Stanton Elementary School, *Washington, D.C.*

Technical Assignment 3:
Exploring Project Challenges and Opportunities

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Executive Summary

The project management services section summarizes an interview that was conducted with the Tompkins Builders' project manager to discover project challenges, methods of resolution for these challenges, and methods of value engineering on this project. It appears that the majority of the Stanton Elementary School issues occur due to the very stringent project schedule. Issues with project financing also make it difficult for Tompkins Builders to effectively plan in the long run because there is always an uncertainty with regard to whether or not the owner will be able to fund the project.

In an effort to learn more about construction issues, documentation of a variety of PACE Roundtable discussions occurred in an effort to assess how these particular issues relate to the Stanton Elementary School project. Analysis of safety concerns and collaborative approaches were performed. Safety is an improving issue in the construction industry, but measures can certainly be taken to improve safety on a construction site. In general, a site environment must be really dedicated to safety in order for workers to take it seriously. This can occur through education of safe practices and persistence in enforcing a safe work environment. Another issue that was discussed was driving collaboration from the office to the field. The general agreement with regard to this topic was that it is the responsibility of the construction manager to promote an environment that is collaborative on a project. Collaborative construction seemed especially relevant to the Stanton Elementary School project due to the manner in which BIM is used on the project and how BIM implementation can be improved.

The PACE roundtable also provided an opportunity to discuss potential ideas for further analysis and improvement on the Stanton Elementary School Project. Ideas ranged from adjusting project phasing to building stronger foundations to allow for later additions to the building. Additionally, generating a cost analysis comparing the current building renovation and addition to the costs of building a completely new school were also discussed.

The Stanton Elementary school uses BIM strategies to help gain an understanding of system coordination and methods of project planning. However, without a concrete BIM execution plan, this project can see improvement with regard to its use of virtual construction. Alternate BIM plans are proposed showing how four-dimensional modeling and site utilization can be products of BIM that help with project planning.

Lastly, sustainable solutions by the Stanton Elementary School are discussed by comparing its LEED plans with the Penn State LEED approach. The plans turn out to be very similar, most likely due to the fact that Penn State is an owner of very many buildings that are similar to the Stanton Elementary School in regard to function. The elementary school project effectively executes its LEED Plan. However, keeping the issues of project financing in mind, the project team could consider sacrificing a few LEED credits if this sacrifice could result in lowering project costs.

Project Management Services

Tompkins Builders acted as the general contractor and began to take part in project planning during the design phase. The project manager indicated that the Tompkins construction team entered the project with about 60% of the design completed. Tompkins Builders was responsible for performing pricing estimates that translated into the estimate for the GMP agreement under which the contract operates. At the onset of the project, there was concern that the entire building would not be able to be built based on project financing. The particular area of the building that was under question was the prekindergarten wing. Tompkins was responsible for performing a cost analysis that would indicate whether or not the project could go on as originally planned.

Project Challenges

The project team saw a great amount of challenges throughout phase one of the project and is currently experiencing similar challenges during the construction of phase two. A lot of these issues are due to the stringent project timeline provided by the owner (DGS). Phase one of this project, the interior demolition and renovation of the existing building, was given a project timeline of 56 days. This is an extremely difficult schedule to meet for a $16 million project. Meeting the project schedule was definitely the most difficult obstacle for the construction team to overcome during phase one of the project. Tompkins was pushed to develop creative solutions to meet this timeline. Construction occurred seven days out of the week with the majority of the days consisting of both day shifts and night shifts. The schedule was not even disrupted for the Fourth of July holiday. The project was able to commence on time, however, issues with obtaining permits and procuring subcontractors provided Tompkins Builders less time to plan the project while in its preliminary stages. Other issues such as foundation issues, foundation subcontractor issues, poor weather, and late delivery of glazing posed even more threats to producing an on-time schedule. The Tompkins team needed to remain poised to complete the project on-time, not only to meet the needs of the owner, but to uphold the agreement that was outlined in the project contract. For each day that the completed project would be late, DGS would retract 10% of the contractor's fee from Tompkins Builders.

Tompkins' project manager indicated that another challenge during construction was maintaining a quality project while still meeting the project schedule. Tompkins was adamant about not deviating from the construction drawings and specifications when addressing quality assurance. The project was delivered as the owner had intended for it to be, and no measures were taken to sacrifice quality as an approach to maintain the project schedule. Another issue that arose was project financing. Tompkins looked for creative solutions to help the owner find a way to get the most out of the building for which the owner was paying without having to sacrifice major aspects of the project, such as the prekindergarten wing as previously mentioned.

Looking back on the work that has been performed to this point in construction, there are certainly some aspects of the project that could have been improved to better fit the client's needs. Tompkins would have liked to have seen more meetings between the architect and the end user (Stanton Elementary School faculty). One example of how this stalled the project would be in reference to the carpet design issue. The elementary school carpet design was intended to feature large diamonds throughout the hallways. This has a significant meaning to the students, for this design was used to organize students and help manage how they travel through the hallways during a typical school day. The architect modified the carpet design to exclude the diamonds, and the incorrect carpet was delivered to the site. Because of this discrepancy, the carpet installation was delayed. This may seem like a small issue, but in a project with an already tight schedule, having a much smoother installation of the carpet throughout the school could have benefited the project manager as they tried to meet the needs of the schedule. In addition, the project contract required that CBE (Certified Business Enterprise) subcontractors were used for this project. This limited the amount of subcontractors that could be chosen to perform work on the project. More efficient contractors could have been available to bid for this project, but never received the opportunity to bid because the project limited eligible subcontractors to those within the Washington D.C district.

Additional potential project issues or concerns could have developed during the demolition phase of construction. There is always a possibility of unforeseen conditions arising during demolition. Fortunately during phase one of the project, there were very few unforeseen conditions, and demolition went very smoothly. Demolition in phase two went fairly smoothly as well, however there was an issue with the steam tunnels near existing building columns. Removing and replacing of concrete needed to be performed to address this issue. Tompkins' project manager indicated that no methods of preplanning or surveying could have substantially helped with eliminating this issue during demolition. It would not have been cost effective to run testing for unforeseen conditions that may have been problematic during demolition.

Value Engineering

Because the Stanton Elementary School project experienced so much trouble with project financing, the project team considered a variety of options to cut down on project costs. The owner's representative, who was well aware of the financing difficulties, was very compliant with Tompkins when they recognized an opportunity to cut down on project costs and schedule. Many of these opportunities focused on replacing design elements that were purely aesthetic with design approaches that were more sensible in relation to cost. A few examples of value engineering by reducing costs by replacing aesthetic elements with more practical methods of design are listed below:

- In phase two of the project, the sunscreens to be installed over the windows were bulky, difficult to install, and expensive. The project team decided to remove the sunscreens from the project completely and instead install glazing with a higher R-value which would limit the amount of natural light that enters through windows.
- Again in phase two of the project, interior columns were designed to have aluminum covers. This was a purely aesthetic feature of design, and after agreement from the owner's representative, Tompkins eliminated this aspect of design from the project, and as a result, lowered project costs and reduced the project schedule.
- The original project plans called for glass handrails throughout the building. While this was an interesting design element, the glass handrails were a purely aesthetic feature. This move was made to reduce costs and accelerate the project schedule.
- A major element of value engineering occurred with the re-evaluation of the stairwell wall design. The building stairwells extend from the basement to the third floor. All

stairwells are encased by concrete masonry unit walls. The original building design called for these walls to be finished with high-impact gypsum walls. After further analysis of this design, Tompkins felt the need to eliminate the high-impact gypsum overlay. The stairwell walls ended up consisting of painted concrete masonry walls only. This change eliminated the need for the cost of the gypsum material, the cost and time of installing scaffolding in the stairwells to perform construction of the gypsum walls, and the time necessary to install the gypsum walls. Issues with safety were eliminated as well when the scaffolding for this construction task was no longer needed after erasing the gypsum installation from the schedule.

- From phase one to phase two, Tompkins Builders saw an opportunity to eliminate costs on air handling units. Switching brands of air handling units during phase two allowed for cost savings without sacrificing quality on the project.

Typically the owner's representative was on board with the project adjustments that Tompkins wished to pursue, for these changes were usually cost and schedule oriented. In some cases, the owner's representative still wanted to push through with original design intentions. In these cases, Tompkins would comply with the owner's wishes. Some value engineering methods which never came to fruition include eliminating the prekindergarten wing from the scope of the project, and not including furnishing of the project. These ideas are too detrimental to the overall success of the project, and never gained serious consideration. One idea that has gained serious consideration is eliminating the playground construction from the project's scope of work. This idea is currently being exercised, as the need for a new playground is minimal compared to the need to meet a budget with the allotted project financing.

Critical Industry Issues – PACE

The breakout sessions offered at the PACE roundtable included *Innovations in Safety* and *Driving Collaboration into the Field*. The safety discussion focused not only on how safety has improved in recent years, but also on how safety can continue to improve in years to come. The discussion focused on collaboration focused majorly on bridging the gap between communication in the office and in the field.

Innovations in Safety

In general, it appears that there is a lack of understanding in the construction industry in regard to safety awareness levels of the project team. Some workers may be very aware of what is safe and what is not, however others may be completely oblivious. One individual at the PACE discussion indicated that all workers need to become more educated about safety on the job site. However, this was debunked when other observations were made indicating that it is not uncommon for an individual to be OSHA safety certified and still disregard safe construction practices. This problem is clearly an issue of personal choices and personal care of safety. Many at the PACE discussion agreed that care for safety stems from the owner's care for a safe project. The general agreement from the discussion was that owners value safe job site. However, it is difficult to really say if this is actually true. The owner has the responsibility to be consistent with safety on a project. When inconsistencies occur, this is where the real issues arise within a safety environment.

The key issue with safety is generating an environment that truly cares about being a part of a safe project. As previously indicated, care for safety begins with the owner, then trickles its way down to the general contractor, and then to the trades. In an instance where one individual is abiding by safety and he or she views another individual exhibit complete disregard for safety, demotivation for attention to safety regulations can begin to occur. A jobsite environment needs to be developed that encourages all individuals to take part in safe construction methods. The decision for a safe work environment really begins at the time of the subcontractor's bid. The general contractor or construction manager needs to identify whether or not they would prefer to bring in a subcontractor who cares about safety, or if they would prefer to procure a subcontractor who had the lowest bid and only cares about performing the work for which they bid. Procuring subcontractors that see the value in collaboration can lead to a better feeling of teamwork and sense of worth on the project, allowing for an easier path to executing safe construction practices. Everyone on the project needs to care about safety in order for safety to really prevail.

A main concern with safety on a project is how important safety becomes when compared to the project schedule. It is much more likely that safe construction practices will be dismissed when a construction team is behind on the schedule. In general, many industry members realized that completing a project on time or ahead of schedule is often the main project objective and is often rewarded. Safety is often considered to be an afterthought. If safety was incentivized as much as other aspects of a project, some believe that this could help increase the safety on a project, even in situations where safe construction practices may limit productivity. Companies must be careful when incentivizing the schedule so that safety is not overlooked.

Another issue with safety has arrived with the recent implementation of new technologies, such as cell phones and tablets, into the field of construction. This advancement in construction was a hot topic throughout the course of the PACE Roundtable, especially during safety discussions. During the safety discussions, some individuals were in favor of reducing or restricting the use of technology on a job site, indicating that some workers are far too focused on their technology (iPhones, iPads, laptops, or other portable devices). As a result, workers become less aware of their surroundings and the many potential hazards on the construction site. This lack of awareness can result in a higher probability of accidents and injuries on a site.

One individual became very heated when the idea of taking away technology had been proposed. This industry member indicated that technology can help provide a much better understanding of the project and allows for faster communication and a quicker project. As a result potential safety hazards could be reduced. This individual also provided examples of other types of technology that have become a normal part of construction such as the remote controlled vibratory trench roller. He explained that the trench roller eliminates the need for a trench box as a safety measure and allows for quicker compaction within a trench. In the end, the conversation steered more towards welcoming technology to the construction site, but having an awareness of the hazards that technology can bring to a site. These hazards can be limited by educating workers of the dangers that being immersed in technology can bring. If the use of technology is limited to particular areas, workers can experience the benefits of technology in a much safer manner.

Regardless of how technology has affected safe construction practices, many industry members believe that construction safety has come a long way in recent years. With that being said, there are still areas that could see improvement across the field of construction with regard to safety. Some ideas that were discussed for future consideration include:

- Keeping the jobsite cleaner. Whether this is the general contractor’s responsibility or if OSHA regulations are placed, keeping the jobsite cleaner will reduce many hazards on a construction site.
- Holding safety meetings weekly. Keeping a project team engaged in the project and aware of potential hazards and safety issues on a regular basis could create a much more safety-oriented work environment.
- Stretch and flex sessions. This is something that is newer to the industry but has certainly proven to produce great results so far in limiting injuries on the site.
- Situational safety training. One company intends to use situational training to test employees’ safety awareness by identifying hazards in a simulated 3D environment. Exploring how new technologies can help improve the safety training process is a unique advancement in safety that can help understand and eliminate safety concerns on a jobsite before they even become a legitimate threat to workers.
- Reducing the use of phones and other technology on site to restricted, safety approved locations on a site can help cut down on the dangers of technology in the field.
- Continuing to use prefabricated systems as much as possible. This is a safer method of construction in a much more controlled environment.

- Identify which contractors practice safe construction methods and which do not. This process would identify each contractor with a safety score that is known by the public. This score can be used in consideration for selecting contractors for a project. The goal would be to encourage contractors to work more safely so that they could procure more work. This is a more radical approach, but could be successful in eliminating unsafe work practices if it were to come to fruition at some point in the future.

The above ideas could all be used as part of a project safety plan for the Stanton Elementary School. A potential area of research could include how seriously safety is taken on the Stanton Elementary School project site. Implementing a safety plan with some of the ideas provided above could potential create a safer project. Current information regarding current safety requirements on the site and injury/accident reports would need to be obtained to perform this type of analysis. This information could also be used to develop a cost analysis regarding how safety issues could have affected the project costs.

Driving Collaboration into the Field

The PACE Roundtable discussion focused on *Driving Collaboration into the Field* seemed to have two major themes: collaboration and communication between team members in the field and in the office, and the implementation of technology and how it can engage collaboration. Construction professionals in attendance for the discussion quickly pointed out a variety of approaches that their firms use to engage in collaboration between project members:

- Organizing pull planning meetings
- Utilizing colocation as a method to bring the trades and the project team together on a jobsite to create a more team-oriented atmosphere
- Orchestrating weekly subcontractor meetings to ensure project quality in conjunction with the project being delivered on time
- Organizing safety walks to ensure safety measures developed by the project team are recognized in the field by all construction team members
- Performing “daily huddle-ups” to keep workers updated on the project

These methods of collaboration help keep everyone on the project, whether in the field or in the office, informed of the latest information with regard to project goals and expectations.

The above methods provide a good start in regard to educating workers and keeping a project team up to date with the latest project information. However, more measures can be taken to ensure that collaboration is at a maximum. A project team must understand that each member of that team is held accountable to be collaborative in order to maintain a collaborative environment between the office and the field. From the very beginning of the project, it is essential to understand the wants and needs of the owner and architect. To account for these wants and needs, collaboration needs to occur at the very beginning of a project. It is very difficult to try to develop a fully collaborative project without beginning the project with this mentality. The way in which a project team attacks collaboration must be consistent throughout the lifespan of the project. This will allow for members to get on board with taking part in collaborative approaches (like the approaches identified above). This will also show a certain value that a project manager will have in his or her team and will allow for all team members to share ideas throughout the course of the project.

If possible, it is also very effective to pick a project team with members who are effective communicators. Having these members on a team or finding a way to stress communication can lead to an easier path for collaboration. Picking a more collaborative delivery method such as design-build, or engaging in integrated project delivery allows for a proven structure that is known to provide a collaborative environment. Identifying collaborative subcontractors is important as well. The subcontractors who want to get onto a job and leave as quickly as possible are detrimental to collaboration. Procuring a subcontractor who is more open to understanding the project and sharing ideas will be much easier to work with on a project.

A big factor in collaboration results in the project team's willingness to accept the use of new technology. Technology poses many benefits to a project team, including easier methods to updating project drawings, communication, performing quality checks, administering safety on a site, and just understanding the project in general. One industry member proposed that all members of a team should have equal access to technological benefits on a project. This would drive collaboration to the next level, for not only will the construction manager have access to the most recently updated project information, but so will the project subcontractors. These individuals are responsible are constructing the building after all, and they will need this information the most. One PACE industry member said, "Put an iPad in a foreman's hand and let him explain his reasoning for performing work the way he does." This is a perfect example of how collaboration can improve between the office and the field. One issue with technology comes with unfamiliarity. It is no secret that there is a technological gap in the industry at the moment. However, many of the industry members at the PACE meeting agreed that older generations in the construction field are becoming more open to using technology as they see the benefits that it provides. At the end of the day, if a new piece of equipment allows for a job to be performed more efficiently, people will be more open to changing their methods.

Collaboration within the Stanton Elementary School project appears to be a major focus on the project. The project must rely on collaborative approaches, for it has to deal with a demanding project schedule. However, there are certainly areas where improvements can be made. As explained previously, there was an issue with design due to unfamiliarity with the carpet requirements in the school. If better collaboration had occurred between the project end user and the architect, the carpet design issue could have been avoided. Specific to the Stanton Elementary School project, research can be performed to determine if any other issues like this occurred due to lack of a collaborative environment on the project. More in depth BIM planning could be developed to include more parties and provide a model to which everyone on the project team has access. Relationships between Tompkins Builders and its subcontractors can be analyzed to determine how well they work together. It could be possible to see how selecting a subcontractor that works in a more collaborative environment would have changed the project. Lastly, cost analysis could be performed to see how the implementation of adding iPads for the contractor, subcontractors, and inspectors would affect the project with regard to project cost versus productivity. All of these options could be considered to determine how collaboration could improve the project.

Feedback from PACE Industry Roundtable

The phasing of the Stanton Elementary School divides the project into two separate phases: a renovation phase and a building addition phase. At the PACE Roundtable, a suggestion was made to analyze the project as if it was a single phase project rather than a two phase project. Completing both phase one and phase two at the same time could have potentially cut down on the project cost and the project schedule. It is possible to explore whether or not a single phase or a two phase project would have been more efficient. Additionally, the project start date could be analyzed to determine how a single phase project could be a potential better fit within the academic schedule.

The existing Stanton Elementary School was a fairly small three story building. At the PACE Roundtable, the question was raised, "would it have been more efficient to just build a new building?" A cost analysis could be prepared to analyze the structure as if the building were to be built as an entirely new project. Renovation projects pose a large amount of unknown conditions that could increase a project cost. These types of projects can see many issues with coordination of the trades during and after demolition. Constructing a new building from the start could cut down on these costs and would allow for more flexibility with design, construction, and project planning.

Since the Stanton Elementary School is a part of a growing community and has already seen the need to expand, it is very possible that the elementary school may need to expand at some point in the near future. To plan for a potential expansion, a recommendation was made to install larger foundations. Larger foundations would be able to support additional stories, allowing for more classroom space if it is needed in the future. The existing pre-kindergarten wing of the school is only one story tall and features sizeable classrooms. Adding two stories to this space would bring this section of the building to three stories and would bring this section to an equal height of the remainder of the building. This would allow for an addition that could support at least twelve classrooms. Planning for this style of foundation system would include gaining an understanding of the projected building loads (for two additional stories), and strengthening the existing foundation based on the currently known foundation and soil bearing capacities.

Additional ideas that were discussed include:

- Coordination between electrical, mechanical, and plumbing systems to reduce the required plenum heights
- Consideration of life cycle costs for various building systems
- Energy analysis of major building systems such as the building envelope and the insulation of this system.
- Implementing precondition surveys and utilizing laser scanners during the demolition phase to allow for better project planning and understanding of the current systems.

Leading Industry Practice Evaluation

Building Information Modeling Use Evaluation

Table 1: BIM Use List Proposal

BIM Use List
3D Coordination and Clash Detection
Design Reviews
Construction Systems Design
Existing Conditions Modelling
Phase Planning by 4D Modelling
Site Utilization Modelling
Architectural Analysis
Structural Analysis
Mechanical Analysis
Plumbing Analysis
Fire Protection Analysis
Electrical Analysis
Telecommunications/AV/Security Systems Analysis
Energy Analysis
Sustainability ad LEED Evaluation
Code Validation

The BIM use list above provides applicable BIM strategies that would prove to be beneficial if implemented on the Stanton Elementary School project. Due to the nature of this project, it would be very helpful to have a BIM model of the building to help with the planning of the project. This project includes a lot of demolition and remodeling of existing space, making it difficult to plan for the installation of the various building systems. While the structure of the existing building can probably be determined with little to no difficulty based on the existing project plans, it may be difficult to understand what the existing building systems may look like underneath the interior enclosures. Using a BIM model can help coordinate this, and may prove to be more trustworthy than the construction documents for the existing building, which are in two-dimensional format and over 40 years old. As depicted on the BIM Use List above, a BIM model will allow for planning of current building conditions through an existing conditions model. A BIM model would also allow for coordination of the trades by creating individual models and collaborative models for architectural, structural, mechanical, plumbing, fire protection, electrical, telecommunications, audio-visual, and security systems analyses. Given the short amount of time to complete the project, having individual and interactive models of each of these systems should allow for more efficient planning.

Implementing BIM strategies also helps with construction coordination and construction systems design. This will be a very important use of a BIM model throughout the project, given the minimal space on the jobsite for coordination among the trades. Project planning on a small jobsite can become more effective due to the opportunity for site utilization modelling and phase planning modeling through a four-dimensional environment. This became essential when the crane was on the site during steel erection of the superstructure. The site was especially congested during that time. Phase planning will allow for an interactive model that will also help the project team determine if they are on pace to meet the strict project schedule. This provides a visual that easily allows the team to assess whether or not the schedule can easily be met with a few adjustments to the schedule. In addition to all of the benefits provided on the BIM use list, utilizing a BIM model also provides the owner with a model with which he can use to track construction as it occurs with regard to as-built conditions. The BIM Level 1 process map depicted by *Figure 1* provides more clarity to the proposed BIM design components with relation to each other and the project timeline. A larger version of this graphic is available in Appendix A.

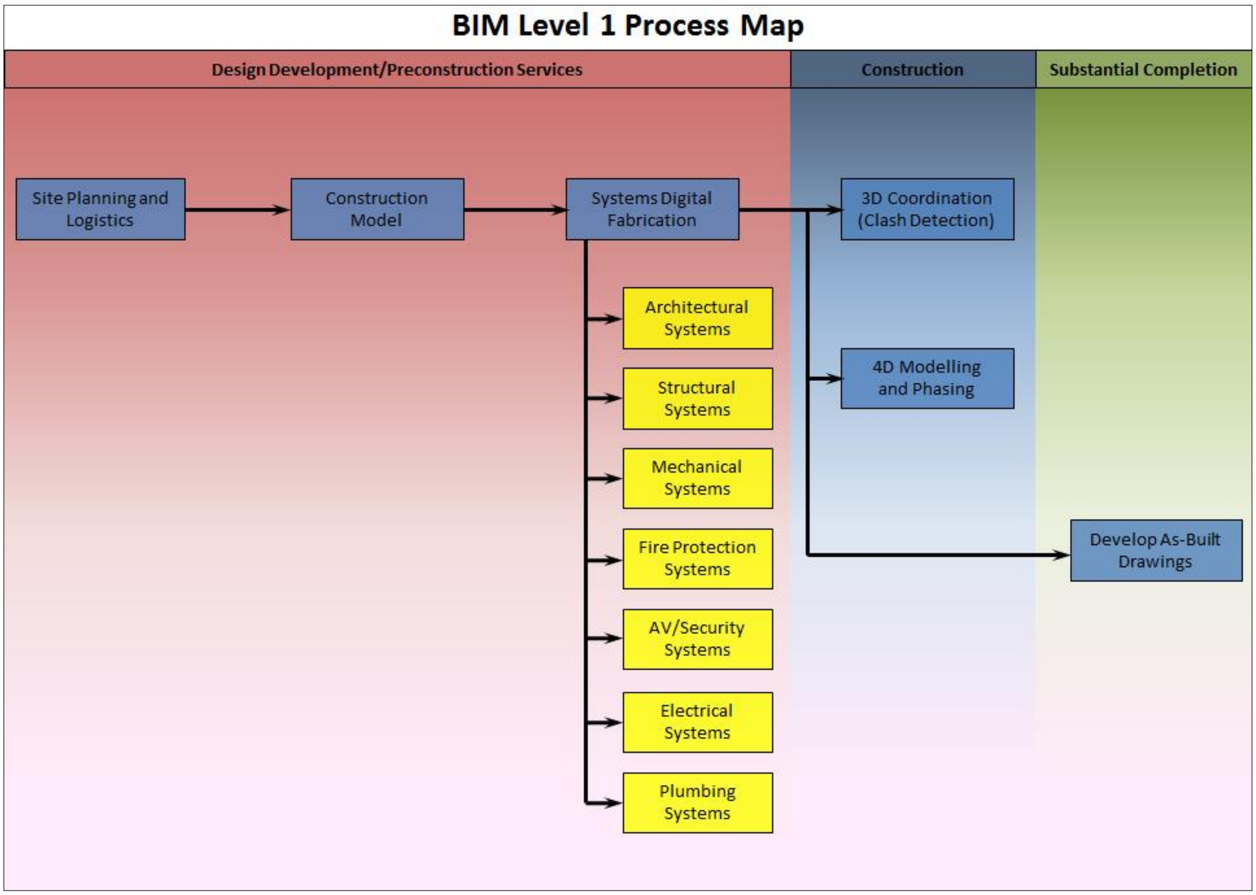


Figure 1: BIM Level 1 Process Map for major BIM Solutions

Current BIM Implementation the Project

The current project BIM implementation strategy is not as involved as the proposed strategy in the previous section. The current BIM execution plan does not include a BIM PxP like most of Tompkins' projects. Tompkins indicated that this project did not require intensive BIM use due to its size. BIM planning did include a BIM MEP coordination kickoff plan that was issued to subcontractors for their own references for MEP coordination throughout the project. With that being said, Thompkins does have a "points of contact list" among the trades and the BIM roles of each of those contact points. Tompkins also developed a brief standard set of requirements for BIM modeling color coding. Document management and a sequence of coordination schedule are also provided in preliminary BIM documentation. Tompkins also provides a project standard for minimum modeling requirements. This standard is applicable to the mechanical, electrical, lighting, plumbing, fire protection, and low voltage systems disciplines. These requirements include items such as applicable equipment to be modelled, thresholds for various piping and conduit sizes, and applicable codes.

Tompkins created a BIM model for the project by using Revit modelling software. This model is updated throughout the course of construction. All disciplines are included in this model with the exception of MEP design. The MEP modeling is performed by the MEP subcontractors. These subcontractors have their own models and update these models as they see fit. Tompkins Builders does not intend to use the BIM model as a source for its as-built drawings. As-built drawings are required to the owner by the contractor as specified in the project contract. Tompkins intends to provide the owner with as-built drawings in the format of two-dimensional CAD drawings. These drawings will be generated by the project subcontractors following the project completion.

BIM has still been used and continues to be used in a variety of ways for this project. Tompkins uses the Revit BIM model for material estimating, quantity takeoffs, quality control, and MEP and interior finish coordination. Additionally, the model is used effectively as a tool to communicate issues between various parties involved on the project. The BIM practices on this project appear to be pretty standard compared to what is normal in the construction industry. At this point, it is unknown whether or not the BIM model was used for project phasing or site utilization. Both elements seem like very applicable BIM uses considering the minimal area provided for site logistics. Besides the fact that Tompkins may not use BIM for this purpose and the fact that Tompkins is not using the BIM model for the as-built drawings (despite ensuring that the BIM model is updated through every stage in construction) Tompkins appropriately uses BIM for Stanton Elementary School, given the size and cost of the project.

Sustainability Implementation

LEED Proposal using the Penn State Model

Penn State University follows strict guidelines in regard to its approach to LEED projects on campus. As an owner, Penn State shows a lot of care not only for the sustainability and life cycle of its buildings, but also for the students who inhabit its buildings. To provide a quality building to its students and faculty, Penn State focuses on five major sustainable aspects of design: energy conservation; natural resources conservation; prevention of environmental degradation; people's health, well-being, and comfort; and the total cost of ownership. Because of Penn State's well-regarded presence as a project owner, its approaches to LEED were used in developing an alternative LEED plan for Stanton Elementary School.

Table 2: Penn State LEED Categories Designated as high priority categories

LEED Category	Credit Classification
Sustainable Sites Credit 4.2: Alternate Transportation – Bicycle Storage & Changing Rooms	SIGNIFICANT EFFORT
Sustainable Sites Credit 5.2: Site Development – Maximize Open Space	SIGNIFICANT EFFORT
Sustainable Sites Credit 6.1: Stormwater Design – Quality Control	SIGNIFICANT EFFORT
Sustainable Sites Credit 7.2: Heat Island Effect - Roof	SIGNIFICANT EFFORT
Sustainable Sites Credit 8.0: Light pollution Reduction – Non-University Park Locations	SIGNIFICANT EFFORT
Water Efficiency Credit 3.0: Water Use Reduction 30%	MANDATORY
Energy and Atmosphere Credit 1.10: Optimize Energy Performance	MANDATORY
Energy and Atmosphere Credit 3.0: Enhanced Commissioning	MANDATORY
Energy and Atmosphere Credit 4.0: Enhanced Refrigerant Management	MANDATORY
Energy and Atmosphere Credit 6.0: Green Power	MANDATORY
Materials and Resources Credit 4.0: Recycled Content – 10% - or - Materials and Resources Credit 4.0: Recycled Content – 20%	MANDATORY SIGNIFICANT EFFORT
Indoor Environmental Credit 1.0: Outdoor Air Delivery Monitoring	MANDATORY
Indoor Environmental Credit 3.1 Construction IAQ Management Plan – During Construction	MANDATORY
Indoor Environmental Credit 3.2 Construction IAQ Management Plan – Before Occupancy	MANDATORY
Indoor Environmental Credit 4.1 Low-Emitting Materials – Adhesives and Sealants	MANDATORY
Indoor Environmental Credit 4.2: Low-Emitting Materials – Paints and Coatings	MANDATORY
Indoor Environmental Credit 4.3: Low-Emitting Materials – Carpet Systems	MANDATORY
Indoor Environmental Credit 4.4: Low-Emitting Materials – Composite Wood & Agrifiber Products	MANDATORY
Indoor Environmental Credit 5.0: Indoor Chemical and Pollutant Source Control	MANDATORY
Indoor Environmental Credit 6.1: Controllability of Systems – Lighting	MANDATORY
Indoor Environmental Credit 6.2: Controllability of Systems – Thermal Requirements	SIGNIFICANT EFFORT
Indoor Environmental Credit 7.1: Thermal Comfort – Design	SIGNIFICANT EFFORT
Indoor Environmental Credit 7.2: Thermal Comfort – Verification	MANDATORY
Indoor Environmental Credit 8.1: Daylight and Views – Daylight	SIGNIFICANT EFFORT

Table 2 provides an outline of the specific LEED categories in which Penn State pursues as an owner. Credits that are deemed to be mandatory must be achieved through LEED design. Credits that are marked with 'significant effort' must show proof that serious attempts were made to pursue these credits. In a case where this type of credit is not pursued, Penn State must be addressed by the design official for failure reasoning. The credits that are noted in *Table* 2 act as the guideline for the LEED plan that should be utilized for the Stanton Elementary School project. Since the variety of the buildings that Penn State owns are used for educational purposes, the applicable LEED credits listed in *Table 2* are mostly applicable to the Stanton Elementary School as well.

In regard to creating a sustainable site, Penn State is mostly concerned with bicycle storage, open space maximization, stormwater design quality control, heat island effects on the roof, and lighting pollution (for branch campuses only). Bicycle storage and lighting pollution are not issues of concern to the project owner for the Stanton Elementary School project. Based on the area in which the school is located, riding a bike to work is not something that is likely due to traffic near the school. It is highly unlikely that the school would opt to allow students to ride their bikes to and from school. Light pollution is not so much of a concern due to the operating hours of the school. Lighting pollution would occur at nighttime, which is after normal operating hours of the school. Maximizing open space is directly applicable to the Stanton Elementary School project due to the lack of space that currently exists on the site. Stormwater design is also very important due to the abundance in hardscape area surrounding the school. The school parking lot has an elaborate drainage plan to help account for such issues as just one example. Consideration of the heat island effect on the building roof is also directly applicable due to the addition of a green roof as part of the phase two construction.

Penn State's approach to water efficiency amounts to putting forth significant effort towards reducing the use of water by up to 30%. Anything past this approach does not gain serious consideration. Energy and Atmosphere sustainable design gains more consideration, however. Penn State attempts to gain credits within this category designing to optimize energy performance within the footprint of a building, enhancing commissioning, enhancing refrigerant management, and utilizing green power. The optimization of energy performance refers to achieving 30% in energy savings within a building. This is applicable to any type of building, and should be a goal for the Stanton Elementary School not only to save on energy, but to save on the costs that come with excess energy usage. Enhancing commissioning is also directly applicable, and again, should be applied on mostly any type of educational project. This will allow for more efficient systems, and will save in energy and energy costs in the long term. Valuing sources of green power will provide a benefit to the environment, however, it is difficult to say how opting for methods of green power will benefit this project. Cost analysis on green power solutions should be run and compared to the current systems to determine which system is cheaper, and which system makes the most sense for this project. With difficulties gaining project financing, it may be more appropriate for the project owner to opt for the cheapest system, even if there is a more sustainable option. Lastly, the value that Penn State sees in enhanced refrigerant management does not translate to the Stanton Elementary School project. Penn State strives to gain points for this LEED credit due the relationship this credit has with Penn State's on campus steam plant. This is not a credit worth pursuing for the Stanton Elementary School project.

Materials and resources is another category in which Penn State does not pay too much attention. Penn State strives to use at least 10% of recycled content on all of its projects. Again, with limited project financing for the Stanton Elementary School, a cost analysis should be run to determine the cost benefits of utilizing recycled materials. If cost benefits are not seen, this may be a LEED area that the project owner opts to ignore.

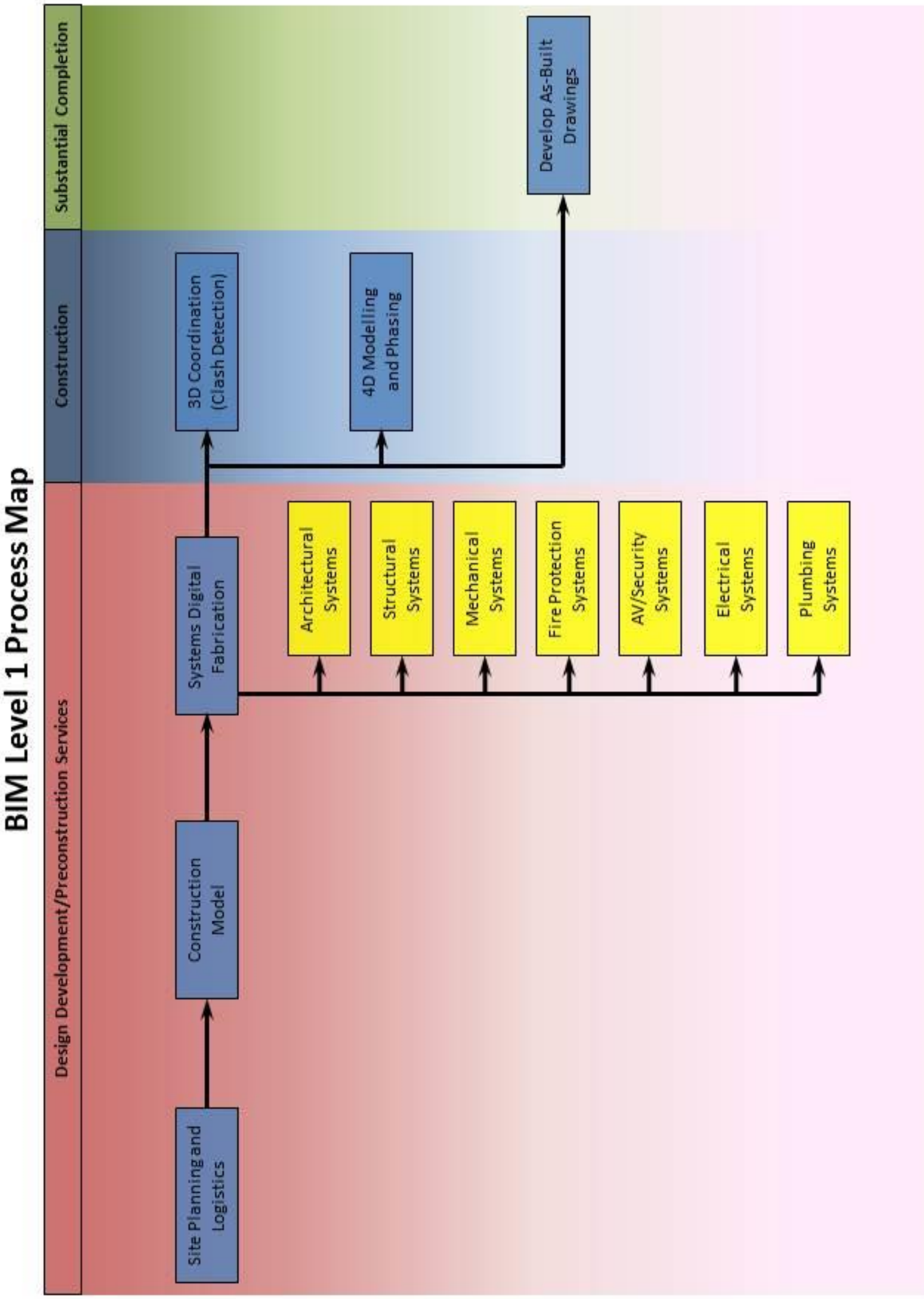
Penn State pays a lot of attention to indoor environmental quality, pursuing over two-thirds of the LEED credit options in this category. In general, Penn State shows a care for outdoor delivery monitoring, indoor air quality management planning, low-emitting material usage, indoor chemical and pollutant source control, controllability of systems, thermal comfort, and daylighting. These are all extremely important components of sustainable design and are all directly applicable to the owner's requirements for this project. The owner wants to deliver a safe environment for its students. Utilizing safe materials and using systems that provide quality air is majorly important for students' health. In addition to health, comfort also should be considered (just as it is in Penn State's LEED plan). Students are more likely to perform better when they are in a comfortable environment. Providing appropriate mechanical design that fits the zoning needs of this type of project is essential. Using LEED design criteria to fit this need can serve as a guideline to help attain a high level of thermal comfort for the building occupants.

Comparison to Current Project LEED Plan

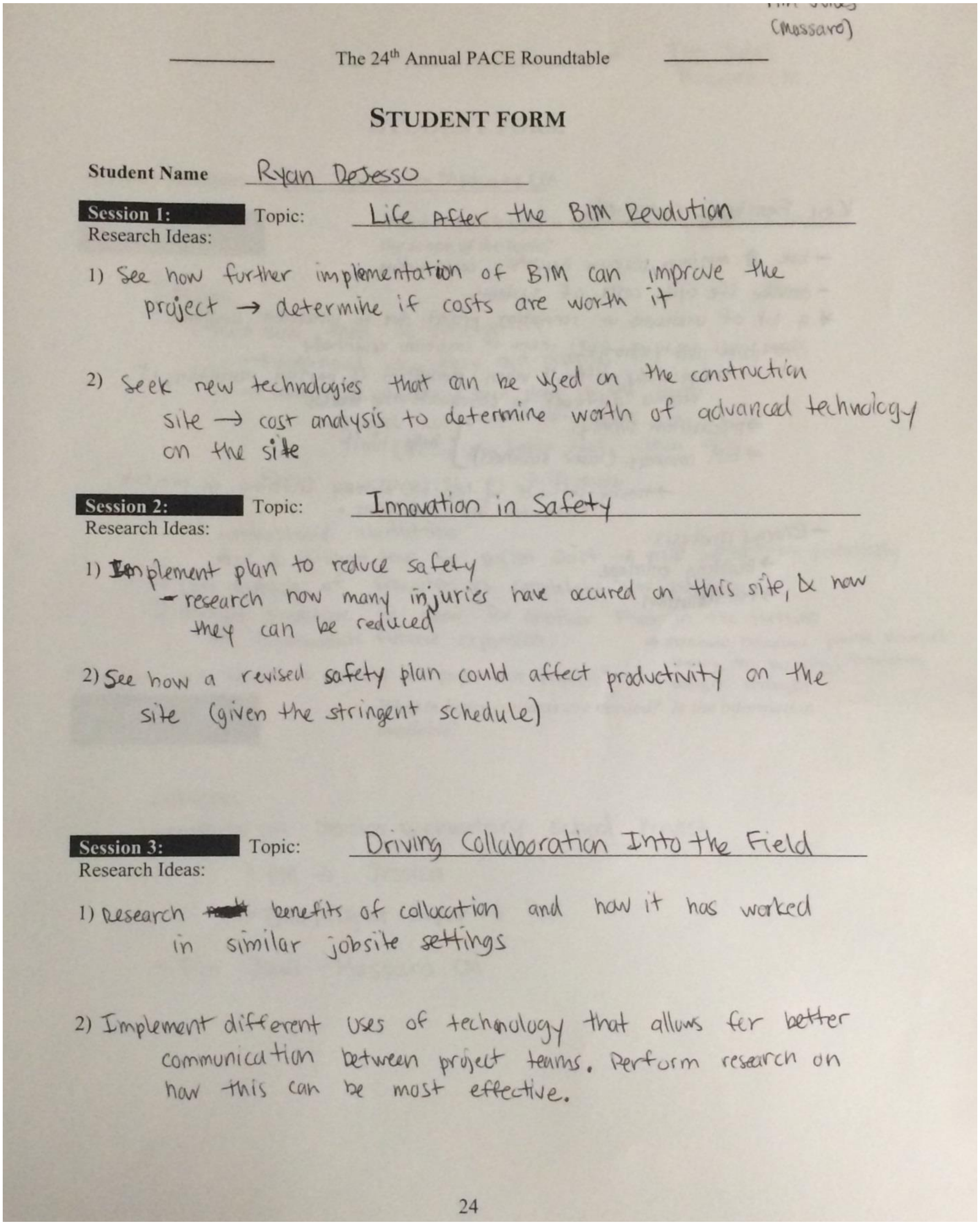
The LEED goals of the Stanton Elementary School project are very similar to the goals that are outlined by Penn State's LEED plan. Stanton Elementary School heavily values a sustainable site, and is pursuing LEED credits for alternative transportation methods. There is more focus placed on sustainable sites in the Stanton Elementary plan than in the Penn State plan, specifically in areas like site selection and community connectivity. There are also LEED pursuits in place for stormwater designs, just as the Penn State LEED plan would recommend. Water efficiency is taken more seriously on the elementary school project. The project will pursue 35% water use reduction compared to the 30% reduction on which Penn State choses to place emphasis. Water efficient landscaping is also being pursued on the school project as well.

The Stanton Elementary school project seems to place more value on energy savings when compared to a typical Penn State project. Enhanced commissioning and green power are pursued. Additionally, improving energy by 34% is one of the lofty goals that Stanton Elementary School is pursuing to gain LEED credits. The elementary school project will place an emphasis on recycling materials, whether it is in recycling project wastes, or in utilizing recycled materials for construction. This is comparable with Penn States plan to use recycled materials. In the indoor environmental quality category, Stanton Elementary School shows that it values planning for indoor air quality management, the use of low-emitting materials, controllability of systems, and thermal comfort. This is almost identical to the proposed plan that uses Penn State's LEED approach as a model. The Stanton Elementary School will also be receiving six out of six available credits for innovation and design processes. In general, the sustainable goals of this project are in line with those set by Penn State but manage to exceed Penn State's sustainable expectations. The Stanton Elementary School project LEED expectations are reasonable, and can easily be met. The project is currently on track to be LEED gold certified.

Appendix A: BIM Level 1 Process Map



Appendix B: PACE Roundtable Student Forms



(Massaro)

The 24th Annual PACE Roundtable

STUDENT FORM

Student Name Ryan DeJesso

Session 1: Topic: Life After the BIM Revolution

Research Ideas:

1) See how further implementation of BIM can improve the project → determine if costs are worth it

2) Seek new technologies that can be used on the construction site → cost analysis to determine worth of advanced technology on the site

Session 2: Topic: Innovation in Safety

Research Ideas:

1) Implement plan to reduce safety
   - research how many injuries have occured on this site, & how they can be reduced

2) See how a revised safety plan could affect productivity on the site (given the stringent schedule)

Session 3: Topic: Driving Collaboration Into the Field

Research Ideas:

1) Research benefits of collocation and how it has worked in similar jobsite settings

2) Implement different uses of technology that allows for better communication between project teams. Perform research on how this can be most effective.

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The 24th Annual PACE Roundtable — Tim Jones, Massaro CM

STUDENT FORM

Industry Member: Tim Jones – Massaro CM

Key Feedback:

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

1) Phasing
- build new, then do renovation
  - → understand why they did phasing the way they did
  - → could have potentially been done in one shot
    - → could cut down on costs (electrically, temp heat, clean up)
  - → run cost analysis on differences
    - more cut for students
- understand limitations
- look @ different times for project start → pick better time potentially

2) Cost analysis of Renovation vs. completely new building

3) Stronger Structure to allow for another Floor in the future to accommodate future expansion
- → structural Drawings provide assum loading for building; foundation design strength

"Sometimes best solution is already on paper (in project)"

Suggested Resources:

What industry contacts are needed? Is the information available?

- advisors
- contacts on Stanton Elementary School Project
  - PM → Jessica
  - BIM / Project Super → Pat
- Tim Jones – Massaro CM

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Key Feedback Continued:

- look @ min/max plenum heights, coordination
- consider life cycle costs of systems

* a lot of unknowns in renovation project due to unforseen conditions, sometimes due to retrofits; unsure of conditions essentially
  - → especially difficult when demolition is partial demolition, it becomes difficult to coordinate the trades
  - ⇒ precondition surveys
  - ⇒ BIM cameras (laser scanners)

  } help limit

  - → timing difficult w/ this b/c already working on project

- Energy analysis
  - → Building envelope
  - → reinstallation

Appendix C: Project Manager Interview Dialogue

Project Manager Interview

Jessica Marine, Tompkins Builders

Could you define some of the project challenges with regard to the project schedule?

The project schedule was very difficult to maintain from the beginning of the project. Phase 1 was required to be finished over the course of an academic summer, providing only 56 days to complete $16 million of work. Issues with procuring permits and receiving final project approval limited the amount of time for planning towards the beginning of the project. Additionally, there were very many changes to the project drawings at the early stages of phase one, making it difficult to bring in subcontractors to begin the work. Additional stress to completing the schedule on time occurred when considering the effect that meeting the schedule had with regard to payment of the general contractor. If the project is not delivered by the expected date, the owner can retract 10% payment or each day that the project is late.

Please identify some of the client requirements for this project and what was done to meet the client's needs.

The biggest need of the client was for phase one to be delivered prior to the start of the 2014-2015 academic year. The owner also requires that substantial completion of phase two is delivered by December 28th to allow for the phase two addition to be in use after the 2015 winter break. To meet these needs, Tompkins increased the amount of hours worked on the project throughout the course of phase one. During phase one, the construction team worked every day of the summer, including weekends and holidays. In addition, the team worked both day shifts and night shifts. It was important for Tompkins to make the subcontractors aware of the project needs with regard to its fast paced schedule.

Project Management Services

Could you explain some of the preconstruction services that were provided to the client?

Tompkins came onto the project to work with the architect while the design was about 60% complete. Tompkins provided various estimating services and pricing exercises that were utilized to develop the project GMP agreement. Tompkins also helped provide cost analysis on the prekindergarten wing construction costs to see if that cost could be met by the project financing provided.

What were some of the biggest challenges or constraints for the client in regard to…

…Quality?

Tompkins provided the owner with a warranty in regard to quality. The warranty guaranteed that quality would be measured based on the requirements outlined in the contract documents.

…Financing?

DGS took a long time to gain project approval and obtain the appropriate financing for this project. This led looking for creative solutions to cutting costs before and during construction. Additionally, it affected the time to plan throughout the course of the preconstruction phase due to uncertainty in the scope of the work to be performed.

…Phasing?

Issues with project phasing came simply in trying to maintain the project schedule. Phase 1 and 2 were initially supposed to be executed in immediate succession, however, issues with project financing pushed phase 2 back. It would have been much easier to be able to stick to the original schedule, but again, project phasing did not allow for this. Additionally, project phasing became an issue with the phase two foundations when the schedule of this particular task took much longer than originally intended.

What are some key areas that could have potential to better fit the project approach to the client's needs?

One approach that could have been taken to better fit the client's need would be to allow the end user to meet with the design team to review the project design to see if all aspects of design meet the needs of the end user. One example of where this would have benefited the project was in the carpet design. The original design featured diamonds throughout the school hallways. This diamond design is used to help with moving students through the halls during the course of the day. The design team was unaware of the meaning behind this carpet and changed the design. This affected the schedule with regard to carpet installation when it was all said and done.

A project constraint that occurred involved the subcontractors that could be selected to work on this project. The project contract required that only CBE subcontractors could be used, limiting the choice of subcontractors only to contracts within the Washington, D.C. district. The client potentially could have benefitted more from a wider selection of subcontractors that could have led to better subcontractors and a better quality project in the end.

Value Engineering Topics

Describe key areas of value engineering that were implemented on the project.

A lot of the value engineering that occurred focused on cutting project costs by substituting cheaper materials for construction systems.

- *Eliminating sunscreens from the window design during phase two. Tompkins opted to install a window with a higher R-value that reduced the amount of natural light that could enter the classrooms. This cut down on project costs and schedule.*
- *Eliminating column covers on the columns at the building's entrance. This was a purely aesthetic feature. In the end, the owner's rep was in favor of eliminating this aspect of design to cut down on project costs.*
- *Replacing the glass handrail design with a more traditional handrail design. Again, in an effort to cut down on project cost, this change was made.*
- *Redesigning the stairwell walls. The original design called for CMU wall backing covered by high-impact dry wall. Tompkins and the owner agreed that the CMU wall*

would alone be sufficient and that the high-impact drywall would not be required. Instead, the CMU walls were painted. This eliminated the cost of the drywall material, the labor to install the drywall system, and the time to build scaffolding for the placement of the drywall system.

- *Changing manufacturers for air handling equipment. Tompkins saw an opportunity for large savings on the project by moving to much cheaper equipment that still fits the needs of the project as outline in the contract documents.*

How did this effect from the owner?

Tompkins was able to benefit the owner by making these changes. The owner agreed to all of the changes that were made, for the owner understood the cost benefits of these changes benefited a project that was undergoing issues with project financing. There were some instances in which the owner did not opt to make the changes recommended by Tompkins, and in those situations Tompkins would build as originally designed. However, the owner was typically very understanding of and open to all suggestions as long as Tompkins could project sounds reasoning for the changes and could explain the benefits from a cost and scheduling standpoint.

What ideas for value engineering were considered but not implemented?

The owner discussed omitting the prekindergarten wing from phase two of the project. There were also discussions of not furnishing the building upon completion. However, financing came through that allowed for each of these opportunities to be pursued. These two things are far too essential to the project to be omitted from the scope of work.

Demolition Phase

What type of unforeseen conditions occurred during the phase 1 demolition?

Demolition went very smoothly during phase one. The as-built drawings turned out to be very accurate, and no major surprises were encountered during phase one demolition. Phase two saw some issues with steam tunnels around were columns existed. The columns needed to be moved in the end. However, this is not a problem that really could have been planned for.

What approaches were taken to resolve any of these issues?

Precondition surveying could have been performed to help plan for such discrepancies. However in the case of this project, the costs of precondition analysis in any form would have likely exceeded the costs of dealing with unforeseen conditions as they arose. For this particular project, nothing could have really been done to prevent the steam tunnels and column clash.