.
FORMATION OF ACADEMIC-INDUSTRY ALLIANCE

Mitigation of Technical Issues

- Discussions with the School of Technology (SOT) IT manager centered on what computer/video equipment where needed to facilitate FTP and webinar access across the university network.

- The major SOT IT problem was computer capacity/capability to process in real-time large data sets and live video streaming. The SOT IT manager dedicated one computer for FTP and webinar access during the live webinar sessions. Students were placed in three groups, each with a dedicated computer to facilitate file exchanges using FTP.

- This was a temporary solution, but it did work.
FORMATION OF ACADEMIC-INDUSTRY ALLIANCE

Challenges and Lessons Learned

- Four of the seven students who participated in the course had prior BIM experiences gained through the introductory BIM course.
- The other three students struggled to fully understand the BIM concepts.
- This is not unusual as one case study of BIM-integrated construction course reported that students had to learn the software on their own as well (Taylor, et. al, 2008).
- Student class schedules conflicted with faculty schedules. Thus, students had to juggle their schedules in order to work with their assigned faculty members on their BIM project.
FORMATION OF ACADEMIC-INDUSTRY ALLIANCE

Challenges and Lessons Learned

- Lessons learned were to team each faculty with an industry BIM expert.

- Better prepare students by continuing BIM best practices throughout CM courses leading up to the Capstone course.
Conclusion and Future Plans

- CM 256 Introduction to BIM is part of the current curriculum and all students are required to take it during their sophomore year.
- However it is not currently applied to any other CM course.
- Students and industry partners agreed that this was a serious flaw and that more emphasis should be placed on BIM integration throughout the undergraduate curriculum.
Conclusion and Future Plans

Moving forward:

- BIM technology integration has to become an annual SOT IT budgeting line item.

- In addition, on-going BIM training for faculty is essential to successful curriculum development and delivery.

- This has begun to change as faculty members have agreed to integrate BIM into their respective courses, including the senior capstone course.
THANK YOU!

Q and A’s
How should we teach BIM?
A case study from the UK

Dr Zulfikar Adamu
School of Civil and Building Engineering
Loughborough University, UK

9th BIM Academic Symposium & Job Task Analysis Review,
Washington, DC; 7 – 8 April 2015
Would that be BIM, BIM, or ... BIM?

- Building Information Model (BIM) is the "digital representation of the physical and functional characteristics of a facility".

- Building information Modelling (BIM) is a "process for generating and leveraging building data to design, construction and operate the building during its lifetime".

- Building information Management (BIM) is the "organization & control of the business process by utilizing the information in the digital prototype to effect the sharing of information over the entire lifecycle of an asset".

According to the UK’s BIM Task Group BIM is “such a wide open subject with interpretations differing throughout the supply chain that we could have spent a year just trying to define BIM”.

This suggests that a universal approach to teaching BIM could be a long way off, even in the same country.
Who has been teaching BIM?:
Some approaches

- A contemporary approach to planning a BIM curriculum (Barison and Santos, 2010) overviews AEC undergraduate programmes in 25 universities, mostly US-based. BIM was taught in the following ways:
  - By six universities at an introductory level (no pre-requisites, not even CAD)
  - by 12 universities at an intermediate level and
  - by seven universities at an advanced level.

- BIM is also taught via distance collaboration, to simulate real-life collaborative working amongst geographically dispersed (cross-professional) students of different institutions.

- Examples of distance collaboration for teaching BIM include:
  - The University of Nebraska-Lincoln and University of Wyoming. (Barison and Santos, 2010).
  - Loughborough University (UK), Coventry University (UK) and Ryerson University (Canada), (Poh, et al. 2014).
Who has been teaching BIM?:
Some challenges

- A study of over 100 US-based AEC programmes and found inconsistencies in how BIM was adopted and accepted by these institutions, based on cultural, economic and academic differences (Becerik-Gerber, et al. 2011).

- Other challenges include:
  - Inflexible or tight curricula means some programmes may not be able to withstand elective courses.
  - Constraints due to graduation requirements, and
  - Lack of reference materials for teaching (Sabongi, 2009).
Opportunities for teaching BIM

- BIM is creating new types of roles and career opportunities like:
  - ‘Model Manager’ (RIBA, 2012);
  - ‘BIM Manager’ (Barison and Santos, 2010a);
  - ‘BIM Coordinator’ and ‘BIM Engineer’ (Wu and Issa, 2013).

- These new career opportunities have to be considered and exploited in the training of AEC students.
  - There is no evidence that separate degree programmes are required for these new BIM-specific ‘professions’.
  - This suggests embedding BIM into existing programmes could be feasible, practical and cost-effective.
BIM in the UK: The 2016 deadline

- From the UK’s perspective, there are four different levels of implementing BIM. These are described as: Level 0; Level 1, Level 2 and Level 3.

Source: BSI, 2013
BIM in the UK: The stakeholders

- The UK Government
- BIM Task Group
- BIM Academic Forum
- Professional Societies (RIBA, CIOB, RICS, ICE, etc)
- Universities
- Sponsoring (AEC) Companies
- Building Research Establishment / BuildingSmart
- Software developers
BIM in the UK: The 2016 deadline

- Of immediate interest in the UK is Level 2, where models are created in BIM applications by specific disciplines.

- These models would be deployed in a common data environment (web-based shared workspace).

  ✓ Level 2 BIM requires COBie output.
  ✓ Level 2 BIM applies to all centrally procured government projects
  ✓ Deadline for implementing Level 2 BIM is 2016,

- So who has been teaching BIM in the UK and how have they been doing it?
Teaching BIM in the UK

- There is **shortage** of pedagogical literature and case studies **about curriculum development** and teaching of BIM in UK higher institutions.
  - Exceptions like McGough, et al. (2013) where BIM was introduced in a first year and a third year module.
  - Can BIM be effectively covered in two modules?

- The most visible/publicised BIM programmes in UK universities’ websites are Postgraduate (MSc) taught programmes.
  - They tend to offer BIM-focused specialisation with evidence of distance learning being a popular (and sometimes only) mode of delivery.
  - Distance learning could benefit practicing professionals wanting to up-skill themselves in BIM – without sacrificing their jobs (recent recession?)
  - Work-based learning is encouraged / required by some MSc programmes
# Teaching BIM in the UK: MSc degree programmes

<table>
<thead>
<tr>
<th>University Name</th>
<th>Programme title</th>
<th>Duration &amp; Study Mode</th>
<th>Delivery format</th>
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<tbody>
<tr>
<td>Westminster</td>
<td>Building Information Management</td>
<td>1 Year (FT); Campus only</td>
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<tr>
<td>Middlesex</td>
<td>BIM Management</td>
<td>1 Year (FT); 2 Years (PT)</td>
<td>Distance learning only</td>
</tr>
<tr>
<td>Salford</td>
<td>BIM and Integrated Design</td>
<td>1 Year (FT); 2.5 Years (PT)</td>
<td>Campus, Distance Learning &amp; International Distance Learning</td>
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<tr>
<td>Liverpool (in London)</td>
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<td>1 Year (FT)</td>
<td>Campus only</td>
</tr>
<tr>
<td>West of England</td>
<td>BIM in Design, Const. &amp; Operation</td>
<td>1 Year (FT); 2-3 Years (PT).</td>
<td>Campus only</td>
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<tr>
<td>Northumbria</td>
<td>Building Design Mgt. and BIM</td>
<td>3 Years</td>
<td>Distance learning only</td>
</tr>
<tr>
<td>South Wales</td>
<td>BIM and Sustainability</td>
<td>1 Year (FT); 3 Years (PT).</td>
<td>Campus only</td>
</tr>
</tbody>
</table>

**FT = Full Time; PT = Part Time.**
Teaching BIM in the UK

- The BIM Academic Forum (BAF) coordinates BIM education in the UK with membership from over 30 UK universities.

- BAF attempts to bridge **institutional** and **pedagogical** gaps on how BIM is taught in the UK. It identifies three types of intended learning outcomes (ILOs) for BIM which are:
  - knowledge and understanding; practical skills; and transferable skills.

- For embedding into a multi-programme curricula, it is necessary to:
  - Have a mapping process to avoid duplication of ILOs.
  - Avoid over-assessment of students
  - Eliminate inconsistencies with accreditation requirements.
  - Phase the changes based on short and/or long term goals.
Teaching BIM in the UK

- In the UK, it is necessary to contextualise and teach BIM with respect to the Government Soft Landings (GSL).
  - GSL is aimed at **easing the transition** between the design/build or capital expenditure (Capex) phase with operational expenditure (Opex) phase.

- The GSL requires post occupancy evaluation (POE) **data to be fed into asset information models (AIM)** with consequences for computer-aided facilities management (CAFM).

- A new generation of AEC professionals will consider POE and aftercare issues including: measuring performance; feeding back to designers; continuous improvement; bridging the gap between predicted targets and actual outcomes.
  - The requirement for a **‘GSL champion’** in each government department is another example of new **job opportunities** created by BIM, at least in the UK.
Teaching BIM in the UK: Towards Level 2 and 2016

- Teaching **BIM at the undergraduate level** is arguably where long-term investment and impact will be most effective.

- Having a **multi-disciplinary cohort** of students is an advantage to teaching Level 2 BIM skills.

- The sequential order of professional tasks associated with collaborative work via BIM modelling should be adopted by students in the form of **role-playing** as exemplified in Becerik-Gerber et al. (2012).

- Such role-playing would be helpful towards acquiring the **range of skills** necessary for efficient and **effective collaboration** with respect to UK’s Level 2 BIM ambitions.
Teaching BIM at Loughborough University: Priority modules for BIM embedding

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Semester 1: 2013/14</th>
<th>Semester 2: 2013/14</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CVA028 (Const. Comm. Mgt 1)</td>
<td>CVB026 (Construction Tech. Management 2)</td>
</tr>
<tr>
<td></td>
<td>CVC037 (Pre Const. Est. Plan)</td>
<td>CVA011 (2D CAD &amp; BIM)</td>
</tr>
<tr>
<td></td>
<td>CVB033 (Health and Safety)</td>
<td>CVA030 (Methods of Measurement)</td>
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<table>
<thead>
<tr>
<th>Phase 2</th>
<th>Semester 1: 2014/15</th>
<th>Semester 2: 2014/15</th>
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<tbody>
<tr>
<td></td>
<td>CVA014 (Construction Tech. Management 1)</td>
<td>CVA027 (Graphic Communications)</td>
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<tr>
<td></td>
<td>CVC022 (3D CAD Modelling)</td>
<td>CVB005 (Construction Management)</td>
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<tr>
<td></td>
<td>CVC039 (Arch. Design Project)</td>
<td>CVC045 (Collaborative. BIM Design Project)</td>
</tr>
<tr>
<td></td>
<td>CVB037 (Measurement and QS)</td>
<td>CVA026 (Building Production)</td>
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<td></td>
<td>CVP320 (ICT for Construction)</td>
<td>CVP335 (Federated Build. Info. Modelling)</td>
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</table>

<table>
<thead>
<tr>
<th>Phase 3</th>
<th>Semester 1: 2015/16</th>
<th>Semester 2: 2015/16</th>
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<tr>
<td></td>
<td>CVB001 (Structural Design)</td>
<td>CVC019 (Project Management)</td>
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<tr>
<td></td>
<td>CVC005 (Design Project)</td>
<td>CVD003 (Teamwork Design Project)</td>
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<td></td>
<td>CVD004 (Design Project Management)</td>
<td>CVC033 (Maintenance, Repair and Refurbishment)</td>
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<td></td>
<td>CVC024 (Architectural Detailing)</td>
<td>CVC037 (Pre Const. Est. Plan)</td>
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<td></td>
<td>CVC030 (Advanced Mechanical Services)</td>
<td>CVC028 (Construction Economics)</td>
</tr>
<tr>
<td></td>
<td>CVB046 (BIM Auditing and Coordinating)</td>
<td></td>
</tr>
</tbody>
</table>

![Loughborough University Logo](logo.png)
Teaching BIM at Loughborough: The BIM Workshop

- In Phase 1 (2013/14) a 5-day extra-curricular workshop on BIM was organised to achieve the following goals:
  - Providing over 100 final year and placement students with a crash course in BIM
  - Evaluating various BIM software being considered for teaching, e.g.
    - Navisworks vs. CATO (for cost estimating) – based on RICS New Rules of Measurement
    - Navisworks vs. Solibri Model Checker (for coordination/clash detection);
  - Networking with experts from industry for future case studies and site visits;
  - Piloting the use of video tutorials for acquisition of modelling skills.
  - Increase awareness and momentum about BIM in the School

- The intention is to make the workshop an annual event, focused on specific high-level BIM themes.
### Teaching BIM at Loughborough: The BIM Workshop

<table>
<thead>
<tr>
<th>Day 4: Thu 3 Apr</th>
<th>Time</th>
<th>Type</th>
<th>Activity</th>
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<th>Venue</th>
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<td>Day 6: Fri 4 Apr</td>
<td>13:00-14:00</td>
<td>Group Work</td>
<td>Group Work: Modelling of SFG Building</td>
<td>Student-led</td>
<td>Various</td>
<td>Group work</td>
<td>NA</td>
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<tr>
<td>Day 6: Fri 4 Apr</td>
<td>15:00-16:00</td>
<td>Group Work</td>
<td>Group Work: Modelling of SFG Building</td>
<td>Student-led</td>
<td>Various</td>
<td>Group work</td>
<td>NA</td>
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<tr>
<td>Day 7: Sat 5 Apr</td>
<td>09:00-10:00</td>
<td>Lecture/Demo</td>
<td>Lecture/Demo: A day in the life of a BIM Engineer</td>
<td>To be confirmed</td>
<td>TBC</td>
<td>NA</td>
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</tr>
</tbody>
</table>
Teaching BIM at Loughborough University: Levels of capacity

- **ADVANCED:**
  - 'BIM Manager'
  - (Part C)
  - Can apply BIM to his/her specialist area
  - Can manage common data environments
  - Understands strategic BIM delivery
  - Can do research /dissertation in BIM-related subject

- **SELF-LEARNER:**
  - (Industry placement)
  - (Part P)
  - Appreciates industry-based application of BIM
  - Fine tunes practical skill sets
  - Engages in professional development
  - Experiences challenges to BIM adoption

- **INTERMEDIATE:**
  - 'BIM Analyst'
  - (Part B)
  - Can coordinate BIM models and do clash detection
  - Can generate and query COBie datasets

- **BEGINNER:**
  - 'BIM Modeller'
  - (Part A)
  - Understands fundamental principles of BIM
  - Can produce BIM models and interrogate BIM data
  - Appreciates need for IFCs and collaborative working
  - Knows the policies and technologies shaping BIM
Teaching BIM at Loughborough: Mass adoption of video tutorials

- Based on a pilot study (BIM workshop) web-based video tutorials are used as a teaching resource for 3D, 4D and 5D BIM skills. It has been observed that:
  - Most students would spend between 30 to 45 minutes watching these videos in one sitting.
  - The majority (64%) of respondents prefer to watch these videos on their personal laptops compared to 34% who watch them while in computer labs.
  - Just 3% watch the videos from smartphones/tablets.
  - About half (49%) of students surveyed stated that they would have to watch a specific video clip twice before understanding the task involved.
  - Only 21% of respondents would watch a video clip once, whereas 24% will need to watch a video clip a few times before ‘getting it’.
  - Only 11% of students thought paper hand-outs were a better way to learn BIM software, 72% thought videos were better while 17% were undecided.

- The use of video tutorials is still being monitored for long-term impact.
Teaching BIM at Loughborough University: Mass adoption of video tutorials

How helpful to your BIM-related coursework are the online video tutorials?
How confident are you in performing design tasks after watching the videos?
How would you rate the range of topics covered in the video tutorials
How would you rate the streaming quality of the video tutorials

Number of respondents

Evaluation scale: 1 = Low; 10 = High
Teaching BIM at Loughborough: New BIM Modules

- There are specific requirements of (Level 2) BIM which could not be integrated into existing modules - without losing focus or sacrificing existing ILOs.

- Two new modules that combine digital (paperless) workflow with collaborative role-playing were developed as options for final year BSc and the MSc students.

- These modules are unique because the ILOs are aimed at:
  - acquiring specific knowledge of standards/protocols and processes for Level 2 BIM;
  - ability to use web-based common data environment – including adherence to BS1192-2007 and PAS1192-2 standards for file/folders and their naming conventions;
  - access rights and security of data in a common data environment (CDE);
  - quality of single and aggregated BIM models with IFC and COBie outputs;
  - team-based response to requested design changes and proper data archiving;
  - task delegation, quality of comments and discussions using communication tools within a CDE.
Teaching BIM at Loughborough: New BIM Modules

- Working with a brief, teams (five students per group) would play typical AEC professional roles but the BIM manager role is rotated.

- These new modules are still in the process of delivery but their assessment is presenting new challenges (paperless workflow).
  - Screenshots of each team’s web-based workspace (4Projects) including the uploaded contents will be captured in multi-media format so that feedback is entirely made of **audio-visual narrative**.

- Multi-media feedback given to each group should **enable students appreciate in-depth critique on the quality of their documents/models** (e.g. the feedback narrative will include navigation of IFC and Revit models by the assessor).
  - It is believed that such multi-media feedback will be effective because students can not only ‘engage with it’ as suggested by Irwin, et al. (2013) but possibly **act on it in future** (Orsmond, et al. 2005).
Teaching BIM at Loughborough: New BIM Modules
Conclusions

- In the UK, BIM is shaped by Level 2 expectations, standards like BS1192-2007/PAS1192 and political deadlines for implementation in public projects.

- Some institutions focus on BIM at MSc level, but long-term impact and investment should consider undergraduate programmes/students;

- For proper integration into multiple AEC programmes, no single academic or module can satisfy the multi-faceted scope of BIM.
  - Embedding BIM into ILOs of existing modules has advantages and opportunities.
  - Role-playing among multi-disciplinary cohorts of students is beneficial;
  - New job roles are emerging; e.g. BIM Manager; BIM Engineer; BIM Coordinator; etc.

- Accreditation needs of AEC programmes should be considered when reconciling BIM learning outcomes with expectations of professional societies.
Conclusions

- It may be reasonable and practical to have a **BIM champion** who would:
  - coordinate the learning /teaching of BIM and ensure consistency and oversight.
  - Supervise the changes to curriculum over a period (phases), depending on internal/external pressures; manpower; economics and the need to build from ground up.

- **Teaching BIM** requires that is **contextualised** within the wider **sustainability agenda**.
  - In the UK, the sustainability strategy involves the Government Soft Landings (GSL).

- **Video tutorials** can help with training on **practical BIM skills** and eliminate the need for academics to develop and update handouts for computer lab sessions.

- Development of **new BIM-dedicated modules** may be necessary to cover unique aspects of BIM.
THANK YOU
Developing BIM Laboratory Exercises for a MEP Systems Course in a Construction Science and Management Program

Rogelio Palomera-Arias, Ph. D.
Rui Liu, Ph. D.

University of Texas at San Antonio

9th BIM Academic Symposium
Washington, DC
April 7th, 2015
Overview

• CSM Program Description
• MEP Systems Course Description
• MEP Laboratory Content
• BIM Exercises Presentation
• Discussion of Experiences
• Future Work
• Summary
UTSA CSM Program

Diagram:
- CSM 2113 Cons. Mat. and Methods
- CSM 2143 Cons. Mat. and Testing
- CSM 3123 Technical Comm.
- CSM 4013 Construction Estimating I
- CSM 4023 Construction Estimating II
- CSM 3143 Structures I
- CSM 4143 Structures II
- CSM 4623 Construction Safety
- CSM 4513 Project Management
- CSM 4523 Proc. Planning & Scheduling
- CSM 4533 BIM for Cons Management
- CSM 4643 MEP Systems
MEP Course Description

• Mechanical, Electrical and Plumbing Systems
  • Heating, ventilation and air conditioning
  • Lighting, power and low voltage wiring and equipment
  • Domestic water, DWV, Fire protection

• Construction Management Focus
  • Systems general operation principles and uses
  • Nomenclature and component identification
  • Basic system design concepts
  • Construction general issues
  • Plan reading, QTO’s, cost estimating,
  • System’s layout and coordination
MEP Laboratory Objectives

- Plan reading
- Material quantity takeoffs
- Basic systems sizing
- Systems modeling and layout
- Fundamental principles
- Building loads
- Basic material and labor estimating (desired)
BIM Laboratory Exercises

- Revit introduction/review
- Electric circuiting
  - Lighting and power
- Electric switchgear and feeders
- Plumbing
- Fire suppression
- HVAC
BIM Basic Model
Plumbing Layout Exercise

- Step by step instructions
- Setup project:
  - Create plumbing views
  - Define piping systems
  - Load fittings and fixtures
- Place piping and fixtures in Building Model based on plans
Plumbing Layout Exercise
Other MEP Systems
# Students Feedback

<table>
<thead>
<tr>
<th>Survey Questions</th>
<th>Student Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Usefulness and appropriateness of using BIM in a MEP course.</td>
<td>• BIM in course is desirable</td>
</tr>
<tr>
<td>• Student proficiency with BIM software and effectiveness of laboratory problems</td>
<td>• BIM is useful for CM</td>
</tr>
<tr>
<td>• Laboratory problems organization and difficulty</td>
<td>• Experience with Revit was limited</td>
</tr>
<tr>
<td>• Appropriateness of the building models used in the exercises</td>
<td>• The exercises helped understand MEP systems</td>
</tr>
<tr>
<td></td>
<td>• Format and length of problems was good</td>
</tr>
<tr>
<td></td>
<td>• Building used was good, would prefer sequential MEP system modeling</td>
</tr>
</tbody>
</table>
Future Work

- Reorganize exercise delivery based on common coordination order
- Fine tune current exercises to decrease “start-up/setup” time
- Develop additional BIM exercises
  - Construction sequencing
  - Automatic QTO’s
  - Plan Schedules
  - Clash detection
Summary

• BIM (revit 2014) was introduced in MEP course
• 6 Lab exercises were developed
• 4 MEP disciplines covered
  • Electrical lighting and power circuiting and switchgear
  • Plumbing
  • Fire suppression
  • Force air (RTU) HVAC
• Simple architectural and structural BIM model provided to students
• Response from students mainly positive
THANK YOU!

Questions, Comments?
Using Real Life Examples of Building Construction For Student Projects To Improve Their Understanding and Concept of BIM Implementation

Dr. Rui Liu, UTSA
Mr. Anand "Andy" Gajbhiye, Joeris General Contractors, Ltd.
Dr. Rogelio Paromera-Arias, UTSA
## Placement Data for CSM Graduates

<table>
<thead>
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<th>TYPE OF EMPLOYER</th>
<th>OF 2009-10</th>
<th>2010-11</th>
<th>2011-12</th>
<th>2012-13</th>
<th>2013-14</th>
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<td>33</td>
<td>30</td>
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<td>Military Service</td>
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<td>Graduate School</td>
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<td>-</td>
<td>-</td>
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<td>Other Employment</td>
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<td>-</td>
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<td>1</td>
<td>1</td>
<td>3</td>
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<td><strong>TOTAL</strong></td>
<td><strong>1</strong></td>
<td><strong>13</strong></td>
<td><strong>36</strong></td>
<td><strong>33</strong></td>
<td><strong>60</strong></td>
<td><strong>143</strong></td>
</tr>
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**98% Placement Rate at Graduation Day**
The demand for graduate construction students with BIM skills is increasing.

UTSA started offering stand-alone BIM course from Fall 2011.

How to introduce front-line practices to the students?
BIM for Construction Management

- 3 Credit
- Lecture and Lab
- 75 minutes twice a week
- 16 weeks
Course Components

- One midterm exam 10%
- One final exam 10%
- Homework projects 30%
- Quizzes 10%
- Two term projects 40%
Term Project II

➢ Goal of term project II
• Be familiar of construction coordination process between general contractor and subcontractors.

➢ Project Requirements
• Clash Detection (25 points)
• 4D Schedule (15 points)
• A 3D Walkthrough Animation (10 points)
Coordination Project Information

- Project Owner: University of Texas-San Antonio
- Project Name: North Paseo Building 1
- Project Value: $36M
- Delivery Method: Construction Manager a Risk
- Challenges:
  - Complex mechanical piping and equipment
  - Complex technology and data systems
  - Tight ceiling spaces
  - Owners wanted As-built BIM Model
- # of People involved in coordination: 19
- Coordination Time: 8 months
- Results:
  - On Time, on budget delivery
  - Smooth MEP Installation process. All Subcontractors were happy-Teamwork!
  - Transparency in project for Owners
MEP models
Clashes

Sanitary clashes with equipment elbow

Move cable tray to left of duct to clear
Attention Electrician

Move tray down out of duct
Attention Electrician
Discussion

Recommendations for teaching BIM Implementations:

- Collaboration vs. Project Delivery Methods
- BIM Contracts/Agreements/Execution Plans
- Generation gap
- New Emerging Technologies
- Prerequisites
Conclusion

- Better prepare the students with BIM knowledge
- High evaluation from the students
Thank you!
Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at WPI and UADY

Maria Gomez, Worcester Polytechnic Institute
Guillermo Salazar, Worcester Polytechnic Institute
Sergio Alvarez, Universidad Autonoma de Yucatan
Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at WPI and UADY

Proposed Course
CE302X Construction Methods and Virtual Construction

Emphasis on selecting method, allocate resources productively using BIM model (VC) to optimize Cost and Time

Enabled through a Term Project

G. Salazar, M. Gomez, S. Alvarez
9th BIM Academic Symposium and Job Task Analysis Review
Washington, DC
Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at WPI and UADY

Development Phase 1
CE302X Construction Methods and Virtual Construction

Term Project

EDC Grant
Virtual Prototypes

G. Salazar, M. Gomez, S. Alvarez
9th BIM Academic Symposium and Job Task Analysis Review
Washington, DC
Major Considerations
During the development of the 3D model in Revit

- The time the student need to dedicate to adapt an existing model to match the needs of the selected construction strategy
- Revit knowledge may vary or null
- Using basic tools like cut, copy, paste, split, move and stretch
- Check the model to avoid unwanted consequences
Virtual Prototype

- **Reinforced Concrete Foundation:**
  - Strip and isolated footings, foundation walls, slab on grade. Reinforcing steel and formwork elements are also included and explicitly modeled.

- **Steel Frame:**
  - Columns, beams, joists, cross bracing, elevated slabs on deck.

- **Exterior & interior walls:**
  - Including finishes, doors and windows.

- **Roof, floors and stairs**

- **Site topography**
Modeling Strategy

Foundation

Challenges:

- Modeling the rebar
- Foundation walls host rebar
- Slab on grade can’t be split
- None formwork families

Solution:

- Modeling small sections @4 corners
- Creation of formwork
Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at WPI and UADY

Modeling Strategy

Steel Frame

Columns, beams, bracing and so on, were modeled individually.
Modeling Strategy
Walls, Floor and Roof

- Walls were modeled as a large single item
  - Finishes were included
- Small sections of floors and roofs were created
Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at WPI and UADY

Initial Model Given to the Students
Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at WPI and UADY

G. Salazar, M. Gomez, S. Alvarez
9th BIM Academic Symposium and Job Task Analysis Review
Washington, DC

BIM Platform WPI-UADY Conceptual
Construction Strategy

Preliminaries

Original Model with LOD 300-350

Site Model with LOD 200
Construction Strategy
Phases and WBS as Proposed by the Students

<table>
<thead>
<tr>
<th>WBS</th>
<th>Type</th>
<th>Name</th>
<th>Description</th>
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<tbody>
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<td>C</td>
<td>Group</td>
<td>Gimnasio</td>
<td></td>
</tr>
<tr>
<td>C.10</td>
<td>Group</td>
<td>Construcción de Gimnasio</td>
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<td>C.10.10</td>
<td>Group</td>
<td>Preliminares</td>
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<td>C.10.10.20</td>
<td>Item</td>
<td>Construcción de bodega de obra</td>
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<tr>
<td>C.10.20.30</td>
<td>Group</td>
<td>Cimbra para zapata aislada</td>
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</tr>
<tr>
<td>C.10.20.30.1</td>
<td>Item</td>
<td>Cimbra Zap Aislada Sec 1</td>
<td></td>
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<tr>
<td>C.10.20.30.2</td>
<td>Item</td>
<td>Cimbra Zap Aislada Sec 2</td>
<td></td>
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<tr>
<td>C.10.20.30.3</td>
<td>Item</td>
<td>Cimbra Zap Aislada Sec 3</td>
<td></td>
</tr>
</tbody>
</table>
Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at WPI and UADY

Construction Strategy
Quantification in Navisworks

G. Salazar, M. Gomez, S. Alvarez
9th BIM Academic Symposium and Job Task Analysis Review
Washington, DC
Construction Strategy

4D Simulation
Construction Strategy
Site utilization planning - space requirements
Construction Strategy
Site utilization planning – clash detection
Conclusions and Future Work

- Incorporate lessons learned from UADY first course offering (Spring 2015)
- Formalize methodology for assessment of Course Objectives & ABET Learning Outcomes (Summer 2015)
- Develop a detailed Course Syllabus (Summer 2015)
- Obtain WPI Approval by CE department & WPI Faculty (Fall 2015)
- Deliver the course at WPI (D term 2016)

Acknowledgments:
UADY Students: America Baas, Sarahi Morfin, Carlos Ortiz, Pamela Alcala
WPI Department of Civil & Environmental Engineering
WPI Educational Development Council
Thank you!

Building a BIM-based Platform to Support Delivery of Construction Methods and Virtual Construction Courses at WPI and UADY

Guillermo Salazar, WPI
Maria Gomez, WPI
Sergio Alvarez, UADY
An Interdisciplinary Approach to Integrate BIM in the Construction Management and Engineering Curriculum

Julide Demirdoven, Ph.D.
BIM EDUCATION

- the shared responsibility of academia and industry.
- addresses the requirements of current professionals, future professionals (students) and their teachers/trainers.
- encompasses all modes of learning (tertiary courses, industry workshops, online media and on-the-job training)
- ranges from spreading awareness to developing highly specialized skills
- should be available in various formats to all disciplines, specialties, roles, education and experience levels
- should be developed and delivered collaboratively

(BIM in practice, Australian Institute of architects, 2012)
BIM IN THE CURRICULUM AT IIT

- improving BIM software skills (ability to create, understand and interpret building information models).
- covering design and construction processes in an integrated environment.
- stimulating BIM professionals’ collaboration with other construction professionals.

This curriculum helps students to understand the plurality in the construction professions.
INTEGRATED BIM COURSES

“The role of the BIM profession is to form an interface between the design and construction processes by minimizing information overload and producing only what is needed.”

Arditi & Demirdoven, 2014

- Project initiation and preconstruction roles cover the design process which is essentially iterative and creative.
- Construction management roles cover the construction process, which are essentially orderly and linear.
- A set of courses need to be offered that cover not only the basic aspects of BIM but also the management of a project designed using BIM.
BIM education for engineering design

The course objectives are:

- to understand the concepts of BIM,
- to review software and technology available for BIM,
- to learn how to use a model created by a BIM software,
- to use Revit as a BIM tool to create and present a 3D design project in a collaborative environment.

EG 430
Introduction to BIM
Undergraduates from all disciplines
BIM education for engineering design

EG 430
Introduction to BIM
Undergraduates from all disciplines

The course content is based on:

- 3D Modeling in Autodesk Revit for Integrated Design Purposes
- Collaboration Workshop: A Real Life Experience with Industry Partnership
Customized course contents and assignments are selected from a variety of textbooks and tutorials addressing the study area of the students.
Revit Worksharing Workshop with an Expert from Industry

April 17, 2014.
Holding a Worksharing Workshop with Mayank Sharma, BIM
The course objectives are:

- to understand the concepts of BIM,
- to review software and technology available for BIM,
- to understand how to use a BIM model in construction management,
- to use BIM to check for interferences and conflicts on project,
- to explore phasing and estimating using BIM,
BIM education for construction management

CAE 573
CM with BIM
Graduates from all disciplines

The course objectives are (cont.):
▌ to explore how BIM can assist in facility management,
▌ to use Vico Software as a BIM tool to create and present construction analysis and reports.

The course content is based on:
▌ Construction project management and control with 4D and 5D models
▌ BIM project execution plan: experiencing teamwork and strategic planning
Phase planning:
Flowline view.
(Vicosoftware screenshot from the student project by the courtesy of Russ, G.)
3D linked to 4D and 5D (Vicosoftware screenshot from the student project by the courtesy of Randazzo, L.)
Information Flow Process Diagram
(from the students’ group project by the courtesy of Kayo, L., Tetik, A., Alothaimeen, I., Kilincarslan, Y., Gureeva, O and
INDUSTRY AND IIT PARTNERSHIPS

- An academic framework informed by research, discipline professionals and other industry stakeholders is a prerequisite for IIT’s BIM Curriculum.
- Both courses are designed to integrate BIM knowledge with a selected BIM tool (hands-on).
- Each course is also supported with additional BIM tools’ trainings by invited industry experts.
- Moreover, professionals are sharing their experience and creating internship and job opportunities prior for IIT students.
Experiencing Worksharing with an Expert from Industry

April 17, 2014.
Holding a Worksharing Workshop with Mayank Sharma, BIM
Learning Bentley BIM with an Expert from Industry
April 24, 2014.
Bentley BIM Training Session, by Tom Lazear, Consultant, Bentley Systems Academic Group.
Experiencing BIMx with an Expert from Industry

April 2, 2015.
ArchiCAD Training Session, by Leeswan Bolden, Consultant, Graphisoft.
March 26, 2015.
Anton Dy Buncio,
Director, Viatechnik.

Knowledge sharing and networking
SURVEY OF THE BIM CURRICULUM

A feedback study was conducted to address the urgent needs for instructional strategies that consider multiple aspects of BIM, including the desired qualifications of a BIM instructor, and feedback from students who have gone through the BIM curriculum.

The survey was first conducted in May 2014 and it is updated in January 2015.

It covers the academic years of 2012, 2013 and 2014.

Out of the 106 distributed surveys, 77 valid responses (73%) were returned.
Demographic information

Level of Education

- Doctorate: 49
- Masters: 22
- Bachelors: 2
- Other: 4

Industry Experience

- No Experience: 26
- Less than < 1 year: 10
- Between 1-5 years: 17
- More than > 5 years: 24
BIM competencies

- BIM will impact my job in the future: 4.40
- I will be left behind and/or struggle to survive if I do not adopt BIM: 3.58
- BIM is/will be very highly important to the industry: 4.36
- Using BIM improves my productivity: 4.27
- BIM is relevant to my business: 3.25
- BIM is a new technology that requires substantial investment in training: 3.97
- Having BIM skills presents significant opportunity for new jobs or positions: 4.31
- It is hard to keep up with technology updating every year: 2.96
- I feel comfortable sharing data with all other parties involved in my project: 3.83
- Making the shift from a traditional 2D workflow to a 3D BIM workflow is very: 2.56
- I wish I hadn't adopted BIM: 1.71
- I am confident in my BIM knowledge and skills: 3.48
BIM competencies

The most positive aspect of using BIM

- Teamwork and collaboration (67%)
- Decision making (15%)
- Sustainability (11%)
- Working internationally (2%)
- Promoting the business (2%)
- Post-completion ease (1%)
- Other (1%)}
Both courses achieved their goals. 97% of the respondents were satisfied with these courses. 86% said they will recommend the courses to others.
CONCLUSIONS

To sustain the momentum of BIM, effective workforce development that aims to balance the supply-demand equation in the labor market is essential. For many, experience with BIM begins in academia.

There is an increasing need to establish and improve BIM knowledge, skills and experience of current construction professionals.

The IIT strategy relative to BIM is successful and expected to help architecture, engineering, and construction professionals to be prepared for the needs of the industry in the future.
Building Information Modelling Educational Framework for Quantity Surveying Students: The Malaysian Perspective
Dr Kherun Nita Ali

Head
Department of Quantity Surveying, Faculty of Built Environment, Universiti Teknologi Malaysia (UTM)

Member
BIM Technical Committee
Royal Institutions of Surveyors Malaysia (RISM)

Co-authors and co-researchers
Dr Nur Emma Mustaffa, Associate Professor, UTM
Quek Jin Keat, Chairman BIM Technical Committee, RISM
Wallace Imoudu Enegbuma, Researcher, UTM
Outline

• BIM in Malaysia
• BIM for QS
• The Framework
BIM IN MALAYSIA
Level of maturity
Currently in Public Sector

• Key player: Public Work Department
• BIM Committee was established where each of the 5 PWD department (Architect, Civil & Structural, Mechanical & Electrical Engineer & QS) has 2 representatives in the BIM Committee.
• On-going BIM pilot projects
• Training is an on-going process.
• PWD BIM Roadmap launched in 2013
Currently in private sector

• Some private organisations are already requesting BIM compliance as a strategic advantage, example, SIME DARBY, BRUNSFIELD, SUNWAY etc
ROYAL INSTITUTION OF SURVEYORS MALAYSIA (RISM)

• BIM Technical Committee was set up in 2011
• Looking into BIM for Quantity Surveying profession
• Human capital development is one of the focuses

• Institutions of Higher Learning become the platform for the human capital development endeavour
BIM allows design and visualisation being implemented in timely manner with high quality information.

QS has to catch up with other designers in term of producing or utilising information related to cost.

**BIM FOR QS**
Benefits of BIM

- Robust information
- Quality communication
- Real-life project visualisation and simulation
- Simultaneous access
- Auto-quantification
- Project documentation
- Multi-dimensional integration

Olatunji et al, 2010; Azhar, 2011
Cost estimating, planning, scheduling, life cycle costing

Quick estimation at any point in the design process

Assist in reducing variability

Auto-quantification
Organic buildings
Change

• The industry needs to be supplied with skilful human capital

• Understanding what BIM can help QS profession, lead us to revisit our own backyard – the backyard where we train and produce QS graduate

• The role of Institution of Higher Learning in providing the industry with the right knowledge and skills.
Change

• BIM-ready graduate?
Knowledge and skills required

• Ability to use the necessary IT tool to extract digital data out of digital 2D or 3D model i.e quantity take off

• Ability to use the necessary IT tool to process the digital data into meaningful information – life cycle costing, cost in use, cash flows, feasibility analysis, cost analysis, quantity analysis, buildability, carbon counting, etc
Knowledge and skills required

• Understanding the concept and practice of Integrated Project Delivery – i.e. management and legal aspects of BIM; roles of BIM Manager, BIM Coordinator, BIM Modeller; BIM Execution Plan, BIM Protocol, BIM Contract Documents; Level of Details (LOD) 100-500); BIM Dimensions 3D-7D; etc
THE FRAMEWORK
RISM initiatives

• BIM Educational Framework for Quantity Surveying Graduates
  • It describes an educational framework for the QS in the context of BIM implementation that charter a route on how the knowledge on BIM principles and its applications can be imparted to the whole-life inter-disciplinary design and construction with the prime focus is on the QS scope of work
RISM initiatives

- The framework was designed through thorough reviews on related literatures and interviews among experts
- It has been validated by industry players through focus group exercise
Aim

• To equip QS graduates with appropriate skills in project delivery through the use of Building Information Modelling
<table>
<thead>
<tr>
<th>AIM</th>
<th>OBJECTIVES</th>
<th>MEDIUM</th>
<th>OUTCOME</th>
<th>OUTCOME</th>
<th>EMPHASIS IN TEACHING</th>
<th>PHYSICAL IMPLICATION</th>
<th>MONITORING FORCE</th>
</tr>
</thead>
</table>
| Visualisation       | Drughtmanship                   | Construction Technology | To be able to appreciate 2D design and basic 3D models                  | To be able to appreciate 2D design and basic 3D models                  | 1. Visualisation of design or element of design in 2D and 3D tools  
2. Understanding the Level of Details (LOD) 100-500                                                                                                          | References  
- Trained staff  
- Hardware  
- Software                                                                                       | Establish a monitoring panel that comprises at least three members who have knowledge and interest in IT to oversee the planning, reviewing and monitoring of this framework |
| Quantification      | Measurement                      | Construction Services   | To be able to apply the quantity take-off software and spreadsheets software | To be able to apply the quantity take-off software and spreadsheets software | 1. The use of software in estimating and able to manipulate the raw data extracted from 3D models into extensive and information-rich cost estimating  
2. Understanding the essence of integrated repository of data that changing in design would subsequently changing the quantity and cost                                                                 | References  
- Trained staff  
- Hardware  
- Software                                                                                       |                                                                                                                                                  |
| Cost Estimating     | Cost Planning & Scheduling       |                         | To be able to understand the fundamental principle of cost planning and cost analysis | To be able to understand the fundamental principle of cost planning and cost analysis | 1. The use of software in every aspect of Cost Planning & Scheduling  
2. Able to manipulate the raw digital data extracted from 3D models into extensive and information-rich cost planning and scheduling                                                                 | References  
- Trained staff  
- Hardware  
- Software                                                                                       |                                                                                                                                                  |
| Planning & Scheduling | To be able to appreciate the economic aspects of construction project using digital data |                         | To be able to evaluate the economics of construction project using digital data | To be able to evaluate the economics of construction project using digital data | 1. The use of software in preparing Cost Analysis  
2. Cost data search from online and offline resources  
3. Able to manipulate the raw digital data extracted from 3D models into extensive and information-rich cost analysis - buildability, constructability, sustainability, cost effectiveness, Cost/Design analysis, Life Cycle Costing etc                                                                 | References  
- Trained staff  
- Hardware  
- Software                                                                                       |                                                                                                                                                  |
| Cost Analysis       | Contract                         |                         | To appreciate the legal implications of the integrated project delivery system | To be able to assess the legal implications of the integrated project delivery system | 1. Every aspect of legal implications of integrated project delivery e.g. rights, ownership, liability, negligence and etc                                                                                       | References  
- Trained staff  
- Hardware  
- Software (for project delivery and project visualisation)                                                                                       |                                                                                                                                                  |
| Professional Practice | To be able to appreciate the complexity of working in interdisciplinary teams and managing collaborative design and production |                         | To be able to appreciate the complexity of working in interdisciplinary teams and managing collaborative design and production | To be able to appreciate the complexity of working in interdisciplinary teams and managing collaborative design and production | 1. Understanding Integrated Project Delivery and each party's professional role  
2. BIM dimension 3D-7D (or nD) should be emphasised  
3. Legal implications of integrated project delivery should be in line with the practice  
4. Keep abreast with latest development in integrated project delivery practice elsewhere by having case study reviews approach  
5. Keep abreast with latest publication in BIM implementation elsewhere  
6. Involve experienced industry players in giving input on BIM                                                                                      | References  
- Trained staff  
- Hardware  
- Software                                                                                       |                                                                                                                                                  |
| Project Management  | To provide an understanding of the complexity of working in interdisciplinary teams and managing collaborative design and production |                         | To be able to appreciate a construction project through visualisation of construction process | To be able to appreciate a construction project through visualisation of construction process | 1. New roles in BIM implementation i.e. BIM Manager, BIM Coordinator and BIM Modeller, Document Manager, Construction Manager  
2. BIM implementation in construction project i.e. BIM Deployment Plan, BIM Execution Plan  
3. Keep abreast with latest development in integrated project delivery practice elsewhere by having case study reviews approach  
4. Keep abreast with latest publication in BIM implementation elsewhere  
5. Involve experienced industry players in giving input on BIM in project management                                                                 | References  
- Trained staff  
- Hardware  
- Software (for project delivery and project visualisation)                                                                                       |                                                                                                                                                  |

*Emphasis for Planning and Scheduling and Management varies according to Diploma and Degree levels. Note the difference of outcome for both levels in column Outcome

* Financial implication applies to all
Objectives lie within the Attainment Skills:

- Visualisation
- Quantification
- Planning & Scheduling
- Management

Outcomes:
- Diploma
- Degree
LEARNING OUTCOMES

DIPLOMA
• able to skillfully master the visualization and quantification utilizing BIM as a foundation to future degree studies

DEGREE
• the foundations are extended to include evaluating and integration of BIM in cost planning and scheduling task, legal liabilities and effective integrated project delivery
To enhance visualization

Medium

Draughtsmanship

Cons. Technology

Cons. Services

Attainment Skills

VISUALISATION

Medium
To improve the level understanding of BIM for effective measurement. Thus improve the employability and demand within the growing BIM industry.
To equip the students with skills in line with BIM compliant software.
To accommodate legal dimension, BIM competence expectancy in the job market and lifecycle BIM management of a project.
Among IT skills required:

- Spreadsheet – MS Excel (primary skill)
- Specialised Software – e.g. CostX, Glodon, Vico, AutoDesk QTO (or any CAD measure software)
- Documentation – Portable Document Format generated, Word Processing
- Project Management – MS Project or the like
Approach

• Lecture and hands-on
• Embedded in courses
Implications

- Facilities – hardware, software, network access, references books or journals
- Training the trainers – lecturers with IT (software) skills
- Realign the syllabus to incorporate BIM – stand alone course or embedded?
Implications

• Physical
  – Library
  – Staff
  – Hardware and software
  – Monitoring Panel

• Financial
  – Staff training and recruitment
  – Procuring books, hardware and software
Challenges to CHANGE
Challenges

• Financial – cost of hardware and software, cost for trainings, cost for new references
• Rapid development of the technology – can we catch up?
• Resistance to change – who to train? Which part of syllabus need to be aligned with BIM? Can all staff embrace the change with adequate knowledge?
Acknowledgements
RISM BIM Technical Committee

- Sr. Quek Jin Keat, Chair of BIM Technical Committee
- Dr. Kherun Nita binti Ali, Universiti Teknologi Malaysia
- Tan Choon Boon, IJM Corporation Bhd.
- Sr. Roznita binti Othman, Jabatan Kerja Raya
- Sr. Chin Keh Liang, Perunding PCT Sdn. Bhd.
- Chin Wei Min, Perunding PCT Sdn. Bhd.
- Suhaibah binti Mohd Ghazali, AQS Services Sdn. Bhd.
Researchers

- Dr. Kherun Nita binti Ali, Universiti Teknologi Malaysia
- Assoc. Prof. Dr. Nur Emma Mustaffa, Universiti Teknologi Malaysia
- Sr. Quek Jin Keat, Chair of BIM Technical Committee
- Wallace Imoudu Enegbuma, Universiti Teknologi Malaysia
Institutions

• Faculty of Built Environment, Universiti Teknologi Malaysia
• Royal Institution of Surveyors Malaysia
• Board of Quantity Surveyors Malaysia
Framework for expanding BIM adoption within the taught curriculum

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George Fu, Ph.D., P. Eng.

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BIM & CIM

• the technology used in the course offering and the approach adopted

• the **application(s)** to enhance understanding of the process in which BIM is embedded

• *the all-embracing pedagogy*
### Course offerings to integrate BIM in the Construction Management curricula

<table>
<thead>
<tr>
<th>Course name offered in the CM program</th>
<th>Topics covered/Software used</th>
<th>Future applications of the topics for understanding BIM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year I</strong></td>
<td></td>
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</tr>
</tbody>
</table>
| Engineering/Constr. Graphics          | - Geometric modeling to represent operations of construction equipment (i.e. a crane, bulldozer, etc.)  
- Some form of 3D building visualizations | - Requirements for productivity, efficiency and safety |
| **Year II**                           |                              |                                                        |
| BIM for Construction Management       | - Learning BIM as a collaboration and coordination tool;  
- Software applications with: Revit Architecture/Structure/MEP, BIM 360 Glue, Navisworks Manage, Tekla Structures, (Tekla BIMsight) | - Mobile technologies for field use; productivity enhancements, visual estimating, accuracies and scheduling realization |
| **Year III-IV**                       |                              |                                                        |
| Project Planning & Scheduling         | - Project Scheduling methods such as Bar Charts, CPM and PERT, AOA, AON and CPM techniques; resource allocation and time/cost trade-off analysis, EVM  
- Software applications with: Microsoft Project 2013, Primavera P6 R8.2, Synchro for linking schedule to a building model and running simulations | - Creating schedules, simulating activities in project examples, comparison of CPM and location-based scheduling, industry lean construction practices |
| **Year IV**                           |                              |                                                        |
| Senior Project - Capstone course      | - Laser scanning, Photogrammetry & 3D applications, Scan-to-BIM integration; Software used: Cyclone, Agisoft Photoscan, Photomodeler, Autodesk Recap Pro, Revit Cloudworx | - Creation of 3D models of existing structures, terrain and topographic modeling; accuracy comparisons by different measurement techniques |
CE (ABET) & CM (ACCE) SLO’s

- (a) through (k) outcomes specified in the 2013-2014 ABET Criteria for Accrediting Engineering Programs.
- The only relevant one is SLO (k): “an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice”

Document 103, Standards and Criteria for accreditation <http://www.acce-hq.org>
- 4. Create construction project cost estimates
- 5. Create construction project schedules
- 8. Analyze methods, materials, and equipment used to construct projects
- 9. Apply construction management skills as a member of a multi-disciplinary team
- 10. Apply electronic-based technology to manage the construction process
- 12. Understand different methods of project delivery and the roles and responsibilities of all constituents involved in the design and construction process
- 15. Understand construction quality assurance and control
- 16. Understand construction project control processes
- 18. Understand the basic principles of sustainable construction
- 19. Understand the basic principles of structural behavior
- 20. Understand the basic principles of mechanical, electrical and piping systems
# BIM Undergraduate Levels in the Construction Management curriculum and the SLOs

<table>
<thead>
<tr>
<th>Levels/Skills</th>
<th>Knowledge and Understanding</th>
<th>Practical Skills</th>
<th>Transferable Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Undergraduate Level I</strong></td>
<td>- Importance of collaboration</td>
<td>- Introduction to technology used across disciplines</td>
<td>- BIM as a process/technology/people/policy</td>
</tr>
<tr>
<td></td>
<td>- The BIM business</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Undergraduate Level II</strong></td>
<td>- BIM construction processes</td>
<td>- Use of visual methods representation</td>
<td>- Value, lifecycle and sustainability</td>
</tr>
<tr>
<td></td>
<td>- Stakeholders’ business drivers</td>
<td>- BIM tools and their applications</td>
<td>- SaaS platforms for projects</td>
</tr>
<tr>
<td></td>
<td>- Supply chain integration with BIM</td>
<td>- Characteristics of a BIM “system”</td>
<td>- Collaborative working</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Inter-disciplinary teams communication</td>
</tr>
<tr>
<td><strong>Undergraduate Level III</strong></td>
<td>- BIM across the disciplines</td>
<td>Technical know-how:</td>
<td>Process/Management:</td>
</tr>
<tr>
<td></td>
<td>- Contractual and legal frameworks/regulation</td>
<td>- Structures, materials</td>
<td>- How to deliver projects using BIM</td>
</tr>
<tr>
<td></td>
<td>- People/change management</td>
<td>- Sustainability matters</td>
<td>- Information and data flows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Green materials and their integration in buildings</td>
<td>- BIM protocols</td>
</tr>
<tr>
<td><strong>Student Learning Outcomes</strong></td>
<td><strong>SLOs: 1, 2, 7, 8, 12, 17</strong></td>
<td><strong>SLOs: 1, 2, 4, 5, 7, 18, 19, 20</strong></td>
<td><strong>SLOs: 1, 2, 4, 5, 9, 10, 15, 16</strong></td>
</tr>
</tbody>
</table>
BENTLEY FlowMaster V8i

Hydraulic Calculator for Open Channels, Pipes, Weirs, Inlets

Results after Running The Software

Worksheet for Pressure Pipe - 1

Project Description
Friction method: Manning Formula
Solve for: Roughness

Input Data
Pressure 1: 28.42 kPa
Pressure 2: 0.00 kPa
Elevation 1: 0.00 m
Elevation 2: 0.00 m
Length: 3.66 m
Diameter: 0.0264 m
Flow Area: 0.0024 m²

Results
Roughness Coefficient: 0.010
Headloss: 2.90 m
Energy Grade 1: 3.47 m
Energy Grade 2: 0.57 m
Hydraulic Grade 1: 2.90 m
Hydraulic Grade 2: 0.00 m
Flow Area: 0.00 m²
Wetted Perimeter: 0.00 m
Velocity: 3.34 m/s
Friction Head: 0.57 m
Friction Slope: 0.79178 m/m

Input data

Welcome to Bentley FlowMaster V8i (SELECTseries 1)

Introduction to FlowMaster
Tutorials...
Create New Project
Create Worksheet
Open Existing Project

Show This Dialog at Start 11/4/2009 (08:11.03)
VALUE OF CIM FOR CM & CE GRADUATES

(HOW CAN WE EXPAND?)

- Highway design
- Bridge design, rail infrastructure
- CIM in infrastructure is seeing a positive ROI
- Experience with cloud sharing
- Large amounts of data using BIM can save significant ☕ & $$$ to Owners
- Model-based cost estimating ($$$)
CONCLUSIONS AND FUTURE VISION

• Software applications are usually **RAM intensive**
• Requires **hardware capable of processing the data** retrieval needed to be accessed in order to perform the modeling functions
• Potential to increase productivity and significantly reduce project cost by using the **BIM or CIM software** *(even with intermediate-level skills that may be acquired during junior and senior years as college students)*
• **ABET & ACCE** accreditation bodies & professional bodies **BIM Forum, AGC of America, BAF**, etc., need to come together to begin addressing the implications of accreditation for curricula incorporating **BIM & CIM**
• Work needed to **standardize student learning outcomes** to meet current & future needs of a transformational (soon to be) **high-tech industry**
Show me the (...modeling skills that will save me the...) $$$$ 

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Department of Civil Engineering and Construction Management, Georgia Southern University, Statesboro, GA
Integration of BIM Course Into Design Curriculum
Case Study: Study program of Architecture, Institut Teknologi Bandung (ITB)

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Institut Teknologi Bandung
Tony Hartanto
Institut Teknologi Bandung

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INTRODUCTION

PRESENTATION STRUCTURE

1. Introduction
   • Context of BIM Education in Indonesia
   • Class overview & course description

2. Course Objective & Implementation
   • Course implementation
   • Understanding BIM and individual projects
   • Collaborative Project

3. Conclusion / Future Integration Development – Research Opportunities
INTRODUCTION

Abstract
The relevance of Building Information Modeling (BIM) is apparent in today’s construction industry. Benefits of implementing BIM has been identified as real-time integration of changes throughout the model which appears both graphically in the views and numerical data in the schedule, which in turn leads to more accurate budget and cost predictions, as well as the minimizations of fragmentations between myriads of different file formats among collaborating consultants. Given these benefits, it is imperative that educational institutions start integrating BIM into their curriculum to prepare future practitioners who will perform better and more efficiently in construction teams.
01. INTRODUCTION
INTRODUCTION

Context of BIM Education in Indonesia
Indonesia AEC Industry Growth & BIM Adoption

- Increasing new property development & constructions
- BIM in its early stages of adoption
- ITB Dept of Architecture, 1st architecture school in Indonesia to integrate BIM into its design curriculum
- Steep learning curve for real application of BIM in professional projects
- Indonesia AEC Schools has yet to integrate BIM into their curriculum
INTRODUCTION

Context of BIM Education in Indonesia
From CAD-Based to BIM-Based – BIM Standards

All participating consultants operate in a pre-defined common BIM framework

*Image and model taken from Revit 2015 Basic Sample File
INTRODUCTION

Context of BIM Education in Indonesia
From CAD-Based to BIM-Based – Current Industry Standard

OUTPUT/FIELD
CONSULTANT
FORMAT
2D CAD Format (.dwg / .dgn . AutoCAD / Microstation) etc
Architect, Interior Designer, Contractor, MEP Consultant

3D Model (.skp / .max / .3dm – Sketchup / 3DS Max / Rhino) etc
3D Visualizer / Designer

Project Schedule / specifications (.xls)
Quantity Surveyor, procurement, contractor

Project Timeline (Microsoft project)
Project Manager, Developer

Area Report (.xls & .pdf / .jpg)
Client, Developer, Property Analyst

*Image and model taken from Revit 2015 Basic Sample File
INTRODUCTION

Class Overview & Course Description

Professor A. Indraprastha & Tony Hartanto
AR 4122 – Introduction to BIM
Course credits: 2
Timeline: 14 weeks

8 bi-weekly teaching module
Guest Lecturer:
ITB Dept of Applied Physics

Autodesk Revit 2014
Autodesk Naviswork 2014
Autodesk Green Building Studio (Educational version)

PT Intiland Development
BIM Division
Anto Sudaryanto
INTRODUCTION

Class Overview & Course Description
The course of AR 4122 – Introduction to BIM was delivered in the span of fourteen weeks, with two major phasing, and one minor phase on analysis in between.

Individual Competencies (Concept – Practice)

Basic environmental simulations in a BIM model

Collaborative Competencies
## INTRODUCTION

### Class Overview & Course Description – Individual Competencies

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Introduction to BIM in the construction industry</td>
<td>Evolution of information technology in architectural design, Design method using BIM technology, Autodesk Revit’s principles and workflow, Autodesk Revit’s user interface and key features</td>
</tr>
<tr>
<td>02</td>
<td>Architectural BIM – Project Setup</td>
<td>Topographic modeling, Image references, Datum: project location, grid, elevation</td>
</tr>
<tr>
<td>03</td>
<td>Architectural BIM – Component Modeling</td>
<td>Basic component modeling, Column, Walls, Openings: window, doors</td>
</tr>
<tr>
<td>04</td>
<td>Architectural BIM - Circulation and Roof</td>
<td>Circulation: Stairs, ramp, Roof types</td>
</tr>
<tr>
<td>05</td>
<td>Architectural BIM - Family Creation &amp; Modeling</td>
<td>Family creation and editing, System families, Loadable families, In-place families</td>
</tr>
<tr>
<td>06</td>
<td>Architectural BIM – Curtain Wall</td>
<td>Emphasis on appropriate modeling and information output of BIM Model</td>
</tr>
</tbody>
</table>

Week #1-
INTRODUCTION

Class Overview & Course Description – Basic Environmental Analysis

07 – Architectural BIM – Mass Modeling and Editing
- Mass modeling and editing
- Creation of energy model & analysis
- Sunpath & lighting analysis

08 – Project Exercise – Mid Semester Exam

Emphasis on learning the basics of visual analysis & energy modeling in BIM.
INTRODUCTION

Class Overview & Course Description – Basic Environmental Analysis

<table>
<thead>
<tr>
<th>Week</th>
<th>Subject</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>09</td>
<td>Introduction to Collaborative BIM</td>
<td>Emphasis on the creation and operation of BIM within a collaborative framework</td>
</tr>
<tr>
<td></td>
<td>• Introduction to Collaborative Revit</td>
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<td>• Setting and the principle of worksheet</td>
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<td>• Project workshop in collaboration with PT. Intiland Development, Tbk.</td>
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<td>10</td>
<td>Collaborative Project Workshop</td>
<td>• Project workshop</td>
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<td>11</td>
<td>Collaborative Project Workshop</td>
<td>• Project workshop</td>
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<td>12</td>
<td>Collaboration Management</td>
<td>• Introduction to Naviswork for clash detection</td>
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<td></td>
<td>• Exercise on project and rectification</td>
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<tr>
<td>13</td>
<td>Collaboration Management</td>
<td>• Project modification and elaboration</td>
</tr>
<tr>
<td>14</td>
<td>Project Finalization (final-term project submission)</td>
<td>• Project finalization</td>
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<td></td>
<td>• Course feedback</td>
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</tbody>
</table>

Week #9-14

*Image and exercise model taken from PT Intiland Development’s South Quarter*
02. COURSE OBJECTIVE & IMPLEMENTATION
Course Implementation (topics and subtopics)

The goal of our AR 4122 – Introduction to BIM course is to teach students on the basics of these topics:

**Individual Competencies (Concept – Practice)**
- Introduction of BIM concepts and applications
- Working in BIM – Autodesk Revit operations basics
- Understanding BIM benefits & utilization of BIM information

**Basic environmental simulations in a BIM model**
- Energy model creation & analysis
- Sunpath & artificial lighting analysis

**Collaborative Competencies**
- Setting up of a collaboration framework in Revit
- Perform basic clash detection simulations of integrated models
COURSE OBJECTIVE & IMPLEMENTATION

Understanding BIM and Individual Projects

- BIM concepts and benefits
- Tools exploration and application on Autodesk Revit 2014 Educational Version
- Basic BIM model information utilization
- Environmental (Sunpath – Lighting – Energy) Analysis

Model Exercise – Bintaro House Project

- Small models allows students to go deep in understanding real constructions and how building systems works.
Understanding BIM and Individual Projects
BIM Concepts & Benefits – Information Modeling Definition

“Information modeling” Demonstration

Building information (wall area, length, etc) are updated with every change to the model geometry.

Benefits

Assurance of building information accuracy
## COURSE OBJECTIVE & IMPLEMENTATION

### Understanding BIM and Individual Projects

**BIM Concepts & Benefits – Level of Development (LOD) Definition & Course Extent**

<table>
<thead>
<tr>
<th>LOD 100</th>
<th>LOD 200</th>
<th>LOD 300</th>
<th>LOD 400</th>
<th>LOD 500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual</td>
<td>Generic Model</td>
<td>Specific Assemblies</td>
<td>Detailed Assemblies</td>
<td>Fabrication – As Built</td>
</tr>
<tr>
<td>The Model Element may be graphically represented in the Model with a symbol or other generic representation</td>
<td>The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation.</td>
<td>The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation.</td>
<td>The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information.</td>
<td>The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements.</td>
</tr>
</tbody>
</table>

**COURSE EXTENT**

- **Traditional Architect / Designer Scope of Work (Indonesia)**
- **Contractor Scope of Work (Indonesia)**

Definitions referring to AIA’s Guide and Instructions to the AIA Digital Practice
### Course Objective & Implementation

#### Understanding BIM and Individual Projects

**BIM Concepts & Benefits – Level of Development (LOD) Definition**

<table>
<thead>
<tr>
<th>LOD 100</th>
<th>LOD 200</th>
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<tbody>
<tr>
<td>Conceptual</td>
<td>Generic Model</td>
<td>Specific Assemblies</td>
<td>Detailed Assemblies</td>
<td>Fabrication – As Built</td>
</tr>
</tbody>
</table>

**Example**

- **Hypothetical building mass with identifiable boundaries / enclosure (massing)**
- **Generic building components / representation** (generic floor, roof, wall)
- **Drawing in accordance to the intended design proposal. Specific details, and materials of components (wall, floor, roof)**

---

**COURSE EXTENT**
COURSE OBJECTIVE & IMPLEMENTATION

Understanding BIM and Individual Projects
BIM Concepts & Benefits – Design Phasing with BIM

<table>
<thead>
<tr>
<th>Pre-Design</th>
<th>Conceptual Design</th>
<th>Developed Design</th>
<th>Detailed Design</th>
<th>As Built &amp; Pre-Fabrication</th>
<th>Construction &amp; Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td>• Context &amp; site modeling</td>
<td>• Conceptual building &amp; site design</td>
<td>• Building, object &amp; site development models</td>
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<tr>
<td></td>
<td>• Climatic analysis</td>
<td>• Preliminary analysis of</td>
<td>• Integration of building systems</td>
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<td>• -</td>
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<tr>
<td></td>
<td>• Room &amp; site modeling</td>
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<tr>
<td>Tools</td>
<td>Revit Arch</td>
<td>Sketchup/ Rhino</td>
<td>Revit Arch</td>
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<td>Green Building Studio</td>
<td>Green Building Studio</td>
<td>Green Building Studio</td>
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<td>AutoCAD</td>
<td>Ms Excel</td>
<td>Ms Excel</td>
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<tr>
<td>Target</td>
<td>Design requirements identification</td>
<td>Preliminary building design simulation</td>
<td>Construction, energy and cost approximation</td>
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<td>Understanding of local weather &amp; site conditions</td>
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NOT DISCUSSED IN THE COURSE.

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Understanding BIM and Individual Projects
Tools exploration and application on Autodesk Revit 2014 Educational Version

Gambar 4 Revit Default User Interface
UNDERSTANDING BIM AND INDIVIDUAL PROJECTS

Basic BIM model information utilization – Area Calculation

Room zoning & area calculation

Utilization of this information allows student to ensure their design is up to the building & room requirements
Understanding BIM and Individual Projects
Basic BIM model information utilization – Cost Estimation

Working Volume & Cost Estimation
Utilization of this information introduces students on the preliminary cost estimation process of projects
Understanding BIM and Individual Projects
Environmental (Sunpath – Lighting – Energy) Analysis

- Large west façade openings to maximize visual access to the desired view (garden). Daily 4 PM sunlight to pose particular concern for visual comfort
- The west facade openings allows too much sunlight into the living room, as can be seen from the lighting studies.
- Too much sunlight heats up a room, potentially increasing it’s the building’s cooling costs and energy consumption
COURSE OBJECTIVE & IMPLEMENTATION

Collaborative Project

• Collaboration framework & method introduction
• Project workshops
• Clash detection simulation exercise & report generation

Model Exercise – PT. Intiland Development – South Quarter

• Larger, and inter-disciplinary model provides students with the opportunity to distribute modeling responsibilities in groups, and integrate them later on in the project workshop stage

*Original model courtesy of PT Intiland Development’s South Quarter Project
COURSE OBJECTIVE & IMPLEMENTATION

Collaborative Project
Collaboration framework & method introduction – PT Intiland Development Framework

Central .rvt file (for coordination)
Linked
Linked
Linked
Central .rvt file (Structure)
Linked
Central .rvt file (Architecture)
Linked
Central .rvt file (MEP)
Linked

Team Member
Team Member
Team Member
Team Member
Team Member

BIM Manager / Coordinator
Integrated Discipline Model
Discipline Manager
(Architecture, Structure, MEP central file)
COURSE OBJECTIVE & IMPLEMENTATION

Collaborative Project
Project Workshops – Intiland South Quarter

*Original model courtesy of PT Intiland Development's South Quarter Project
COURSE OBJECTIVE & IMPLEMENTATION

Collaborative Project
Project Workshops – Clash Detection

Autodesk Revit – Interference Check

Autodesk Naviswork Manage – Clash Detective

*Original model courtesy of PT Intiland Development’s South Quarter Project*
03. CONCLUSION – FUTURE INTEGRATION / DEVELOPMENT
CONCLUSION – FUTURE INTEGRATION / DEVELOPMENT

Future Course Material Development

- User interface & basic tools exploration to be taken out of the course
- Basic operations & modeling to be moved to the 2nd year course Computational

BIM Concepts & Individual Modeling Competencies

Basic Environmental Simulation

Collaborative Project

14 WEEK TOPIC DISTRIBUTION

(2014 SPRING) AR 4122 – Introduction to BIM

WEEK

(2015 SPRING) AR 4122 – Introduction to BIM

WEEK
CONCLUSION – FUTURE INTEGRATION / DEVELOPMENT

Future Course Material Development

(2015 SPRING) AR 4122 – Introduction to BIM

Topics Revision for Upcoming BIM Class

Individual Competencies (Concept – Practice)
- BIM concepts and applications review
- Basic component modeling (wall, floor, roof, ceiling, etc) taken out

Basic environmental simulations in a BIM model
- Sunpath, shadows & artificial lighting analysis
- Energy modeling & airflow simulation using (Vasari & FlowDesign)

Collaborative Competencies
- Structural and MEP model integration
- Introduction to construction simulation using Naviswork
CONCLUSION – FUTURE INTEGRATION / DEVELOPMENT

Future Collaboration & Research Opportunities

ENERGY SIMULATION & BUILDING PERFORMANCE WORKSHOP

Ery Djunaedy, PhD
University of Idaho, Boise, USA
ITB, NUS, TU/e

ARCHITECTURAL COMPUTATION WORKSHOP SERIES

Waktu:
Senin-Selasa,
27-28 Mei 2013

performative design: computational craftmanship
CONCLUSION – FUTURE INTEGRATION / DEVELOPMENT

Future Collaboration & Research Opportunities
Design Phase – Building Element Class - LOD Relationship Guideline

<table>
<thead>
<tr>
<th>Keluaran Fase Pekerjaan</th>
<th>Schematic Design</th>
<th>Developed Design</th>
<th>Detailed Engineering Drawings</th>
<th>Construction Documents</th>
<th>Record Model (Operation)</th>
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<tbody>
<tr>
<td>Model Element</td>
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</table>

Under Development
THANK YOU
BIM in the Intro to Construction and Facilities Management course

Kevin R. Miller & Clifton Farnsworth
Brigham Young University
Class Overview

• Intro to Construction & Facilities Management
• 25 students per section
• 3 sections
• Many of the students are new to Construction and Facilities with no prior experience
• Course structured similar to a studio classroom setting
Course Topics

- Scale and Basic Math
- Plan Reading
- Building Information Modeling
- Estimating
- Scheduling
- Site Selection & Project Feasibility
- Project Management
- Facilities Management
Scale & Basic Math

• Review basic math calculations
• Explain different Units of Measure (UOM)
  • SF, SFCA, BF, etc
• Teach how to read an Architectural Scale
Plan Reading

• 18,000 SF Church

• Students answer questions from the Architectural, Structural, Civil, Mechanical drawings and Specs.

• Scale measurements from drawings
Building Information Modeling

• **Text:** Design Integration Using Autodesk Revit 2015, Daniel Stine

• **Chapters covered**
  • Designs a simple office/warehouse project
  • Law office project
    • Floor Plans
    • Roofs, Floors, Ceilings
    • Structural Systems
    • Interior Design
Estimating

• Estimate the Law Office project in Excel from paper documents

• High Level takeoffs
  • CY of Footings
  • SF CMU, Walls, Ceilings, Floor Coverings
  • BSF Fire Sprinklers, MEP

• Even though students have model the project, I still get asked things like, “what are the Footings?”

• Modeling helps, but does not guarantee students’ understanding

• [http://cmfac.groups.et.byu.net/miller/cm105/assign/Law%20Office/Law%20Office%20EstimateSchedule2013.xlsx](http://cmfac.groups.et.byu.net/miller/cm105/assign/Law%20Office/Law%20Office%20EstimateSchedule2013.xlsx)
Scheduling

• Create a bar chart in Excel of the Law office project
• Durations and activities come from the estimate

http://cmfac.groups.et.byu.net/miller/cm105/assign/Law%20Office/Law%20Office%20Schedule%20Template.xlsx
Site Selection & Project Feasibility

- 3 sites to choose from for the Law Office
- Students examine the financial and site constraints to pick the site.
- Once the site is selected, students model the parking lot, sidewalks, landscaping for the site.

http://cmfac.groups.et.byu.net/miller/cm105/assign/Final%20Project15/Real%20Estate%20Template%20v5.xlsx
Project Management

• Once a site is selected, students generate a site specific Project Management plan

• Layout the following
  • Jobsite site trailers
  • Fencing
  • Gates
  • On-site traffic flow
  • Employee parking
  • Lay down Areas
  • Pedestrian flows outside the site
Facilities Management

• Still under development
• Planning on converting the Law office to a Insta-Care facility
• Working with local health care network to get the program information for a Insta-Care facility of similar size.
Conclusion

• Good overview of Construction & Facilities Management
• Students are engaged throughout the semester
• Touching the course content through BIM, estimating, and scheduling aids the student learning
TWO YEAR TRANSDISCIPLINARY BUILDING LIFECYCLE CORE CURRICULUM
IAI Marketing Diagrams (1999)

Lack of Sharing

Information Sharing
Agree on Semantics and Syntax AND store data in one place (conceptually)

- building information model—an approach to documentation that dictates that all project data be stored in one and only one location. This concept is the result of a fresh look at the construction process, taking into account modern computational tools.
  - Cyon Research White Paper, 2003

Grobler, Francois, Technical Coordinator.
Agree on Semantics and Syntax:

- Participants can communicate using a common language
- Any participant can communicate with any other participant
- Facilitates high performance teams

Grobler, Francois, Technical Coordinator.
Life cycle Interoperability: BIM

Grobler, Francois, Technical Coordinator.
http://www.slidefinder.net/t/the_sable_project_towards_unification/sable_presentation_general/10482406
Figure 1 – Schematic diagram of phases and stages in the whole life

David Geffen School of Medicine at UCLA. (n.d.). *Curriculum*. Retrieved 1 11, 2015, from Medschool UCLA: [http://apply.medschool.ucla.edu/body.cfm?id=93](http://apply.medschool.ucla.edu/body.cfm?id=93)
T-shaped Professionals, T-shaped Skills, Hybrid Managers

Proposed Transdisciplinary Building Lifecycle Curriculum

The diagram describes the relationship of the proposed Lifecycle curriculum within the existing curricula structure.
Core Curriculum with Resource Support

DEMAND
Portfolio & Asset Design: Performance Requirements

ACQUISITION OF FACILITIES
Form and Building Systems Design
Material and Systems Acquisition
Construction and Assembly Sequencing

FACILITIES IN USE
Facilities Management, Operation and Maintenance

Life-Cycle Curriculum with Collaborative Project Workshops
Professional Cognitive Socialization
Building Life-Cycle Knowledge Communities
Real Time Digital Tool System for Education-Research-Practice
Building Life-Cycle Ontology

TWO-YEAR GRADUATE BUILDING LIFE-CYCLE DESIGN CORE PROGRAM
Collaborative workshop projects derived from tasks described in ISO 15686-10
Problem-Centered Collaboration Properties

Pedagogic properties and attributes for the teaching and education using a problem-centered collaborative approach.

Project Workshop Pedagogy:

PROBLEM-CENTERED COLLABORATION

1. Learning is a constructive and creative process
2. Learning is problem solving
3. Learning needs to be meaningful and experienced-based
4. Learning is social and collaborative.
5. Students rotate perspectives as in different professional roles
6. Workshop topics need not be given in typical project order.
7. Workspace for the collaborative team will have common meeting space with individual stations.
8. Work process will be determined by team.
9. Consultants will be used by team to support their learning and problem solving efforts.
10. Use knowledge system resources.
11. Etc.
Proposed Two Year Building Lifecycle Transdisciplinary Curriculum with Industry Feedback Loops
TWO YEAR TRANS DISCIPLINARY BUILDING LIFECYCLE CORE CURRICULUM

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EPILOG

- It’s a comprehensive anticipatory designed paradigm shift.
- (a FullerKuhn production)
Enhanced collaboration between Construction management and architecture students utilizing a building information modeling (BIM) environment

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Overview

• Introduction
  • Trends in BIM Education
  • Defining BIM for Integrated Education at ASU

• Course Overviews
  • ADE 522: Advanced Architectural Studio II (NAAB)
  • CON 575: Information Technology for Construction (ACCE)

• Integration
  • Basis for Integrated Course Offering
  • Proposed Framework for Course Offering

• Challenges

• Goals + Expected Outcomes

• Conclusions + Future Research
Introduction

- Trends in BIM Education*
  - Distance Learning
  - Collaboration
    - Industry
    - Multidisciplinary
  - Rate + Style of Introduction**
    - Architecture/Design/Engineering
    - Construction Management

*Lee and Hollar 2013
**Becerik-Gerber et al. 2011
Introduction

• Defining BIM for Integrated Education at Arizona State University
  • A modeling technology and associated set of processes to produce, communicate, and analyze building models (Eastman et al. 2008)
  • An enhanced collaborative educational model between architecture construction management students
    • Simulation - Semester project deliverable
    • Process Mapping + Benchmarking
    • Open Communication + Feedback Loops

Image courtesy of autodesk: http://www.autodesk.com/solutions/building-information-modeling/overview
Course Overviews

- ADE 522: Advanced Architectural Studio II
  - National Architectural Accreditation Board
    - Integrated Architectural Solutions
      - Research
      - Integrated Evaluations + Decision-Making Process
      - Integrative Design
        - Technical Documentation
        - Accessibility + Site + Safety + Systems + Assemblies

Image courtesy of Arizona State University
Course Overviews

• CON 575: Information Technology for Construction
  • American Council for Construction Education (ACCE 2011)
    • Critical Thinking and Creativity
    • Use of Information and Communication Technology
    • Current Issues in Construction
    • Complex Project Decision Making and Associated Risk Management
    • Advanced Construction Management Practices

Image courtesy of Kitchell
Integration

• Basis for Integrated Course Offering
  • Link The Design School with the Del E. Webb School of Construction in a collaborative effort
  • Bring together interdisciplinary, collaborative student teams to simulate delivery of an APDM project
  • Meet with professional teams across AEC industries to understand constraints and opportunities of real precedents
  • Implement industry practices to provide students with enhanced learning experience
  • Allow students from both disciplines the freedom to innovate and apply knowledge presented during semester towards final project.

Image courtesy of Chasey et al. – Arizona State University
Integration

• Proposed Framework for Course Offering
  • Share information presented in each course between interdisciplinary students
  • Utilize emerging technologies to facilitate information exchange between interdisciplinary student teams (i.e. Autodesk Superstructure, A360 and BIM 360 Glue).
  • CON student teams to provide periodic deliverables such as estimates based on Architecture student teams Revit models, BIM Execution Plan, 4D Schedule, etc.
  • Present final project to panel of “Owner Representatives” utilizing all required deliverables.

Image courtesy of Autodesk
Challenges

• Compressed Schedule
  • Concurrent Introduction of multiple softwares (i.e. Autodesk Revit, Navisworks, BIM 360, Bluebeam Revu, Dprofiler, etc.)
  • Traditional Process Learning vs. Integrated Process Learning
• Lack of student experience in project delivery aspects
• Dual Program Graduate Student Coordination
• Bridging the cultural gap of studio-based Architectural education and laboratory-based Construction Management education with students who have limited professional experience.
Goals + Expected Outcomes

- Increased dialogue, understanding, and appreciation between The Design School and DEWSC about the similarities or differences of educational models serving future building industry professionals
- Enriched Student Experience in utilizing, and critically assessing simulated industry practices
- Engagement of multidisciplinary student teams introducing widened perspectives to the project delivery approach
- Instructor(s) acquiring relevant feedback from student teams in order to refine processes
- A unique educational experience that will help both sets of students differentiate themselves in the competitive professional environment
Conclusions + Future Research

• Students need more interaction with multidisciplinary coordination to provide greater value to industry upon graduation

• Multidisciplinary collaboration in a University setting will provide stronger workforce entry

• Collect data with beta group of Design School and DEWSC students to gauge experience, satisfaction with process

• Consider other possible academic engagements between The Design School and DEWSC
  • Increased DBIA student chapter engagement from both Schools
  • More courses that can serve the education of both student sets
  • More independent research projects that engage both disciplines
Best Practices and Lessons Learned in BIM Project Execution Planning in Construction Education

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Graduate Research Associate

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Del E. Webb School of Construction
School of Sustainable Engineering and the Built Environment
Arizona State University
BIM Education

• Two components
  – Computer applications

• What buttons do I click to run a clash report?
BIM Education

• Two components
  – Computer applications
  • How do I extract quantities from a BIM model?
BIM Education

• Two components
  – BIM Management
  • How should I plan for BIM in construction?
BIM Education

• Two components
  – BIM Management

• What level of development do I need from the design team to facilitate 3D coordination?
BIM Education

• Two components

• Which is more important?
  – Both!
BIM and ASU

• 2\textsuperscript{nd} year course
  – Introduction to:
    • Traditional Engineering Drawings
    • Building Information Modeling

• 4\textsuperscript{th} year course
  – Application of:
    • Technical BIM Skills
    • BIM Planning Techniques
    • Semester Project
CON 453 – Project Management I

• BIM as a tool for managing construction
• Fall 2013 / Spring 2014
  – Two separate course components
    • One related to BIM computer applications
    • One related to BIM management
• Fall 2014 / Spring 2015
  – One integrated course project
    • Component of BIM computer applications
    • Component of BIM management
What did we learn from teaching?

• Questionnaire given to instructors and TA’s
  – Describe how BIM PxP content was presented
  – How was the learning content assessed
  – What aspects were well understood
  – What aspects were frequently misunderstood
  – What aspects would you change
  – What additional prerequisite courses would you recommend
What did we learn from teaching?

<table>
<thead>
<tr>
<th></th>
<th>Separate Projects</th>
<th>Integrated Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presented how?</td>
<td>Standardized process using Penn State’s BIM PxP Guide</td>
<td>Incorporation of BIM tools to meet objectives of project proposal</td>
</tr>
<tr>
<td>Assessed how?</td>
<td>Through development of BIM uses within PxP</td>
<td>Incorporation of BIM tools to meet objectives of project proposal</td>
</tr>
<tr>
<td>Aspects well understood?</td>
<td>Students were able to understand the basic purpose of BIM PxP</td>
<td>Attempts to align PxP to computer application deliverables among team</td>
</tr>
<tr>
<td>Aspects frequently misunderstood?</td>
<td>How to actually implement, track, and score</td>
<td>Defining information exchanges, process mapping, ownership of certain BIM uses</td>
</tr>
<tr>
<td>Suggestions for modifications?</td>
<td>Explain how a developed PxP can influence team member behaviors on a project</td>
<td>Expanding project to allow teams to tailor PxP to their specific objectives</td>
</tr>
<tr>
<td>Suggestions for prerequisites?</td>
<td>Early introduction into the undergraduate program and cross-disciplinary collaboration with design and engineering students</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

• Benefits from individual projects:
  – Mistakes made in planning do not hinder downstream BIM application

• Benefits from integrating projects:
  – Real-world challenges of actually implementing plan

• Opportunity: Cross-disciplinary integration!
BIM and ASU (Future)

• Interdisciplinary collaboration
  – One Project
    • Architect
    • Civil Engineer
    • Construction Management
  – BIM for facilitating collaboration
| ASU  
<table>
<thead>
<tr>
<th></th>
</tr>
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<tr>
<td><strong>Ira A. Fulton Schools of Engineering</strong></td>
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<tr>
<td><strong>Sustainable Engineering and the Built Environment</strong></td>
</tr>
<tr>
<td><strong>Herberger Institute for Design and the Arts</strong></td>
</tr>
<tr>
<td><strong>The Design School</strong></td>
</tr>
</tbody>
</table>

| Construction Management | Construction Engineering | Civil Engineering | Architectural Studies | Landscape Architecture | Interior Design | Environmental Design |
Thank you!

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Del E. Webb School of Construction
Arizona State University
Design Disassembled:
Understanding Building Systems Through BIM

Tracy A. Stone, AIA LEED BD+C, Adjunct Faculty
MacKenzie King, LEED Green Associate, Graduate
Design Disassembled: Understanding Building Systems through BIM

Introduction
Design Disassembled: Understanding Building Systems through BIM

Introduction

Tectonics 2: Detail Design Course
Interior Architecture Department
Woodbury University School of Architecture

3 Learning Outcomes
to investigate “Design for Disassembly”:

- Sustainability and Life-Cycle Analysis
  - Material Characteristics
  - Material Connections

Students had the option of using of BIM as a design tool.
To understand building systems, students must move beyond a volumetric exploration of form to look at the individual components that together comprise the structural and finish systems.
Design Disassembled: Understanding Building Systems through BIM

Course Description

1. Design Problem

2. Select Materials

3. Design for Disassembly

EXHIBIT GOALS

To create a modular system that allows for multiple pin-up surfaces and model and process book locations

MODULE

TO

STUDIO DESKS

QUANTITY OF STUDS

ASSEMBLY KEY

Carboni/Wintraub, 2010
BIM Impacts on Teacher/Student Communication

2D Drafting Software Confusion
BIM Impacts on Workflow

BIM Modeling Thought Process
Learning Outcome 1: Sustainability + Life-Cycle Analysis

Course Objective: Students understand how to critically apply concepts, principles and theories of sustainability to the selection of materials and building systems.

The class objective was to interrupt the construction demolition waste stream and take advantage of the embodied energy in the selected construction materials by planning for their transition to a future use.

King/Ho/Obermayr, 2009
Design Disassembled: Understanding Building Systems through BIM

Learning Outcome 1: Assessment

Course Objective: Students understand how to critically apply concepts, principles and theories of sustainability to the selection of materials and building systems.

Quantification of Elements
Design Disassembled: Understanding Building Systems through BIM

Learning Outcome 1: Assessment

Course Objective: Students understand how to critically apply concepts, principles and theories of sustainability to the selection of materials and building systems.

Exploded Module into Basic Components

“The construction industry consumes “40% of all extracted materials, produces one-third of the total landfill waste stream, and accounts for 30% of national energy consumption.”

King, 2009
Learning Outcome 2: Material Characteristics

Course Objective: Students understand material characteristics, including structural strengths and weaknesses, and material life cycle analysis implications.

Class visit to Interior Removal Specialists, a demolition contractor, specializing in the diversion of interior construction materials from the landfill.
Learning Outcome 2: Assessment

Course Objective: Students understand material characteristics, including structural strengths and weaknesses, and material life cycle analysis implications.
Design Disassembled: Understanding Building Systems through BIM

Learning Outcome 2: Assessment

Course Objective: Students understand material characteristics, including structural strengths and weaknesses, and material life cycle analysis implications.

“Each material has different characteristics and requires separate considerations, but the ultimate objective in the engineering sense is to determine the most efficient and economical system that can be coordinated with the design solution.”

Obermayr, 2009
Design Disassembled: Understanding Building Systems through BIM

**Learning Outcome 3: Material Connections**

Course Objective: Students understand how to design and represent material connections and details.

**Modeling Connections to Evaluate/Explain Design**
Learning Outcome 3: Assessment

Course Objective: Students understand how to design and represent material connections and details.

Modeling Connections to Evaluate/Explain Design
Learning Outcome 3: Assessment

Course Objective: Students understand how to design and represent material connections and details.

Material Specific Hanging System
Learning Outcome 3: Assessment

Course Objective: Students understand how to design and represent material connections and details.

Material Specific Hanging System
Challenges Related to Technology

“As with any sophisticated software, a significant learning curve is associated with BIM. [...] BIM requires a deeper understanding of the systems being modeled”.
Conclusion

**Efficient Communication**
- The instructor could quickly understand the students’ design intent via the 3D model, resulting in more efficient communication between the two

**Component-based Design**
- component-based approach to design enables the type of investigation into building systems required by this technical course
- BIM technology promotes component-based thinking, and the program enhanced the students’ understanding of the relationship of structure to form

**Resource conservation**
- The ability to quantify materials and components using the 3D model made sustainable decisions related to material usage easy to analyze

**Design Evaluation**
- The model allowed students to study the connections and evaluate details within a design project more fully than is possible with a small-scale physical model or through translation to 2D drawings.
Design Disassembled: Understanding Building Systems through BIM

Evaluating the Impact

<table>
<thead>
<tr>
<th>Student</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
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<tr>
<td>Type of Student:</td>
<td>Typically High Performance (HP), Mid Performance (AP), or Low Performance (LP)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>LP</td>
<td>MP</td>
<td>HP</td>
<td>HP</td>
<td>HP</td>
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<td>LP</td>
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<table>
<thead>
<tr>
<th>Final Presentation Requirements</th>
<th>DIM Users</th>
<th>Non-DIM Users</th>
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<tbody>
<tr>
<td><strong>Floor Plan</strong></td>
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<td></td>
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<tr>
<td>Provided - 1 pt, Rendered - 2pts</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Sections (2)</strong></td>
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<tr>
<td>Each: Provided - 1 pt, Rendered - 2pts</td>
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<td>4</td>
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<tr>
<td><strong>Elevations (2)</strong></td>
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<td>4</td>
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<tr>
<td><strong>Graphic Component - Axon / Diagram</strong></td>
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<tr>
<td>Provided - 1 pt</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Details - Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of Traditional 2D Details</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td># of 3D Details</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td><strong>Assembly/Disassembly Diagram</strong></td>
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<td>6</td>
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<tr>
<td><strong>Renderings</strong></td>
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<td>Provided - 1 pt for each</td>
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<td>1</td>
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<tr>
<td><strong>Unique Elements Extracted from 3D Model</strong></td>
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<tr>
<td>Provided - 1 pt for each</td>
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**TOTAL POINTS**

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<tr>
<th>DIM Users</th>
<th>47</th>
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<th>80</th>
<th>97</th>
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<td>68</td>
<td>18</td>
<td>50</td>
<td>41</td>
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Design Disassembled: Understanding Building Systems through BIM

Acknowledgements

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REFERENCES


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GRAPHISOFT
ARCHICAD
http://www.graphisoft.com/archicad/
Introducing Laser Scanning Technology in a Graduate BIM Class

R. Raymond Issa
Hamzah Shanbari
Nathan Blinn
Outline

- Introduction
- Construction information systems class
- History of laser scanning
- Implementation
  - Class projects
  - Scanning campus buildings
  - Results
  - Challenges
- Conclusion
Introduction

- BIM is becoming the new standard in the construction industry
- The technology is advancing at a fast pace
- Construction schools need to keep up with the advancing technology
- Laser scanning technology is helping the construction industry create more accurate documentation
Construction Information Systems Class

- Graduate level course
- Introduces students to the expanding VDC domain
- Students perform hands-on lab exercises using several software packages including Autodesk Revit and Navisworks, Vico Office and Synchro Professional.
- Students can pass the course only after demonstrating their modeling and model analysis skills in a final hands-on test.
History of Laser Scanning Tech

- The two common operation principles for laser scanning are Time of Flight and Phase-Shift Comparison

  - Time of flight: calculates the coordinates, in 3D space, of its surroundings based on the amount of time it takes the laser signal to return to the device after being reflected

  - Phase-Shift comparison: harmonic wave of a modulating beam returns to the device the phase difference between what was transmitted and what was received which allows for the calculation of distance
Laser Scanning Technology in Construction

- Interest in the technology ranges from new construction to as-built verification and even archaeological and heritage applications.

- It is important to understand that laser scanning is a tool which can lead to more accurate models when integrated with other computer modeling programs to produce more detailed deliverables.
Implementation: Class Project

- The class was divided into 5 teams
- Each team was assigned a campus building to model based on minimal floor plans (emergency evacuation plans) and without any section or elevation drawings. The provided floor plans were not-to-scale and did not include any annotations or details.
- Teams were instructed to rely on the provided point-clouds generated from the laser scanner to complete their models.
- Site visits were encouraged.
Implementation: Class Project

Table 1. Class projects breakdown

<table>
<thead>
<tr>
<th>Team</th>
<th>No. of Students</th>
<th>Building</th>
<th>Size (Sq. Ft.)</th>
<th>Number of Scans</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>4</td>
<td>Fine Arts B&amp;D</td>
<td>23,500</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>Fine Arts A&amp;C</td>
<td>34,300</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>Little Hall</td>
<td>25,000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>Architecture</td>
<td>46,000</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Turlington Hall</td>
<td>30,000</td>
<td>9</td>
</tr>
</tbody>
</table>
Implementation: Scanning Buildings

- Faro Focus 3D laser scanner was used to scan the designated campus buildings

- Students were introduced to the technology in class and advised on the proper settings/techniques to complete the most optimum and efficient scans

- They were invited to join the scan teams for the execution of the scan plans developed for their buildings and witness the scanning process first hand
Implementation: Scanning Buildings

Laser scanning plan for Turlington Hall
Implementation: Scanning Buildings

Point-cloud for Turlington Hall
Implementation: Results

- All teams were able to complete their project with more than acceptable results
- The delivered models were within $\frac{1}{2}$” of actual site measurements
- Students were able to reconstruct the building from the point-clouds, as well as assess the buildings and generate educated decisions on the materiality and composition of the many hidden elements
Implementation: Results

Completed model for Turlington
Implementation: Results

Completed model for Architecture
Implementation: Results

Completed model for Architecture
Implementation: Results

Completed model for Fine Arts Complex
Implementation: Results

Completed model for Fine Arts Complex
Implementation: Results

Completed model for Little Hall
Implementation: Challenges

- Due to the fact that the texture of scanned surfaces might affect the alignment of the points, students found it somewhat difficult to pull dimensions pertaining to the same surface and had to be careful to get accurate results.

- The size of the point-cloud files made it more challenging for the students to use them on their personal computers, especially within Revit.
Exposing students in the construction management program to the latest technologies in the field will give them a competitive advantage in the job market.

The laser scanning technology has been positively received and proved to be useful to this course’s students.

The study showed that students are eager to try new methods and approaches in the classroom as they are developed.

Conclusion
Thank you

Questions
BIM EDUCATION IN ASEAN

The Demand for BIM Practitioners

Institute of Virtual Design and Construction

Version 3.0 – Mar 31 2015
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ABSTRACT

• A global demand for qualified BIM Practitioners.
• Insufficient number of BIM practitioners (in ASEAN).
• Raised the overall cost for BIM operation.
• Causes unequal shifts in resourcing BIM practitioners worldwide.
• ASEAN members comprise of 10 countries that are in heavily development.
• Specifically with Singapore.
• Vibrant youthful populations and governments are fully vested in general education.
ABSTRACT

• Confusion over BIM qualifications.
• An appropriate BIM education program is needed now.
• What are the components for an effective well-rounded BIM educational program?
• Development and implementation of a truly qualified BIM educational program.
• The goal is to develop an internationally recognized, stand-alone certification for qualified BIM practitioners.
INTRODUCTION

1.2 The Arrival of BIM Education
- A system that focuses purely on creating qualified BIM practitioners
- Similar to the process that qualifies other industry professionals such as Architects, Engineers, Managers and Project Managers.

1.3 BIM Adoption in Asia and ASEAN
- In 2015, Singapore’s BCA mandated the use of BIM
- China, Hong Kong, India, South Korea and Japan have begun to established governmental level requirements.
- ASEAN nations such as Indonesia, Malaysia and Vietnam are expected to issue new BIM regulations in 2015.
1. INTRODUCTION

1.4 The Hurdle for BIM
- "Skills and capabilities of using the technology.
- "A good understanding of construction processes.
- "Good project management capabilities to work well as a team."

1.7 The Current Self-Educated Practitioner of BIM
- Self-trained, self-titled and self-promoted as BIM experts.
- Training of a particular BIM software platform.
- Involves real work experience and further self-education.

1. He Xixing, general manager of Shanghai Jianke Engineering Consulting Company, Ltd.,
ESSENTIAL BIM EDUCATION

2.1 Tailor-made Curriculum and Internship Programs
• A tertiary education system must be in place.
• Create tailor-made curricula and internship programs.
• Create unified standards defining a qualified BIM practitioner.

2.2 Industry-wide Standard Certification for BIM Practitioners
• Different regions will have different BIM regulations.
• BIM knowledge is common across the globe
• To standardization of certification for BIM practitioners.
ESSENTIAL BIM EDUCATION

2.6 The Essential BIM Curriculum Components
• ASEAN BIM curriculum model should focus primarily on two key components.
  1. Adoption and acceptance by the ASEAN AEC industry.
  2. Creation of a well-rounded BIM curriculum with real-world experiences within the region.

2.7 The Essential Levels of BIM Curriculum
• The BIM practitioner should be educated in three essential areas:
  • Level 1 – Modeler
  • Level 2 - Coordinator
  • Level 3 - Manager
LEVELS OF BIM EDUCATION

2.7.1 Level I – Modeler

Building Information Modeling (BIM)

• This beginning level of the BIM curriculum focuses on:
  • BIM and the modeling process
  • Historical industry transformation, workflows, standards and data management
  • Maximize the effectiveness of the modeling procedures

• A typical Modeling curriculum covers the following primary topics:
  • Level I-A: Introduction to BIM
  • Level I-B: Building Information Modeling and Procedures
  • Level I-C: BIM Data Management
LEVELS OF BIM EDUCATION

2.7.2 Level II – Coordinator

BIM Coordination

• This intermediate level focuses on:
  • The collaboration and workflow optimization of the BIM process
  • Detections, calculations, estimations, and scheduling.
  • Logistics and sustainability are absolute necessities for this level of knowledge.

• A typical Coordination curriculum covers the following general topics:
  • Level II-A: BIM Collaboration
  • Level II-B: BIM Calculation, Estimation and Scheduling
  • Level II-C: BIM for Sustainability and Analysis
  • Level II-D: BIM Coordination
LEVELS OF BIM EDUCATION

2.7.3 Level III – Manager

BIM Management

• This advanced level focuses on:
  • Sophisticated modeling procedures and unique technologies
  • Communication, standards, protocols, workflows
  • Scope creation and training

• A typical Management curriculum covers the following central topics:
  • Level III-A: BIM Advanced Modeling
  • Level III-B: BIM Technology
  • Level III-C: BIM Management and Training
BIM EDUCATION STRUCTURE

2.8  The BIM Curriculum Structures
• Class lectures
• Workshops – Lab work
• Real-world experiences
• Should identify and create partnerships with as many as possible of the various recognized BIM programs across the globe.

2.9  Participation of the BIM Industry Professionals
• Involvement of industry professionals with region-based experiences as educators
• Provides students with unique regional perspectives.
CONCLUSION

3.1 The Inevitability of BIM Education

• Asia, including ASEAN countries, is recognized as the largest emerging market in the world.
• This region has become the hot spot for finance, manufacturing and developments.
• This region is one of the slowest adopter of BIM.
• The lack of qualified BIM practitioners has impeded on the growth of BIM adoption throughout Asia.
• This lack is also slowing the adoption of this crucial “game changer” for the entire AEC industry.
• A highly valued, internationally recognized, and well-rounded BIM educational program geared towards the development of truly qualified BIM practitioners now becomes a necessity for the advancement of BIM as a whole in ASEAN, Asia and the rest of the world.
ACKNOWLEDGMENTS

3.1 Supply the Demand for BIM Practitioners

- This paper was created as a foundation for the education model of the Institute of Virtual Design and Construction (IVDC) – a private educational institution registered in Vietnam and Singapore in conjunction with the John von Neumann Institute for Advanced Learning and the Vietnam National University.
- IVDC created specialized programs dedicated to the advanced learning of BIM knowledge for post-graduates, professionals and corporations. The students are carefully selected from their respective architecture, engineering and construction management degree programs. They are thoroughly screened, tested and required to meet specific requirements prior to admission.
THANK YOU!