The Story of BIM Adoption at Penn State

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Associate Professor of Architectural Engineering
Director, Computer Integrated Construction Research Program

Architectural Engineering

- Graduate 100 students each year
- Focus on engineered systems in buildings
- 5 year program, ABET accredited program
- 4 option areas
  - Construction
  - Structural
  - Mechanical
  - Lighting / Electrical
- Upon graduation, most students work for:
  - Engineering consulting firms,
  - Large integrated architectural practices, or
  - Large construction companies
Architecture

• 5 year, National Architectural Accrediting Board (NAAB) accredited program
• Graduate 40 students each year
• Educational priorities:
  • The practice of architecture: drawing, model-making, service learning, and hands-on construction activities with non-traditional means of building delivery (such as design-build and digital fabrication)
  • Visualization & Fabrication: advanced visualization methods, with the study of building delivery and fabrication processes.
  • Sustainability: research agendas in the area of sustainability and "green architecture."
• One semester study abroad in Rome, Italy

In the beginning…

• 2D CAD
• Isolated engineering analysis applications
• Hand takeoffs and CMP schedules
Evolution of BIM Implementation

2004:
- Started a 1 credit BIM Seminar course with Autodesk’s assistance

2005:
- Started integrating Revit Architecture into 2nd year CAD course
- 4D Modeling in undergraduate curriculum
- Students started to use Revit for architecture projects

2006:
- Expanded BIM into earlier courses

2007:
- Workshop addressing Revit, 3DsMax and Integrated Environmental Solutions IES<VE>

Current & Future Courses with BIM in AE

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engr Design</td>
<td>Working Drawings</td>
<td>Architecture Studio</td>
<td>Architecture Studio</td>
<td>Senior Thesis</td>
<td>Structure Modeling</td>
</tr>
<tr>
<td>Architecture Studio</td>
<td>Mechanical Engr for Bldg</td>
<td>Lighting / Elec Engr for Bldg</td>
<td>Structural Engr for Bldg</td>
<td>Energy Modeling</td>
<td>Energy Modeling</td>
</tr>
<tr>
<td>Engineering</td>
<td>Construction</td>
<td>Intro to Construction</td>
<td>Precon Services</td>
<td>Project Controls</td>
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</tr>
</tbody>
</table>

The Pennsylvania State University
Current Status

in Architectural Engineering

- Architectural BIM
  - Starts in 2nd Year for all students (some see Revit in 1st year)
  - Used throughout architectural studio courses (2nd & 4th Yr)
- Engineering Analysis
  - Structural, lighting and mechanical analysis tools used
  - Limited interoperability, but under development
- Construction Analysis
  - Automated takeoffs and 4D CAD taught in 3rd year
  - Advanced 4D CAD and design coordination in 5th year

Courses with BIM in Architecture

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>Arch Studio</td>
<td>Arch Studio</td>
<td>Arch Studio</td>
<td>Arch Studio</td>
</tr>
<tr>
<td>Engineering</td>
<td>Environmental control systems</td>
<td>Tech System Integration</td>
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</table>

The Pennsylvania State University

BIM in Education
Current Status

*in Architecture*

- Architectural BIM
  - Starts in 2nd Year
  - Used in architectural studio courses (2nd to 5th Yr)

- Engineering Analysis
  - Daylighting and energy analysis tools used

- Professional Practice
  - Teaching the advantages of BIM for collaboration and integrated practice

Supporting Resources
Immersive Construction (ICon) Lab
An affordable virtual environment and interactive workspace

Characteristics:
- 3 large backlit screens
- 3D stereoscopic visualization
- Interactive SMARTBoard display
- 20 tablet PCs
- Surround sound
- VNC nodes for each screen

Immersive Environments Lab (IEL)
Digital Fabrication

3-axis CNC Router

Lasercutter

Student Examples
Signature Engineering Building

AE Associates
Group #17
Jim Gawthrop
Sonja Hinish
Charlie Miller
Ralph Kreider

Second Floor Plan

Example Slides from AE 441

Group Members
Jim Gawthrop
Sonja Hinish
Lindsay Lynch
Charlie Miller
Ralph Kreider

Dean's Office
AE Spaces
Library
Example Slides from AE 441

Group Members
Jim Gawthrop
Sonja Hinish
Lindsay Lynch
Charlie Miller
Ralph Kreider

Elevations

East Elevation

South Elevation

Building Sections

North – South Section

East – West Section
Night Exterior Perspectives

View of the North Entrance

Aerial View From Rec Hall

Material and Life Sciences II

Preconstruction Services Proposal

MACH 5

Ralph Kreider, Charles Miller, Maria Piergallini, Carmen Brusco, Michael Webb
**Building Geometry**

- Completed by August of 2010
- 4-story 258,735 ft² research/lab building
- Each floor averages over 60,000 sq. ft.
- Each floor is stacked on top of each other with an offset
- Steel frame cantilever system supporting the open center courtyard

**Cost Saving Proposal**

The move away from the cantilever design to the use of steel columns would significantly lower the cost of the structural system as the steel supports can be greatly downsized.
Who is MACH 5?

Project Background

Estimate Summary

Summary Schedule

Construction Plan

LEED NC Analysis

Safety Plan

Use of BIM

Questions?

Each section is approximately 17,000 ft²

Existing Conditions
Effectiveness of Building Information Modeling in Value Engineering, Sequencing, & Site Logistics

T.C. Williams High School Replacement Project

Kyle Conrad
AE Senior Project — Spring 2007
Construction Management
Building Information Model [ BIM ]

T.C. Williams High School
GTO - Current Constructions

<table>
<thead>
<tr>
<th>Building</th>
<th>SF</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Gymnasium</td>
<td>40,927 sf</td>
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<tr>
<td>10&quot; CMU</td>
<td>12&quot; CMU</td>
<td>14,928 sf</td>
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<tr>
<td>14&quot; CMU</td>
<td>19,448 sf</td>
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<tr>
<td>5' CMU</td>
<td>7,439 sf</td>
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</tr>
<tr>
<td>9' CMU</td>
<td>19,037 sf</td>
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<tr>
<td><strong>Sub-Total</strong></td>
<td><strong>140,571 sf</strong></td>
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<table>
<thead>
<tr>
<th>Auditorium</th>
<th>SF</th>
<th>Notes</th>
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<tbody>
<tr>
<td>10&quot; CMU</td>
<td>19,048 sf</td>
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<tr>
<td>12&quot; CMU</td>
<td>0,321 sf</td>
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<tr>
<td>14&quot; CMU</td>
<td>0,061 sf</td>
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<tr>
<td>9' CMU</td>
<td>10,967 sf</td>
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<tr>
<td><strong>Sub-Total</strong></td>
<td><strong>88,767 sf</strong></td>
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<table>
<thead>
<tr>
<th>Mech/Elec Wedge - Auto Strip</th>
<th>SF</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>10&quot; CMU</td>
<td>16,526 sf</td>
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<tr>
<td>9' CMU</td>
<td>5,217 sf</td>
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<tr>
<td><strong>Sub-Total</strong></td>
<td><strong>21,743 sf</strong></td>
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<table>
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<tr>
<th>Misc.</th>
<th>SF</th>
<th>Notes</th>
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<tbody>
<tr>
<td></td>
<td>45 sf</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>194,371 sf</strong></td>
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Autodesk Revit Structure 4

- Apply Loads per contract drawings
- Basic Wind Speed
  - 90 mph
  - Exposure B
- Importance Factor of 1.15 applied to loading per structural engineer's direction

**Q & A**

Kyle Conrad – Construction Management
Student Examples
5th year Technical Systems Integration

Student Examples
5th year Technical Systems Integration

Student Examples
5th year Technical Systems Integration
Views of the Faculty from 2007 Survey

How important is it for students to use (or learn to use) different analysis applications?

<table>
<thead>
<tr>
<th>Department</th>
<th>Very Important</th>
<th>Important but Not Crucial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architectural Engineering</td>
<td>33.3%</td>
<td>54.5%</td>
</tr>
<tr>
<td>Architecture</td>
<td>66.7%</td>
<td>45.5%</td>
</tr>
</tbody>
</table>
When should students be introduced to BIM?

Department
- Architectural Engineering
- Architecture

AE faculty willing to make adjustments in their courses

AE faculty that would need assistance to implement changes
The Path Forward

Challenges to overcome

- Faculty training
  - One day seminars
  - Teaching assistants with application knowledge
- Student training in applications while achieving educational objectives
  - Application tutorials
  - Autodesk training sessions
  - Lower level course implementation
- Institutional knowledge transfer on interoperability
  - BIMwiki Initiative to capture standard workflows (bim.wikispaces.com)
Lessons Learned

- Acknowledge faculty concerns and address them
- Take every opportunity to inform and train
- Students can effectively push the technology into the classroom if:
  - They are allowed
  - They have access to the software
  - They are aware of the capabilities and benefits
- Knowledge sharing is important, and difficult…
  - We tend to relearn continuously
- A good computing infrastructure and manager is critical

And we are just getting started…
Future tasks that we are pursuing

Integrated design studios with integrated design tools (Spring 09)
- Architecture, Architectural Engineering and Landscape Architecture students working together in groups to design and plan the construction of a project

Senior Project (Thesis) (Fall 09)
- Year long team design project executed on a BIM platform with construction, lighting, mechanical and structural students

Common repository of learning content for self guided learning
- BIMwiki initiative (bim.wikispaces.com)

Integrated course assignments enabled by common models
- An integrated 3rd year course series around a common building project (Mechanical, electrical, lighting, structural, acoustical and construction system design)
Acknowledgements

- Colleagues in Architectural Engineering, Architecture, Landscape Architecture and Information Technology Services
- Raymond A. Bowers Program
- The National Science Foundation
- Computer Integrated Construction Research Program members
- Software vendors
- Supporting industry members

"You never change something by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."

- Buckminster Fuller

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CIC Website: www.engr.psu.edu/ae/cic