Steidle Building Renewal Project

Rendering provided by Mascaro Construction Company

Technical Report III

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Construction Option

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Executive Summary

For this report, construction management practices, both those utilized on the Steidle Building project and those being developed throughout the industry, were studied and analyzed. It is important to look at the ways construction are being delivered, especially those that are either very recent or just being developed.

The first section of this report analyzes the industry practices that are being used on this project. Specifically, the implementation of BIM and the pursuit of LEED certification will be evaluated. Often decisions that are made that pertain to BIM or LEED that often sacrifice sensible solutions in favor of trying to be extra innovative or green. The purpose of this section will be to evaluate how BIM and LEED were integrated into the project and to determine which decisions were well thought out and those that could have been improved upon.

The second section of this report summarizes four seminars at the 24th Annual PACE Roundtable. It is important to learn about new technologies and methods that are being developed within the industry as one of them could provide a solution to a problem on one's own project or workspace. The topics covered within this report are what developments are following after BIM's revolution, the challenges and opportunities presented to people as they begin to implement BIM within their own projects, why it is important to focus on hiring and developing young people and new hires that are entering the construction industry, and how construction companies are changing and developing around new technologies in the industry.

The third section highlights an interview focusing on the management and value engineering services Mascaro provided to the project was also conducted as part of this report. The interview took place on November 4th at the Mascaro Construction site trailer. It was held with the Project Manager, who is the highest-ranking person at the site who is there full time. Subjects addressed during the interview were general details about their provided services, how those services integrated into the project's approach, and the role of Value Engineering on the project. Their input was taken into consideration when performing the industry practice evaluation. Further details may be found in the summary transcript, located in the appendices.

Leading Industry Practice Evaluation

Building Information Modeling (BIM) Use Evaluation

For this project, the focus of BIM should be on maintaining the flow of construction, starting from planning and continuing through operation. Given how the construction manager was brought in for preconstruction services, it was prudent to include them as part of the full process. However, given the smaller nature of the project, it would be unreasonable to ask the project team to implement a large amount of Uses when most of them wouldn't add much value to the project. So the question becomes, "Which BIM Uses add the most value to this particular project?"

To begin with, when planning out the building, it is important for the owner to define their needs and wants and to create a design requirements program for the architects and engineers to refer to when designing the new building. Included with this design program are the existing conditions, which would be useful when modeling the renovated space. A full site analysis would be unnecessary as the site has been predetermined and there is little the project team can do to influence it.

Once initial planning is complete, the design phase may commence. The architects and engineers, it is assumed, will author the design using a 3D modeling software program. They will work with jointly the construction managers to run 3D coordination, clash detection and design model reviews. These will be done, at a minimum, at the schematic design and development design stages, before the 100% Construction Documents are created. Additionally, the engineers will be required to verify that the existing conditions model is properly integrated with the design model, while the construction manager will create an initial 4D model to assist with coordination and reviews. After all of this is complete, the Construction Documents including the various models will be generated and distributed to the construction team. The various engineering analyses were omitted from this process as it is assumed that the responsible engineers will perform their own analyses using their software or method of choice, independent of the BIM process. The same applies to Cost Estimation as the construction manager will have their own, independent method for estimating the costs and tracking them throughout the project.

Once construction is underway, the construction manager will be responsible for continuing to perform 3D coordination and updating the 4D model as unforeseen conditions occur. This will be done with the assistance of the architect and owner. Meanwhile, the subcontractors will be responsible for running 3D Control and Planning for their respective trades. Many trades are already using digital software integrated with a 3D BIM model to layout their work, so including it made sense. Site Utilization Planning was not selected as enough detail would be conveyed in the 4D model that it would become redundant. As the project nears completion, the construction manager will be responsible for creating and verifying a record model that shall be handed over to the owner for the purpose of facility management.

Once the owner receives the record model, they will be responsible for managing it. This includes running asset management, integrating maintenance scheduling software with the model, and continuing to update the record model as changes and updates are made to the building. Given the owner's current ability to digitally manage their facilities, these uses were included. Meanwhile, the others were omitted since the owner does not currently have the capabilities to properly implement them. All of the selected BIM Uses may be found below in Table 1, while the Level 1 BIM Process Map may be found in Appendix A.

Table 1: BIM Uses Selection over the Four Project Life-Cycle Stages, Theoretical

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
X	PROGRAMMING	X	DESIGN AUTHORING		SITE UTILIZATION PLANNING	X	BUILDING MAINTENANCE SCHEDULING
	SITE ANALYSIS	X	DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
		X	3D COORDINATION	X	3D COORDINATION	X	ASSET MANAGEMENT
			STRUCTURAL ANALYSIS		DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
			LIGHTING ANALYSIS	X	3D CONTROL AND PLANNING		DISASTER PLANNING
			ENERGY ANALYSIS	X	RECORD MODELING	X	RECORD MODELING
			MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
			SUSTAINABLITY (LEED) EVALUATION				
			CODE VALIDATION				
	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION		COST ESTIMATION		COST ESTIMATION		COST ESTIMATION
X	EXISTING CONDITIONS MODELING	X	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

Compared to the BIM plan put together by the project team, the BIM plan developed for this report is similarly structured. BIM is brought in for early planning processes and is built upon throughout the project, with the final record model being turned over to Penn State. However, there are also key differences between the two use selection plans. Penn State includes many more BIM Uses on the Steidle Building project that are either mandatory or should have significant effort put in, some of which are specific to Penn State. While this is certainly ambitious, it could put undue strain on the parties involved, resulting in some uses being neglected or dismissed. The plan developed for this report takes that into account, instead focusing in on allocating BIM Uses based on what each party should be capable of doing. All of Penn State's selected BIM Uses may be found below in Table 2.

Table 2: BIM Uses Selection over the Four Project Life-Cycle Stages, Actual

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
	PROGRAMMING	X	DESIGN AUTHORING	X	SITE UTILIZATION PLANNING		BUILDING MAINTENANCE SCHEDULING
X	SITE ANALYSIS	X	DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN	X	BUILDING SYSTEM ANALYSIS
X	ENERGY ANALYSIS	X	3D COORDINATION	X	3D COORDINATION	X	ASSET MANAGEMENT
		X	STRUCTURAL ANALYSIS		DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
		X	LIGHTING ANALYSIS		3D CONTROL AND PLANNING		DISASTER PLANNING
		X	ENERGY ANALYSIS		RECORD MODELING	X	RECORD MODELING
		X	MECHANICAL ANALYSIS	X	ASSET MANAGEMENT	X	CONTINUOUS COMMISSIONING
			OTHER ENG. ANALYSIS	X	CONSTRUCTABILITY REVIEWS		
			SUSTAINABLITY (LEED) EVALUATION	X	MEANS & METHODS MODEL DEVELOPMENT		
			CODE VALIDATION				
		X	PRECON COORDINATION				
		X	ASSET MANAGEMENT				
	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION		COST ESTIMATION		COST ESTIMATION		COST ESTIMATION
X	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

Furthermore, the BIM Process Map developed by the project team, found in Figure 1 on the next page, does not accurately reflect all the BIM Uses that had been planned for the project. Instead, it focuses on the progression of ownership of the BIM model and how the different parties are to interact on the project. The theoretical BIM Process Map developed for this report represents all of the planned BIM Uses as well as the information exchanges that occur throughout the process, but it does not convey how each party is to work together. Depending on the needs of the project team, either report or a combination of the two would be the best choice

Overall, when compared to this report's plan, Penn State's BIM plan is more ambitious but not necessarily as detailed. This could either allow for more creativity within the project team or it could be more prone to being ignored as the members of the project team make minor changes but retain their more traditional work ethic. Oversight of the BIM process by Penn State would be required in order to make sure that they get the result they desire.

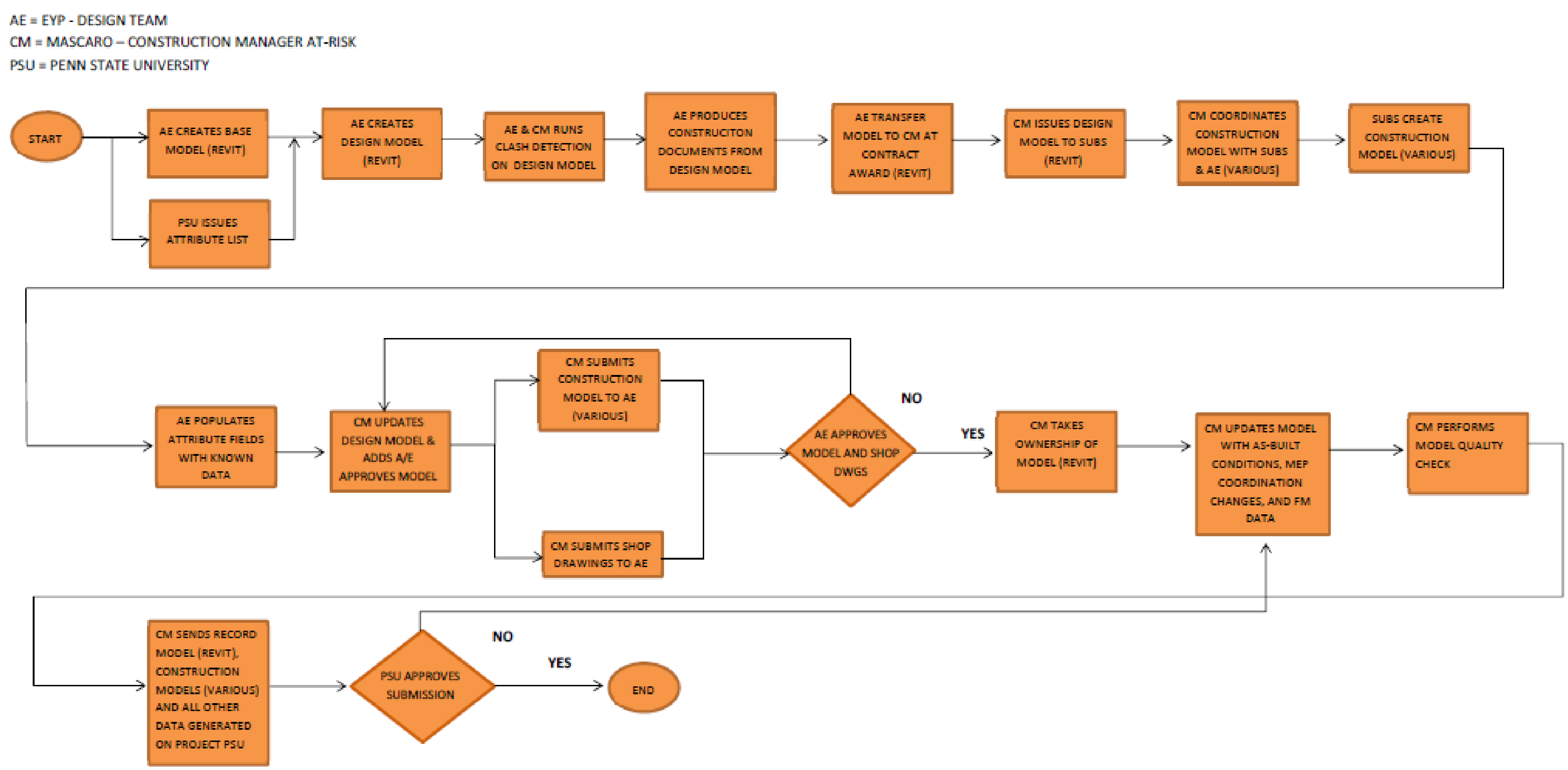


Figure 1: Original BIM Execution Process Diagram developed by the Steidle Building project team. Courtesy of Mascaro Construction Company

Sustainability Implementation

One of the goals of the Steidle Building Renewal Project is to create a sustainable structure with a certification level of LEED Silver or higher based on the LEED 2009 for New Construction and Major Renovation rating system. It aims to achieve that level through a diversified approach across all aspects of sustainable development: sustainable sites, water efficiency, energy & atmosphere, materials and resources, indoor environmental quality, and innovation in design. The full LEED Points system scorecard for the project may be found in Appendix B.

However, sometimes smart design is sacrificed in favor of trying to earn one or two more LEED points. Other times, the goals of the project align themselves very well with earning LEED points if the team is willing to go the extra mile. So what elements of this project lend themselves very well towards LEED, what elements weren't as conducive and thus were eliminated, and what elements may not have been as wise to include or exclude?

For example, it was originally intended that the restrooms on the first floor were going to be smaller in order to accommodate showers as part of the Alternative Transportation – Bicycle Storage and Changing Rooms Credit. However, during the design process the showers were removed and the restrooms were expanded. The project team realized that people would be able to use the showers at nearby facilities, which would also count towards the credit. This decision was very wise on the part of the project team. It prevented space from being unnecessarily sacrificed to fulfill a LEED credit that would have been fulfilled anyways.

At the opposite end of the spectrum is the design of the HVAC systems in the offices of the existing building. The way they are currently designed, a fan coil unit provides conditioned air to the space. The return air grilles, instead of going back through a return line, lead back to the fan coil unit in tandem with a small make-up air duct coming from the penthouse AHU (Refer to Figure 2). This was done in order to provide energy savings and help to earn the Optimize Energy Performance credit. However, while this will help to improve the building's energy performance, the air quality will suffer as stale air, that possibly will begin to smell poorly and become stuffy, continues to be recycled in the space. This could become a huge issue to the building occupants, who have to work in these spaces during the semester. If additional measures were added to improve the quality of the recycled air, or a return air system was implemented, then this issue wouldn't be a problem.

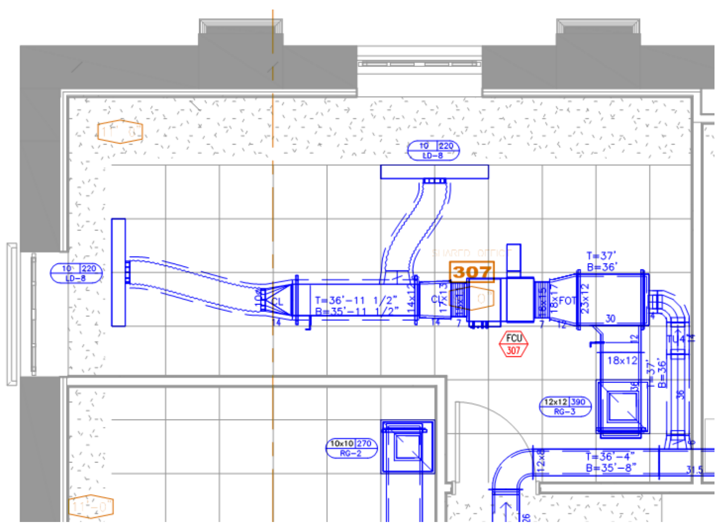


Figure 2: Air Conditioning system for a typical office space in the existing building. Image courtesy of Mascaro Construction Company.

Finally, there is one potential area that may be a missed opportunity for this project. Currently, this building is not going after any points for On-Site Renewable Energy, which could net the project as much as an additional seven points. There are many ways the renewable energy credit could be met, such as installing solar panels or solar water heaters on the roof above the penthouse. Now, it is very likely that since this building is being serviced by Penn State's steam plant, that including these kinds of devices would not have been financially viable. They also would have a potential impact of the penthouse roof structure, adding to the costs. However, if Penn State values the idea of going green and is willing to spend a little extra money on a system like this, then the opportunity is there to experiment with potentially many different kinds of renewable energy sources. This experimentation would provide valuable information that would help influence future decisions regarding renewable energy, not just from a cost perspective but also from a materials and energy research perspective. Given how much Penn State focuses on research, then this opportunity could have been very beneficial to Penn State in areas other than finances.

Critical Industry Issues – PACE Roundtable Session Summaries

Life After the BIM Revolution

BIM is one of the most widely recognized emergent processes for designing and planning in the construction industry. However, there are still many aspects of BIM that need further development. This keynote speech looks at the current state of BIM, the ways it needs to be developed in the future, and the current trends in the industry – specifically from the perspective of the computer science industry – that could lead to these necessary developments.

Currently, BIM has numerous capabilities that can add significant value to a building project. There are over 4,500 software tools for architects, engineers, construction managers, and facility managers. It has tons of uses, including 3D coordination, 4D modeling and 5D modeling, and more are being developed. Many agencies support the use of BIM, including several governments that mandate the use of BIM on their projects.

So with BIM having been heavily developed so far, what is there left to do? To start, there are still a few elements that need to be defined as part of the model. Model views need to be defined since none of the project team members need to see all of the elements, just those that they need to perform their duties. The representation of model details need to be defined for each of the project stages instead of just for the end product. Second, software engineers need to properly develop new BIM products and tools. Innovation can still occur, but developers have to be aware of what the industry requires and implement those needs in their products. Third, the levels of integration and interoperability need to be refined. Again, this goes back to the idea that no one on the projects needs all of the information contained in the BIM model. The levels need to distinguish what each party will receive in terms of information exchanges. Fourth, product manufacturers and suppliers need to be brought on board in order to properly model said products. It is beneficial for the industry if there are libraries contain both general and manufacturer-specific products that can be readily modeled for a project as they would contain the required level of detail and information. In order for these libraries to exist, the manufacturers and suppliers need to be part of the process for creating the libraries. This would ensure that the most accurate models and product data are present and readily available. Lastly, BIM education needs to be coordinated at both the national and international level. Aspects of BIM like product identification or role responsibility vary from region to region and country to country, so educating professions on those variations would help companies take on BIM projects that may be different than what the companies are accustomed to.

Many of these challenges are currently being addressed, especially within the computer science industry. The first such method to address these challenges is through the use of video game engines and environments. These are being used to improve the visualization of the project and providing more realistic renderings. In fact, this is being taken further with the advent of virtual reality technology (VR). Through the use of VR, an immersive or non-immersive building environment can be created to provide real-time rendering and navigation throughout the building model. These tools are able to assist in designing and reviewing the model, and support is being generated to eventually allow the VR model to be published to the construction managers and contractors for on-site coordination and verification. The second method is augmented reality (AR), which is similar to VR but doesn't create an entire virtual environment. Instead, an AR device allows users to overlay digital information onto real world objects. This could be used to support architectural engineering tasks in the building environment. However, it would require additional sensors on the project site in order to link the as-built simulations to the building data. The third method is the development of Human-Computer Interaction (HCI). This allows a user to manipulate a virtual object through a movement modeling device (e.g., Microsoft's Kinect). However, work is still being done to further model the abilities of human interaction to allow for smoother manipulation, so this technology may still be a few years off. The final method is through the creation of a Built – Environment Information Fabric (BEIF). A BEIF is a large scale data source of construction information. Currently, infrastructure projects and building complexes are looking at utilizing BEIF's, but industry developers are trying to create a BEIF for general use on construction projects. These methods, along with numerous others, look to vastly improve the design and construction process while promoting communication and collaboration.

Post BIM – Challenges and Opportunities

As BIM continues to develop, many limitations arise as it is implemented on construction projects. The first is owner's expectations. Often owners don't define what they want from BIM, rather they state their end goals and leave the rest up to the discretion of the design team. Owners need to be educated on BIM's capabilities if they want BIM to be properly implemented on their project. Building off of this, the second limitation is that BIM is not singularly defined. This hinders the proficiency of industry professionals in understanding BIM. The third limitation is that subcontractors often lag behind in the industry. Sometimes, this is due to the fact that they see BIM as unnecessary to the project, but other times they are resistant to changing how they work. The fourth limitation is that after the model has been turned over to the owner for facility management, the maintenance departments don't update the model when building changes are made (i.e. new equipment). This is problematic when the building has to undergo another major project and the project doesn't have accurate information to work off of. The final limitation is determining the scale at which BIM should be used on a project. When defining the Level of Detail for the model or models, some details are not needed for the larger or less complex models or projects. It is also worth noting that the project team needs to be aware of regional requirements concerning BIM.

To mitigate these limitations, there are many changes that are being implemented in the industry. The first of these changes is getting the subcontractors in early for the design process. This helps to promote communication early on and to review designs from a constructability standpoint. The second change is to focus on fixing the model early on instead of solving problems during installation. This reduces the number of RFI's and Change Orders on a project, saving money, time and headaches in the long run. The last change is to use a preconstruction team on an IPD project. This means that not only the architect and engineers are involved with preconstruction activities, but so are the construction managers and the general contractors. In fact, IPD isn't necessarily needed for this kind of collaborative environment; rather, focusing on early involvement and fostering a cohesive team will achieve collaborative success.

Enabling the Workforce: Hiring, Developing and Retaining Young Leaders

The construction industry has experienced consistent growth over the past several years and seems to be continuing to grow. This has led to a shift in focus from winning jobs and trying to get work to finding the necessary workforce to complete the increased construction demand. This includes hiring, and by extension retaining, recent college graduates to become the next generation of project managers and construction leaders.

However, before the industry starts looking at these young leaders, the requirements for defining leadership must be outlined. The primary areas that employers look to is social influence and emotional intelligence. It is important for new hires to be strong in these areas and looking to develop them further. They also need to evaluate leadership based on how well the new hires' personality aligns with the values and culture of the company workspace. In addition to leadership within the company, employers also want leadership in the community. Many of the new hires have held leadership positions while in college, so the employers want to see that transition from college life to the company workspace.

In addition to defining leadership requirements, the expectations for new hires need to be outlined. Often new hires will have tested out companies via internships in order to find "the right fit" for them. These internships don't necessarily gauge the level of education of the intern, but if whether or not the potential new hire shares the values of the company. It is expected that the intern will choose a company that best aligns their values. The other big area of expectation is finding out how willing these people are to undergo uncomfortable situations. These situations help to develop social and leadership skills, as well as provide valuable learning experiences.

One of the concerns pertaining to construction is how women find their way in the workforce. Stereotypes have persisted in this industry, but thankfully they are being broken down as more women enter the industry. Again, it's more so about the culture of the company that you want to grow in – if the company still has sexist tendencies, then that company will find it very hard to hire recent female graduates and will miss out on their valuable input.

Another concern for construction companies is appealing to young people and new hires. Their culture needs to promote a balance between giving these new hires responsibility and helping them to gain the necessary skills. Companies need to recognize the skill levels of their new hires and assign responsibilities accordingly. That said, it is also prudent for new hires to not make an early decision. They should be willing to see all they can see, take every opportunity that comes their way, and travel everywhere.

The final concern is when new hires have a supervisor that doesn't support their development, in terms of leadership, skill, or otherwise. The best way to fix this is to talk to people about what they want. Again, it's all about finding what the right fit is and gaining the different kinds of experiences they want to have. It is also important for new hires to "brand" themselves – basically establishing who they are as they network with others, both inside and outside of the company. The other way to avoid having an unsupportive environment is to have multiple advisors and supervisors. It is never a good idea for new hires to place themselves under one single person, as it not only increases the risk of working in an unsupportive environment but also limits the potential opportunities and experiences that could come their way.

Technology in Construction: The New "Norm" of Construction Competencies

As technology continues to progress and develop, it is important to understand what's out there now and what trends are being observed. Currently, there is a shift away from developing tools to assist in the design or construction process to tools that support collaboration between the designers and constructors. Engineering and virtual design and construction (VDC) skill sets are slowly converging as this push towards collaborative environments continues. It is becoming more and more apparent that the construction industry needs people with the drive to broaden their skill sets to reflect this shift. Still, there is a split with students today who see VDC and BIM as a separate "specialty" instead of recognizing how they are quickly becoming the industry norm. They need to understand the deeper meanings behind the technology, not just how to use it, if construction innovation is to continue. It's not just limited to students either; traditionally, there has been the school of thought that the consumers of new technology and the creators of it are separate entities. However, intermediary roles are quickly developing, roles that need to understand both sides while looking for new technological applications. The people in these roles need to not just know the software, but also have experience in the field and knowledge of the design requirements. Most importantly though, they need to know how to build and how to work with people. Construction cannot be thought of as a purely technological industry.

So with these trends and developments going on now, what can be expected of construction technology in the future? Well, the industry will start looking to more well-rounded people, with familiarity across various tools. That means the construction industry needs geeks. That's right, geeks are a necessity to the construction industry as companies need to use their specialist skills and interests to continue to improve construction processes. Companies also need to foster a culture of innovation, providing leadership support while keeping the doors open to fresh ideas. These expectations, while achievable, need buy-in from across the board. This can be difficult as much of the industry is resistant to change. However, this psychological resistance can be overcome if the technology's value can be shown and proven to the more hesitant industry members. Those experienced with the technology need to be brought on board to ease the transition. Playing off of the idea of competitive drive can also work, but one would need to be sensitive to how the technology is introduced. Above, the technology needs to actually solve real problems in the industry, not try to fix something that most people don't consider broken.

With this introduction to new competencies, should companies go to students who may have been exposed to the new technology early on, or should companies go to specialists in other fields who may be able to offer new perspectives? Truth be told, innovation and ideas do not necessarily come from people required to innovate within R&D departments. Often these ideas come from unexpected places. The only real requirement for innovators is that they have to know building design and construction. It is often a good idea that these innovators come from teams with complementary skills. Students do have the required core competencies and skills and should be provided opportunities to innovate, but getting work done for a project or a company should not be sacrificed. Frankly, though, given that software and technology is almost always changing, everyone could be considered a student. There is always a need to teach and learn about new technologies, which in turn can be used to teach core competencies.

As college students leave school and enter the workforce, there are several questions for them to consider when analyzing the use of technology on a project:

- Is there value in parametric approaches (e.g. Grasshopper, Dynamo) in construction?
- What problems are models being built to solve? Are they focused on specific problems?
- How do we assess the "right size" for technological approaches on a project?
- How do we stimulate a culture of innovation?
- How do we motivate older personnel to buy into these technological developments?
- How can project recording be automated (e.g. using drones to take progress photos)?
    - To what point is it useful?
- How can we move away from documentation standards based on paper drawings to virtual models?
    - What are the uses, needs and constraints to doing so?

Feedback from the PACE Roundtable may be found in Appendix C

<u>Project Manager Interview Summary</u>

This section summarizes an interview with the Project Manager, Matt Morris, for the Steidle Building Renewal Project. The two major areas of discussion were Mascaro's project management services and the use of Value Engineering on the project. Both areas presented unique problems to Mascaro and the project team, but these issues were overcome. This summary incorporates the interview along with the background context of the project.

Project Management

In the beginning phases of the project, Mascaro was brought on to provide pre-construction services to Penn State and EYP Architects and Engineers in 2013. Their responsibilities included budgeting, constructability reviews and initial scheduling of the project's milestones. They also directly collaborated with Penn State and EYP on the implementation of BIM.

This was the first time that Mascaro, as well as EYP, worked with Penn State. At first, communication was difficult between the parties as they tried to navigate the hierarchy of Penn State's Office of Physical Plant (OPP). Eventually, though, the people involved managed to establish the proper lines of contact to form a cohesive project team. Other communication-based problems that Mascaro encountered during pre-construction were that OPP didn't conduct their own design review until after the construction documents were 100% completed and that the BIM model was not fully coordinated by the time the project went out to bid. These issues and other smaller ones did cost a lot of money to fix, but the experience has benefitted the project team by showing problems that can be anticipated and avoided in the future by implementing less expensive changes.

Once pre-construction was completed, the project went out to bid in January 2014. However, Penn State decided to bring on Mascaro as the construction managers for the project based on their performance during pre-construction. Their duties then shifted to include maintaining the budget and schedule, coordinating the on-site trades, handling the RFI's and submittals, and directing the implementation of BIM on the project. The increase in responsibility means that the number of issues that Mascaro has to deal with has increased. This includes not just the issues carrying over from the BIM model in pre-construction, but also problems from dealing with differing site conditions to resolving disputes involving different trades to managing the changes made by EYP and Penn State. Yet, all of these problems have been dealt with by maintaining composure and communicating with the necessary people to resolve the conflicts. As the project has progressed, the process for resolving conflicts has gotten better and better due to the improving integration of the project team.

Value Engineering

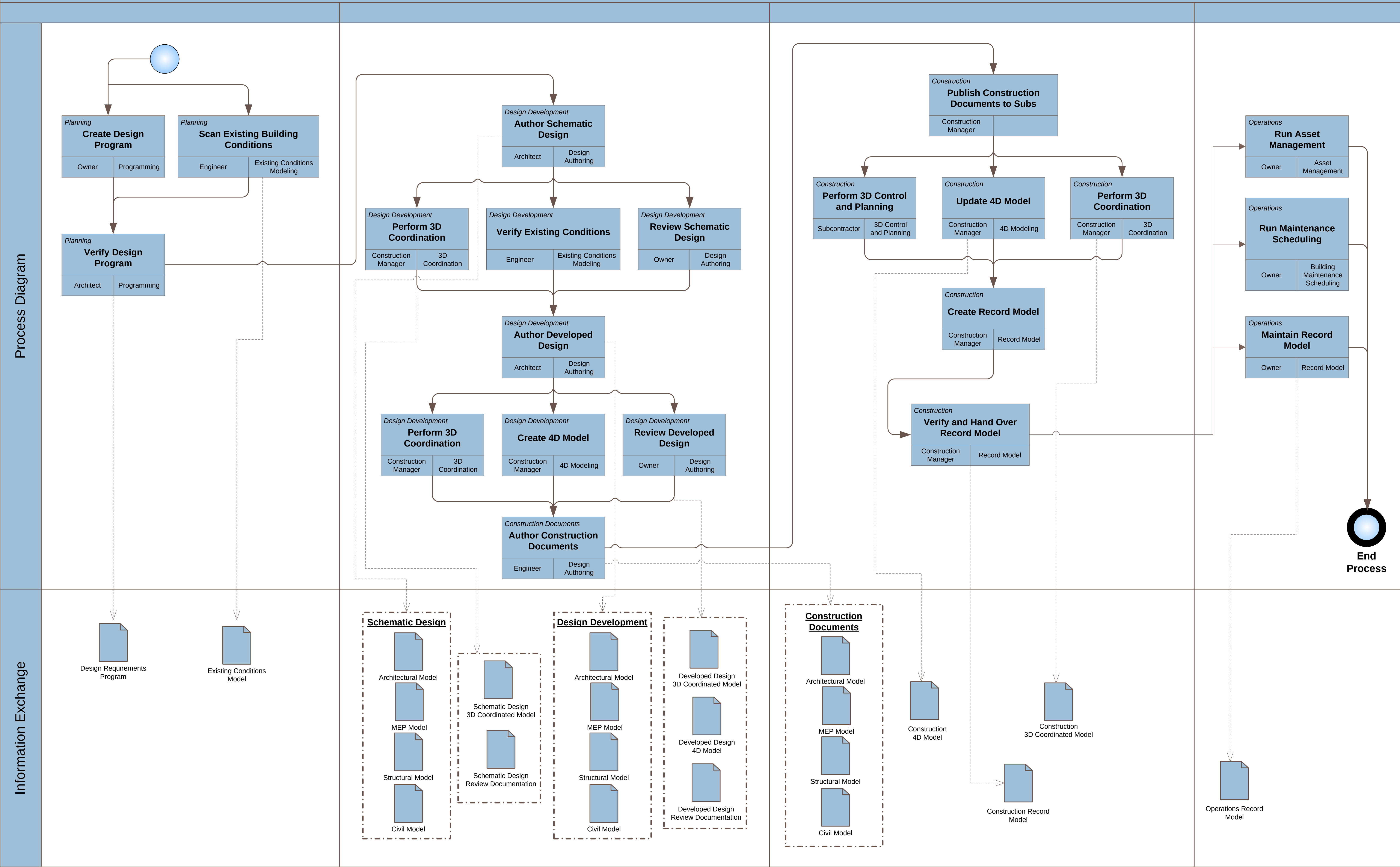
Value Engineering is a key aspect to almost every construction project as all construction management firms and project owners want to have the project completed for as little cost to them as possible. If an alternative product or method can be utilized on a project that saves time and money, then it ought to be implemented.

On this project, many different areas were considered for value engineering analysis. This included the MEPF systems, changes to the Lab spaces, revisions to the atrium space, and determining different kinds of details and finishes for the building. In a few cases, the changes do not save time or money for the project, but add value by further aligning the design with the goals of Penn State. Furthermore, the scope of the changes range from something as small as reducing the amount of new HVAC equipment installed to something as large as revising the design of the atrium to include a fire-rated window wall that would eliminate the need for the smoke exhaust system above it which is very expensive.

For the most part, the vast majority of the changes were accepted. The largest source of savings in the accepted changes dealt with keeping some aspect of the existing building as opposed to replacing it with something new. Even though these changes resulted in large savings, the bulk of the changes revolved around reducing or eliminating various elements within the building. The only area where value engineering suggestions were largely denied stemmed from changes to the HVAC system. Overall, value engineering saved the project team over $2.5 million by the time the project went out to bid. Additional savings have been realized during the course of construction but as of yet have not been tabulated.

Appendix A: Level 1 BIM Process Map

Steidle Building Renewal Project – Level 1 BIM Process Map



Appendix B: Steidle Building LEED Points Scorecard

LEED 2009 for New Construction and Major Renovation
Project Scorecard

Project Name: Steidle Building Renewal, PSU Project # 00-01306.00
Project Address:

Yes	?	No			
19	4	2	**SUSTAINABLE SITES**		**26 Points**
Y			Prereq 1	**Construction Activity Pollution Prevention**	**Required**
1			Credit 1	**Site Selection**	**1**
5			Credit 2	**Development Density and Community Connectivity**	**5**
		1	Credit 3	**Brownfield Redevelopment**	**1**
6			Credit 4.1	**Alternative Transportation -** Public Transportation Access	**6**
1			Credit 4.2	**Alternative Transportation -** Bicycle Storage and Changing Rooms	**1**
	3		Credit 4.3	**Alternative Transportation -** Low-Emitting and Fuel-Efficient Vehicles	**3**
2			Credit 4.4	**Alternative Transportation -** Parking Capacity	**2**
1			Credit 5.1	**Site Development -** Protect or Restore Habitat	**1**
	1		Credit 5.2	**Site Development -** Maximize Open Space	**1**
1			Credit 6.1	**Stormwater Design -** Quantity Control	**1**
		1	Credit 6.2	**Stormwater Design -** Quality Control	**1**
1			Credit 7.1	**Heat Island Effect -** Nonroof	**1**
1			Credit 7.2	**Heat Island Effect -** Roof	**1**
			Credit 8	**Light Pollution Reduction**	**1**

Yes	?	No			
6			**WATER EFFICIENCY**		**10 Points**
					4
Y			Prereq 1	**Water Use Reduction**	**Required**
2			Credit 1	**Water Efficient Landscaping**	**2 to 4**
				[2] Reduce by 50%	2
				[ ] No Potable Water Use or Irrigation	4
2			Credit 2	**Innovative Wastewater Technologies**	2
2			Credit 3	**Water Use Reduction**	**2 to 4**
				[2] Reduce by 30%	2
				[ ] Reduce by 35%	3
				[ ] Reduce by 40%	4

Yes	?	No			
19		1	**ENERGY & ATMOSPHERE**		**35 Points**
Y			Prereq 1	**Fundamental Commissioning of Building Energy Systems**	**Required**
Y			Prereq 2	**Minimum Energy Performance**	**Required**
Y			Prereq 3	**Fundamental Refrigerant Management**	**Required**
10			Credit 1	**Optimize Energy Performance**	**1 to 19**
				[ ] Improve by 12% for New Buildings or 8% for Existing Building Renovations	1
				[ ] Improve by 14% for New Buildings or 10% for Existing Building Renovations	2
				[ ] Improve by 16% for New Buildings or 12% for Existing Building Renovations	3
				[ ] Improve by 18% for New Buildings or 14% for Existing Building Renovations	4
				[ ] Improve by 20% for New Buildings or 16% for Existing Building Renovations	5
				[ ] Improve by 22% for New Buildings or 18% for Existing Building Renovations	6
				[ ] Improve by 24% for New Buildings or 20% for Existing Building Renovations	7
				[ ] Improve by 26% for New Buildings or 22% for Existing Building Renovations	8
				[ ] Improve by 28% for New Buildings or 24% for Existing Building Renovations	9
				[10] Improve by 30% for New Buildings or 26% for Existing Building Renovations	10
				[ ] Improve by 32% for New Buildings or 28% for Existing Building Renovations	11
				[ ] Improve by 34% for New Buildings or 30% for Existing Building Renovations	12
				[ ] Improve by 36% for New Buildings or 32% for Existing Building Renovations	13
				[ ] Improve by 38% for New Buildings or 34% for Existing Building Renovations	14
				[ ] Improve by 40% for New Buildings or 36% for Existing Building Renovations	15
				[ ] Improve by 42% for New Buildings or 38% for Existing Building Renovations	16
				[ ] Improve by 44% for New Buildings or 40% for Existing Building Renovations	17
				[ ] Improve by 46% for New Buildings or 42% for Existing Building Renovations	18
				[ ] Improve by 48%+ for New Buildings or 44%+ for Existing Building Renovations	19
		1	Credit 2	**On-Site Renewable Energy**	**1 to 7**
				[ ] 1% Renewable Energy	1
				[ ] 3% Renewable Energy	2
				[ ] 5% Renewable Energy	3
				[ ] 7% Renewable Energy	4
				[ ] 9% Renewable Energy	5
				[ ] 11% Renewable Energy	6
				[ ] 13% Renewable Energy	7
2			Credit 3	**Enhanced Commissioning**	**2**
2			Credit 4	**Enhanced Refrigerant Management**	**2**
3			Credit 5	**Measurement and Verification**	**3**
2			Credit 6	**Green Power**	**2**

LEED 2009 for New Construction and Major Renovation
Project Scorecard

Project Name: Steidle Building Renewal, PSU Project # 00-01306.00
Project Address:

Yes	?	No			
5		1	**MATERIALS & RESOURCES**		**14 Points**
Y			Prereq 1	**Storage and Collection of Recyclables**	**Required**
1			Credit 1.1	**Building Reuse** - Maintain Existing Walls, Floors and Roof	**1 to 3**
				1 Reuse 55%	1
				Reuse 75%	2
				Reuse 95%	3
			Credit 1.2	**Building Reuse -** Maintain Interior Nonstructural Elements	**1**
1			Credit 2	**Construction Waste Management**	**1 to 2**
				1 50% Recycled or Salvaged	1
				75% Recycled or Salvaged	2
		1	Credit 3	**Materials Reuse**	**1 to 2**
				Reuse 5%	1
				Reuse 10%	2
1			Credit 4	**Recycled Content**	**1 to 2**
				1 10% of Content	1
				20% of Content	2
1			Credit 5	**Regional Materials**	**1 to 2**
				1 10% of Materials	1
				20% of Materials	2
			Credit 6	**Rapidly Renewable Materials**	**1**
1			Credit 7	**Certified Wood**	**1**

Yes	?	No			
15			**INDOOR ENVIRONMENTAL QUALITY**		**15 Points**
Y			Prereq 1	**Minimum Indoor Air Quality Performance**	**Required**
Y			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	**Required**
1			Credit 1	**Outdoor Air Delivery Monitoring**	**1**
1			Credit 2	**Increased Ventilation**	**1**
1			Credit 3.1	**Construction Indoor Air Quality Management Plan -** During Construction	**1**
1			Credit 3.2	**Construction Indoor Air Quality Management Plan -** Before Occupancy	**1**
1			Credit 4.1	**Low-Emitting Materials -** Adhesives and Sealants	**1**
1			Credit 4.2	**Low-Emitting Materials -** Paints and Coatings	**1**
1			Credit 4.3	**Low-Emitting Materials -** Flooring Systems	**1**
1			Credit 4.4	**Low-Emitting Materials -** Composite Wood and Agrifiber Products	**1**
1			Credit 5	**Indoor Chemical and Pollutant Source Control**	**1**
1			Credit 6.1	**Controllability of Systems -** Lighting	**1**
1			Credit 6.2	**Controllability of Systems -** Thermal Comfort	**1**
1			Credit 7.1	**Thermal Comfort -** Design	**1**
1			Credit 7.2	**Thermal Comfort -** Verification	**1**
1			Credit 8.1	**Daylight and Views -** Daylight	**1**
1			Credit 8.2	**Daylight and Views -** Views	**1**

Yes	?	No			
2			**INNOVATION IN DESIGN**		**6 Points**
1			Credit 1	**Innovation in Design**	**1 to 5**
				Innovation or Exemplary Performance	1
				Innovation or Exemplary Performance	1
				Innovation or Exemplary Performance	1
				1 Innovation	1
				Innovation	1
1			Credit 2	**LEED® Accredited Professional**	**1**

Yes	?	No			
1			**REGIONAL PRIORITY**		**4 Points**
1			Credit 1	**Regional Priority**	**1 to 4**
				1 Regionally Defined Credit Achieved	1
				Regionally Defined Credit Achieved	1
				Regionally Defined Credit Achieved	1
				Regionally Defined Credit Achieved	1

Yes	?	No		
67	4	4	**PROJECT TOTALS (Certification Estimates)**	**110 Points**

Certified: 40-49 points Silver: 50-59 points Gold: 60-79 points Platinum: 80+ points

Appendix C: Feedback from PACE Industry Roundtable

STUDENT FORM

Student Name Jeffrey Duclos

Session 1: Topic: Post-BIM - Challenges & Opportunities

Research Ideas:

1) Incorporating the trades during BIM coordination meetings (not just weekly work planning)

2) Educating Owners on BIM implementation to promote integration in projects

Session 2: Topic: Enabling the Workforce (Panel)

Research Ideas:

1) Aligning expectations with a company's culture & values

2) Teaching social skills for everyday use

Session 3: Topic: Technology in Construction

Research Ideas:

1) Documentation Standards - Moving from Paper to Models

2) Assessing the proper amount of technological applications on a project.

STUDENT FORM

Industry Member: Abby Kreider - Project Engineer, Barton Malow

Key Feedback:

Which research topic is most relevant to industry? What is the scope of the topic?

Technology in Construction

Documentation Standards - Looking at how to implement documentation within model data & attributes instead of "digital paper"

Post-BIM

Analyzing the contractual structure to see how BIM was impacted (positively and/or negatively)

Suggested Resources:

What industry contacts are needed? Is the information available?

1-2: Bringing in OPP contacts, AE educators, & end users

2-1: Meeting executive board members

1-1: Discuss with the foremen about the value of coordinating work in the BIM model