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

Current
Future

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

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

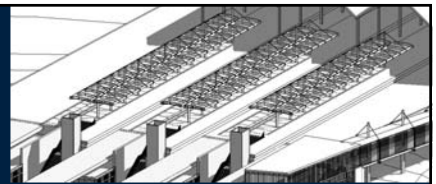
Courses with BIM in Architecture

Current
Future

	Year 1	Year 2	Year 3	Year 4	Year 5
Architecture		Arch Studio	Arch Studio	Arch Studio	Arch Studio Professional Practice
Engineering			Environmental control systems		Tech System Integration

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

BIMStorm LAX in the ICon Lab

ICon Lab Rendering

Virtual Construction Simulator activity in the ICon Lab

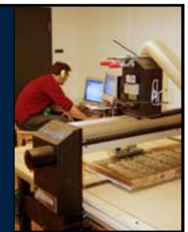
Characteristics:

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

Immersive Environments Lab (IEL)

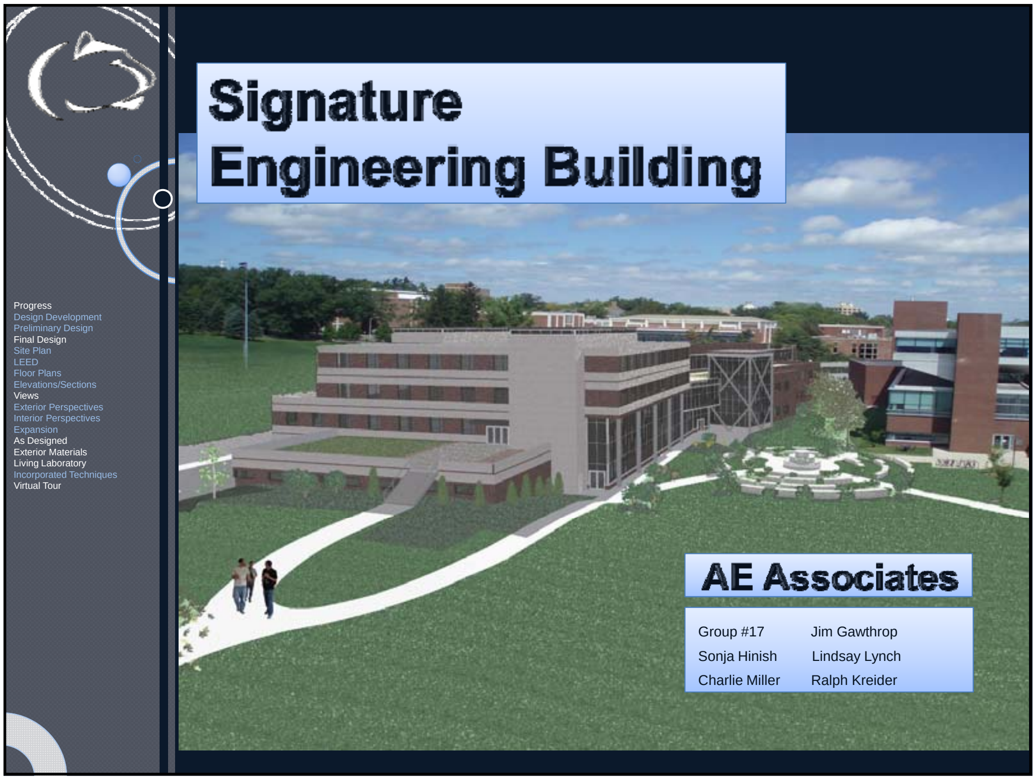
Digital Fabrication

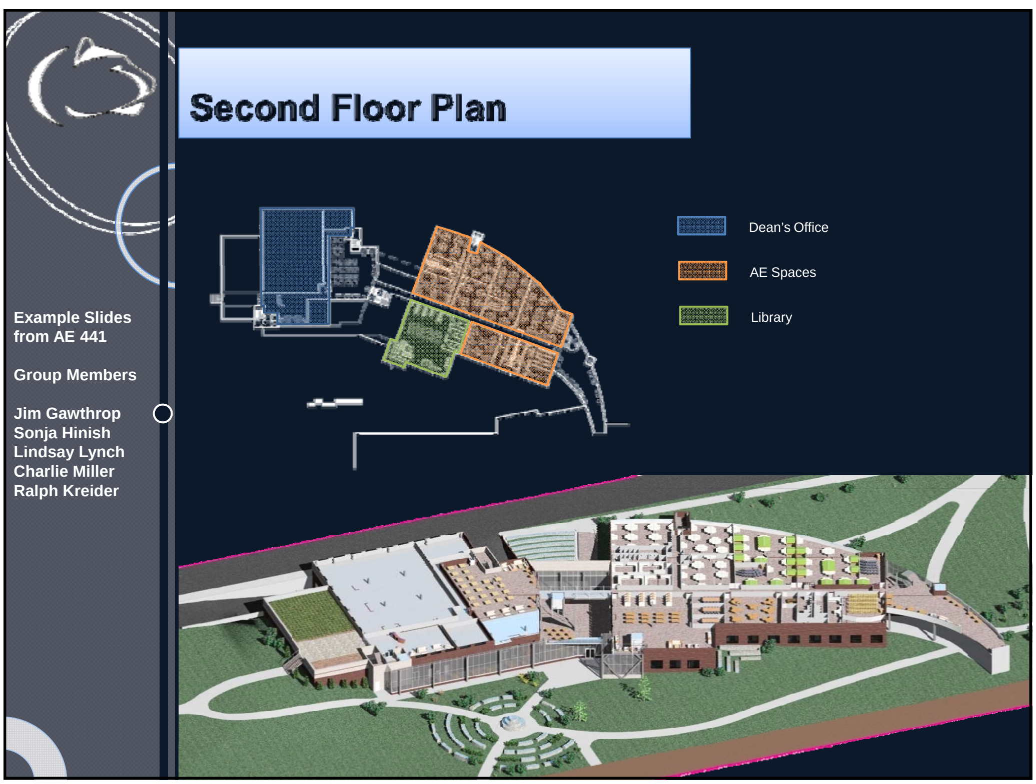
3-axis CNC Router



Lasercutter

Student Examples


Signature
Engineering Building
Progress
Design Development
Preliminary Design
Final Design
Site Plan
LEED
Floor Plans
Elevations/Sections
Views
Exterior Perspectives
Interior Perspectives
Expansion
As Designed
Exterior Materials
Living Laboratory
Incorporated Techniques
Virtual Tour
AE Associates
Group #17
Jim Gawthrop
Sonja Hinish
Lindsay Lynch
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

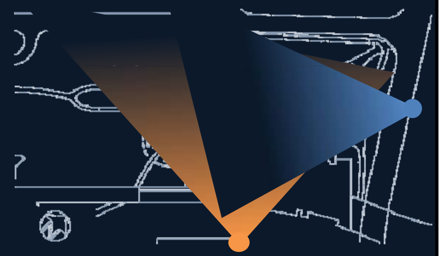
Example Slides from AE 441

Group Members

Jim Gawthrop
Sonja Hinish
Lindsay Lynch
Charlie Miller
Ralph Kreider

Elevations

East Elevation



South Elevation

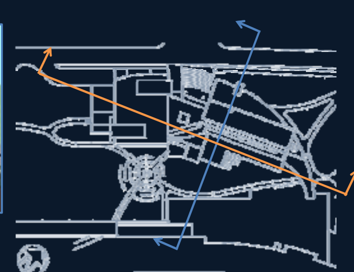
Example Slides from AE 441

Group Members

Jim Gawthrop
Sonja Hinish
Lindsay Lynch
Charlie Miller
Ralph Kreider

Building Sections

North – South Section



East – West Section

Night Exterior Perspectives

Example Slides from AE 441

Group Members

Jim Gawthrop
Sonja Hinish
Lindsay Lynch
Charlie Miller
Ralph Kreider

View of the North Entrance

Aerial View From Rec Hall

Material and Life Sciences II

Example Slides from AE 441

Group Members

Jim Gawthrop
Sonja Hinish
Lindsay Lynch
Charlie Miller
Ralph Kreider

Preconstruction Services Proposal

MACH 5

Ralph Kreider Charles Miller
Maria Piergallini Carmen Brutico
Michael Webb

MACH 5

Building Geometry

- Completed by August of 2010
- 4-story 258,735 ft^2 research/ lab bldg
- 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

View through corner.

View of green roofs form parking deck.

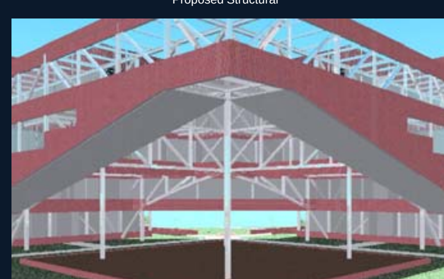
View of green roofs from Thomas.

MACH 5

Cost Saving Proposal

Current Structural

Proposed Structural



Who is MACH 5?
Project Background
Estimate Summary
Summary Schedule
Construction Plan
LEED NC Analysis
Safety Plan
Use of BIM
Questions?

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.

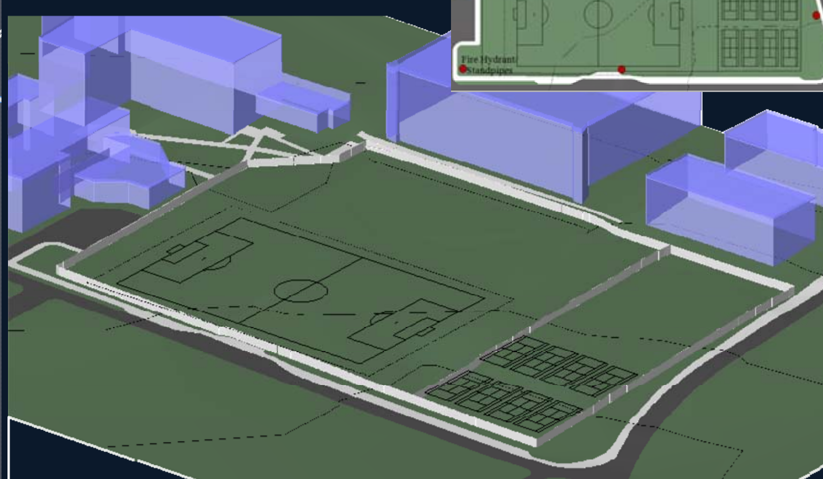
MACH 5

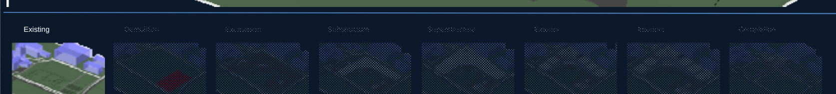
Construction Phasing

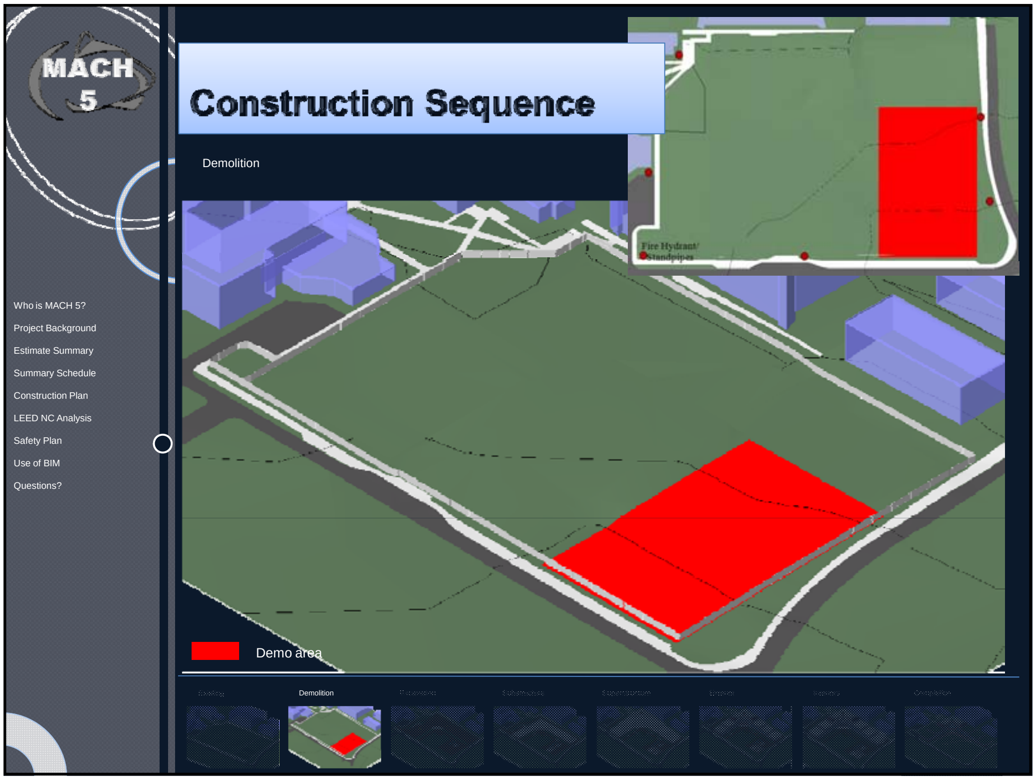
Each section is approximately 17,000 ft^2

MACH 5

Existing Conditions






MACH 5
Construction Sequence
Demolition
Who is MACH 5?
Project Background
Estimate Summary
Summary Schedule
Construction Plan
LEED NC Analysis
Safety Plan
Use of BIM
Questions?
Fire Hydrant/ Standpipes
Demo area
Demolition


MACH 5
Construction Sequence
Excavation
Who is MACH 5?
Project Background
Estimate Summary
Summary Schedule
Construction Plan
LEED NC Analysis
Safety Plan
Use of BIM
Questions?
Excavator Flow
Excavator Flow
Site offices and parking
Fire Hydrant/ Standpipes
Soil Retention
Excavation

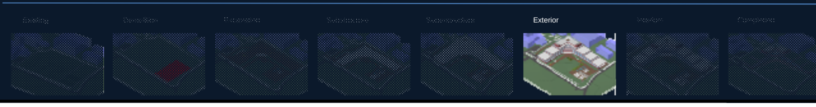

MACH 5
Construction Sequence
Substructure
Who is MACH 5?
Project Background
Estimate Summary
Summary Schedule
Construction Plan
LEED NC Analysis
Safety Plan
Use of BIM
Questions?
Building Footprint
Traffic Flow
Traffic Flow
Soil Retention
Substructure


MACH 5
Construction Sequence
Superstructure
Who is MACH 5?
Project Background
Estimate Summary
Summary Schedule
Construction Plan
LEED NC Analysis
Safety Plan
Use of BIM
Questions?
Utilities
Traffic Flow
Superstructure

MACH 5

Construction Sequence

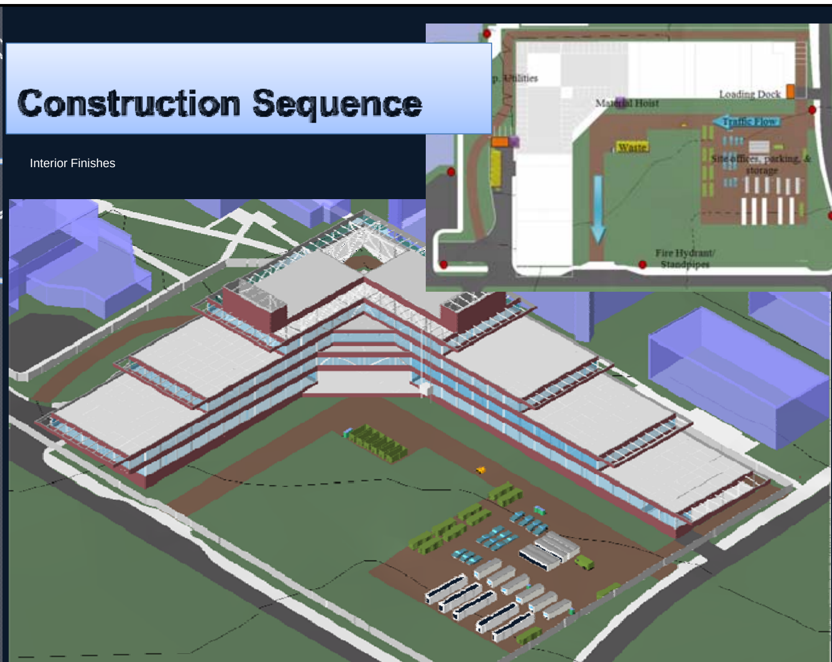
Exterior Enclosure

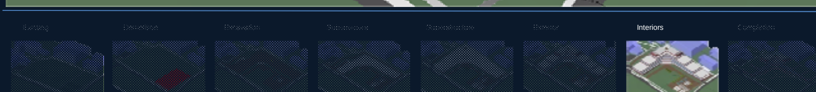


MACH 5

Construction Sequence

Interior Finishes





Who is MACH 5?
Project Background
Estimate Summary
Summary Schedule
Construction Plan
LEED NC Analysis
Safety Plan
Use of BIM
Questions?

MACH 5

Construction Sequence

Completion

- Who is MACH 5?
- Project Background
- Estimate Summary
- Summary Schedule
- Construction Plan
- LEED NC Analysis
- Safety Plan
- Use of BIM
- Questions?

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

PENNSTATE

Building Information Model [BIM]

- Project Background
- BIM
- Alternative Building Materials
  - Gymnasium
    - Acoustics
  - Heat Transfer
  - Structural
    - Frame
- Work Sequencing
- Site Logistics
- Conclusions / Recommendations
- Q & A

T.C. Williams High School QTO - Current Construction		
Gymnasium		
	10" CMU	49,827 sf
	12" CMU	14,828 sf
	14" CMU	19,440 sf
	6" CMU	7,469 sf
	8" CMU	19,007 sf
	Sub-Total:	**110,571 sf**
Auditorium		
	10" CMU	19,046 sf
	12" CMU	8,281 sf
	14" CMU	13,981 sf
	6" CMU	8,661 sf
	8" CMU	10,857 sf
	Sub-Total:	**60,826 sf**
Mech/Elec Wedge - Auto Strip		
	10" CMU	16,587 sf
	6" CMU	1,625 sf
	8" CMU	5,217 sf
	Sub-Total:	**23,429 sf**
Misc.		**45 sf**
	Total:	**194,871 sf**

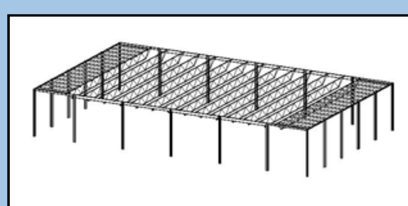
T.C. Williams High School QTO - Solarcrete System			
Gymnasium			
	12" Panel	66,167 sf	2,595 lf
	Sub-Total:	**66,167 sf**	**2,595 lf**
Auditorium			
	12" Panel	42,367 sf	1,900 lf
	Sub-Total:	**42,367 sf**	**1,900 lf**
Mech/Elec Wedge - Auto Strip			
	12" Panel	21,383 sf	1,220 lf
	Sub-Total:	**21,383**	**1,220 lf**
	Total:	**129,917 sf**	**5,715 lf**

Kyle Conrad – Construction Management

Structural Moment Frame

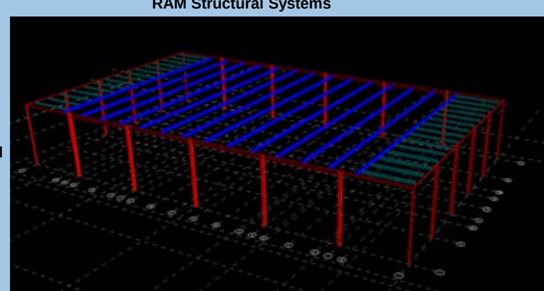
- Project Background
- BIM
- Alternative Building Materials
  - Gymnasium
    - Acoustics
  - Heat Transfer
  - Structural
    - Frame
- Work Sequencing
- Site Logistics
- Conclusions / Recommendations
- Q & A

Autodesk Revit Structure 4



- **Register with RAM International to obtain link for exporting Revit Structure 4 files to RAM**
- **Install Link**
- **Reopen Revit Structure 4 to export model to RAM**

RAM Structural Systems

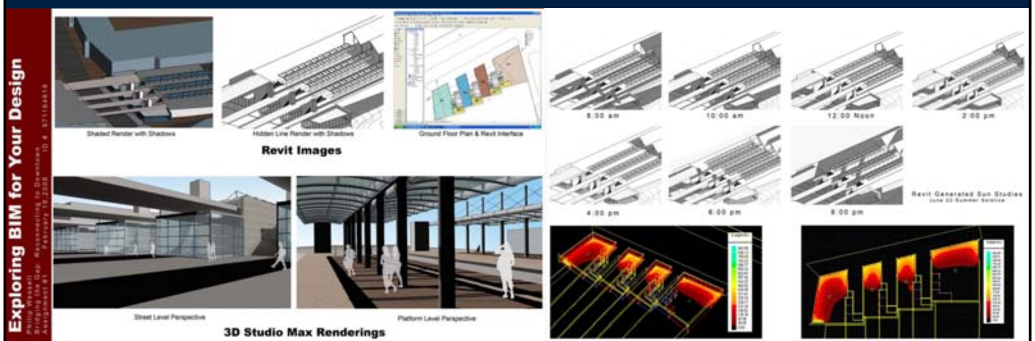


- **Apply Loads per contract drawings**
- **Basic Wind Speed**
  - **90 mph**
  - **Exposure B**
- **Importance Factor of 1.15 applied to loading per structural engineer's direction**

Kyle Conrad – Construction Management

Student Examples

5th year Technical Systems Integration



student Philip Wessell, using Revit, 3dsMax and IES<VE>

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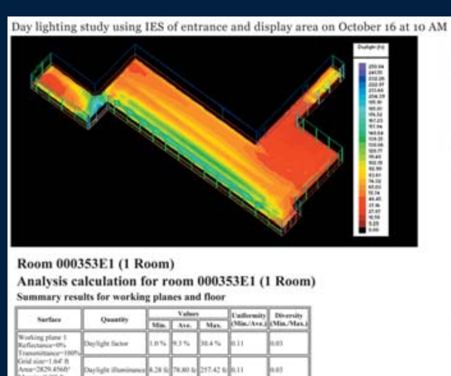
Student Examples

5th year Technical Systems Integration



student Nathan Derr, using Revit, 3dsMax and IES<VE>

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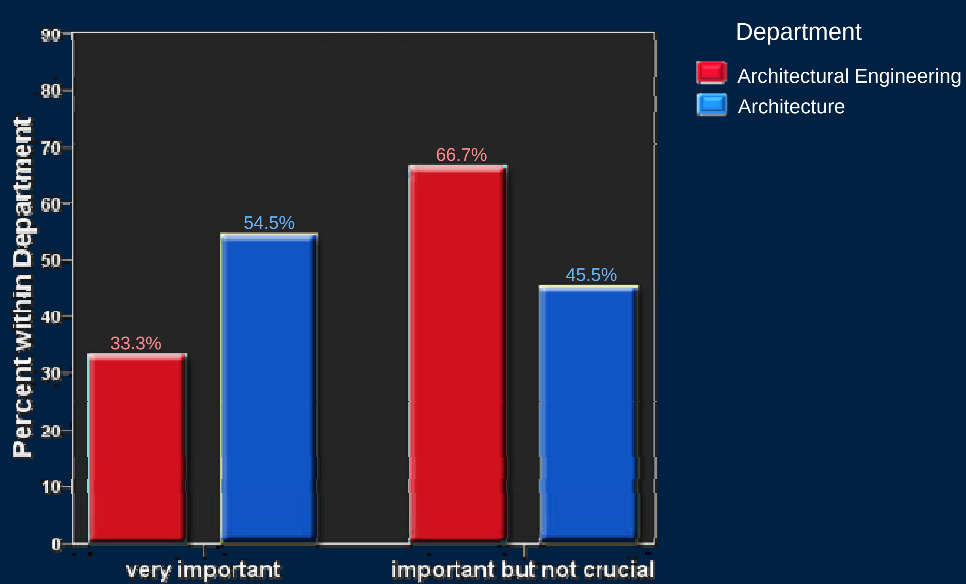
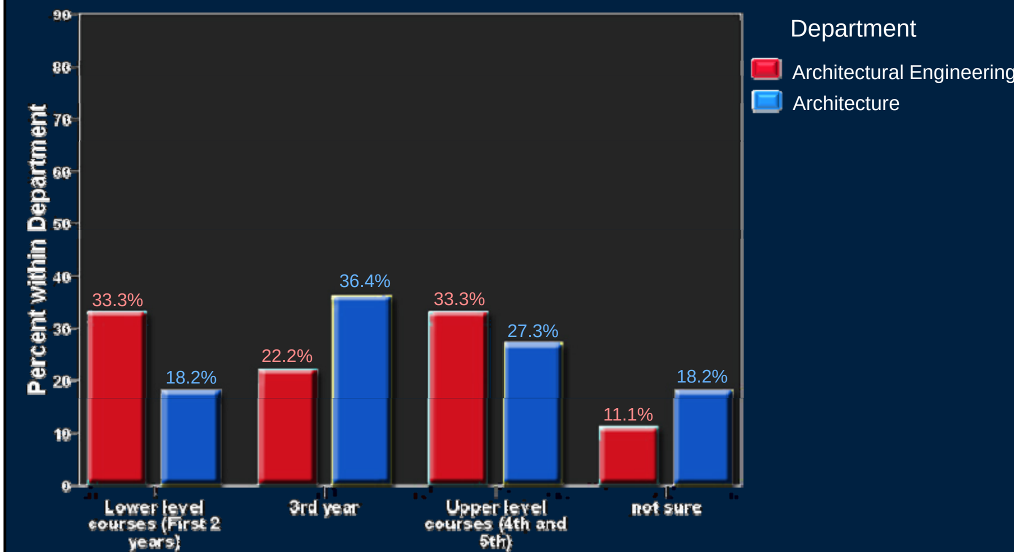
Views of the Faculty from 2007 Survey

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

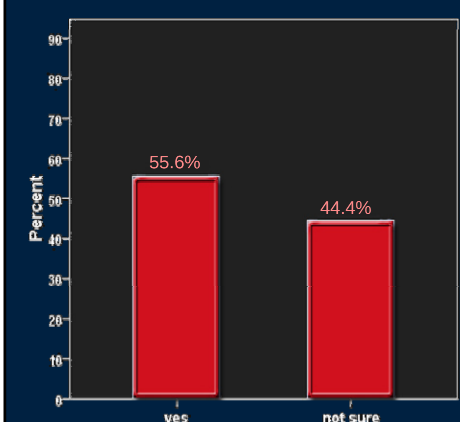


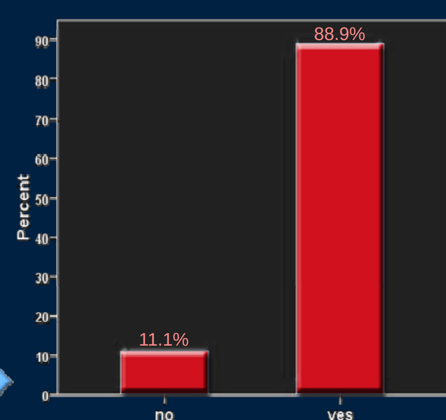
When should students be introduced to BIM?



AE faculty willing to make adjustments in their courses

AE faculty that would need assistance to implement changes





The Path Forward

BIM in Education *The Pennsylvania State University*

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)

BIM in Education *The Pennsylvania State University*

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.wikispace.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