Out of Site: A Pedagogical Perspective of Emerging Transitions in Architectural Practice

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ABSTRACT

Energy Efficiency is one of the five strategic themes of the Penn State Institutes of Energy and the Environment (PSIEE), which has supported a Sustainable Housing Initiative (SHI) that intends to leverage faculty and student expertise on residential building planning, design, and construction. The goal of this initiative is ambitious - to initiate a process that will radically transform the residential building sector, with partners that will scale-up innovation to a regional and eventually national or international scale. There is significant interest and expertise related to these ideals at the Pennsylvania State University notably within the Stuckeman School.

As a short-term agenda for the collaborative team of the Sustainable Housing Initiative, two classes worked in coordination with Penn State's Office of Physical Plant (OPP) and Housing, Food Services and Residence Life to improve the environmental performance of buildings on campus, particularly the new residence halls. The intended outcome of this challenge can be achieved as outlined below by approaching it through two different methods - curriculum and research; two strengths of Penn State.

As a curricular idea, a 'real' project was used to make suggestions from the sustainability standpoint to enhance a Request For Proposal (RFP) document for Trippe Hall, a proposed design-build residence hall project on the Behrend campus of Penn state. This project was chosen as a case study for projects assigned to Architecture and Architectural Engineering (AE) students in the fall semester of 2014. While the Architectural Engineering students in the ARCH 441 studio produced design proposals for Trippe Hall with a focus on environmental design using their expertise in building systems; the Architecture students in the ARCH 412 seminar class worked in a series of integrative design charrettes to develop presentations of sustainable strategies relevant to Trippe Hall. The two student groups worked in a collaborative manner – the ARCH 412 class acted as consultants on sustainable practices to help enrich the design projects of the ARCH 441 students. Both groups engaged with 'client' representatives from Penn State's Office of Physical Plant and Housing and Food Services on a regular basis.

The information gathered and analysis developed during this curricular effort are informing a larger agenda of the Sustainable Housing Initiative – the process of leveraging the University's strong research base to distill the lessons learnt from this collaborative project and understand the potential implications for the architecture, engineering and construction (AEC) industry.

CHALLENGES FOR SUSTAINABILITY IN THE HOUSING SECTOR

By 2030, the housing market in the U.S. will have added an estimated 58.9 million housing units that did not exist at the turn of the century (Nelson, 2006). This will create an enormous burden on existing finite natural resources, and some steps have been taken to implement policy change by raising the bar at both the government level (through more stringent ASHRAE and local building codes) and through organizations such as LEED, Green Globes, etc. While these systems are creating awareness about better construction practices and safer building materials, there is still some debate about whether they have caused a fundamental shift in the way buildings are designed and consequently the way they approach energy consumption reduction and sustainability. For example, the Residential Energy Consumption survey by the U.S. Energy Information Administration notes that newer homes (built post 2000) in the U.S. consume the same amount of energy as homes built prior to 2000; primarily because these newer homes are approximately 30% larger than the older ones. Therefore, in combination with the facts presented earlier; we can assume that energy consumption by the residential sector has only increased over the years notwithstanding the efforts of the government and other stakeholders.

SUSTAINABLE HOUSING INITIATIVE AND THE DEMONSTRATION PROJECT

The Sustainable Housing Initiative (SHI) was formed in 2012 at the Pennsylvania State University as a response to energy and environment-related challenges in the residential sector and to discuss the potential for a game changing initiative in the areas of housing and sustainability. The SHI builds off of past Penn State successes, including the 2007 and 2009 Penn State Solar Decathlon Homes, the Union County Energy Efficient Housing Program projects, the American Indian Housing Initiative, and the GridStar Smart Grid Experience Center modular home at the Philadelphia Navy Yard. Each project demonstrates the importance of a holistic approach and the necessity for establishing local connections and reinforcing community development in realizing a replicable and “scale-able” model for sustainable housing. The SHI working group consists of members with a diverse range of research expertise – from building science and design, to community behavior and materials research. Over the last three years, this working group has collaborated to identify a vision for the Initiative at Penn State, and this vision developed out of a significant overlap in interests - these include sustainability, specifically social sustainability related to community and occupant / resident impacts, energy efficiency and a fordability.

The SHI’s faculty members’ interests and prior experience link all three measures of scholarship – research, teaching and outreach – and the working group members saw an opportunity for the SHI to serve to connect the three through a focused and immersive collaborative experience. In turn, a compelling aggregate of university research resources would be brought to the table to examine human behavior, material sciences, energy systems science, architecture, architectural engineering, landscape architecture, agriculture, community development, and Penn State institutes and centers. From the discussions within the working group emerged the search for a demonstration project that is characterized by extreme energy and sustainability best practices, one that is large enough to inform and impact multifamily housing production and provide a research industry / academic platform with a process that is scalable and repeatable.

This sub-typology of the ‘demonstration project’ in the housing sector was then debated in the context of the resources available, potential for industry partnership, the strengths of the SHI members and the possibility of involving all the three aspects of scholarship mentioned earlier (research, teaching and outreach). Housing typologies that were considered included multi-family housing projects appropriate for brownfield sites, Infill housing in existing urban fabric, and University housing (residence hall) projects.

It became apparent that the SHI could best leverage its strengths in a University housing project as it could:
- Best integrate available research, teaching and outreach opportunities
- Create a more ‘controlled’ and conducive environment for experimentation
- Offer the best possibility for influencing change in a ‘real project, and
- Answer a conundrum that is unique to residence halls: “Who is the client?”

In University housing projects, the definition of the ‘client’ falls in a gray area – is it the University and its facilities management organization (in the case of Penn State, the Office of Physical Plant) which sets out the spatial requirements of the project and directly hires and pays the designers for their services; is it the office of Housing, Food services and Residential Life, which is responsible for identifying the needs and supplying funds for the project; or is it the students, who are not only the users of the residence halls but also pay for the design and construction of the residence halls indirectly through their University fees? Unlike most other building typologies, in which the client is considered to be the person / organization that directly pays for the designers’ services and inhabits the building; in University housing projects, the students - who despite being the users of the building and paying indirectly for the designers’ services – are rarely considered as vital stakeholders. The selection of a residence hall project as a test-case for the SHI would therefore provide distilled recommendations for not only the general residential sector, but also specific strategies for residence hall design and construction arising out of a unique collaborative process with the designers, the university and the students. The Penn State residence halls also have a strong tradition of sustainable lifestyle education programs and have become a site for beta-testing new programs at Penn State, including many recycling program improvements, energy-saving initiatives and an active student group called Eco–Reps - a group that includes freshman volunteers who engage in peer–to–peer education. Therefore, it is only fitting that a more formalized sustainable vision for the residence halls be developed to inform decisions now and well into the future.

THE PROCESS

In the summer of 2014, the working group engaged with representatives from the Penn State Housing and Food Services (HFS) and the Office of Physical Plant (OPP), to use the proposed Trippe Residence Hall (Fig. 1) as a real demonstration project for the execution of student research and professional interchange. It is to be noted that Trippe Hall was represented a certain 'standard' in residence halls - it was a 250-bed, $25 million freshman hall similar in spatial requirements to residence halls on most university campuses. This project would help the University and the design team of the Trippe Residence Hall to better understand the expectations of the end users of the building, the students. Two members of the SHI working group led a class each in the fall 2014 semester – while the students of the ARCH 441 class (Juniors in the Architectural Engineering department) produced design proposals for the Trippe Hall project with the objective of designing a 'net-zero' building; the students in the ARCH 412 seminar (predominantly graduate and undergraduate Arts and Architecture students) worked in a series of integrative design charrettes to develop presentations of sustainable strategies relevant to Trippe Hall and other Penn State housing solutions. In addition, the students of ARCH 412 acted as consultants on LEED® (USGBC Leadership in Energy and Environmental Design) and sustainable practices to the design projects of the ARCH 441 students. The aim of this curricular exercise was to promote interdisciplinary opportunities and to further research in sustainable approaches to multiple-dwelling unit design that, in turn, will inform Housing Services at Penn State.

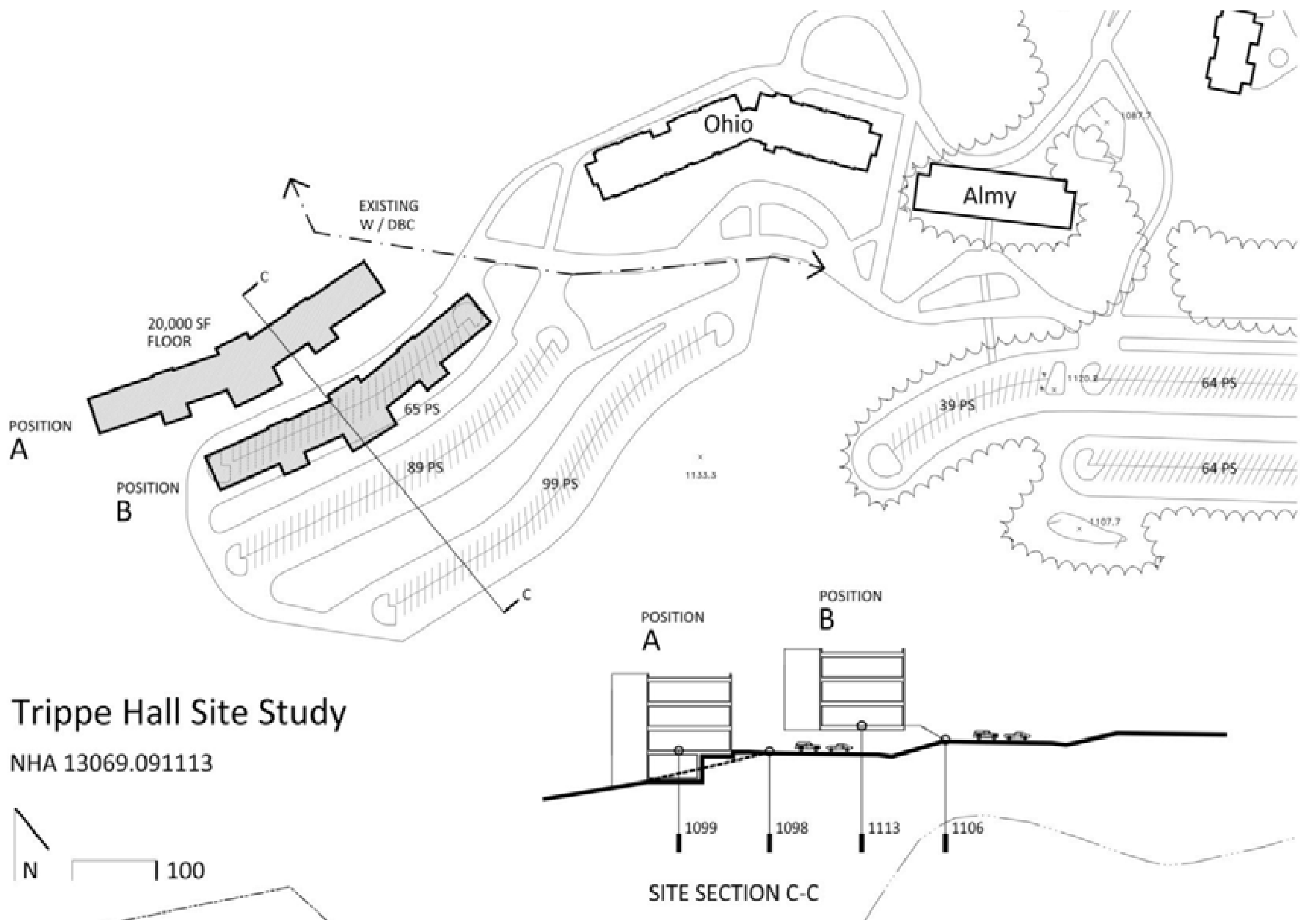

Figure 1. Trippe Hall site study showing the proposed location of the residence hall at the Penn State Behrend campus in Erie

Collaborating with Penn State's Office of Physical Plant / Housing and Food Services, the Penn State Sustainability Institute, and the students enrolled in ARCH 441, the graduate and undergraduate students in ARCH 412 worked in teams (Fig. 2) to research sustainability strategies and develop a 'Living Green' presentation and report intended to inform Trippe Hall and future University residence hall projects.

Students enrolled in ARCH 412 worked in teams to produce a final report that would provide guidance for the new construction, retrofit, operations, and occupation of residential life facilities and set the groundwork for future student projects and initiatives. This project was seen as an opportunity to integrate sustainability design goals and educational objectives into a vision in a way that allows the residence halls to be a working example of Penn State's sustainability initiatives. The goals specific to this class were to

- Provide an opportunity to integrate environmentally conscious design goals / green design principles into a real project by working with campus professionals
- Develop education goals and materials on sustainable design appropriate for Penn State design and construction projects and
- Develop the leadership and facilitation skills to become productive contributors on sustainable design project teams by gaining experience in inter-disciplinary sustainable design collaboration and participating in the Integrated Design Process (IDP) during collaborative project charrettes

Arch 412 student teams were comprised of four students each, and the teams and the project were conceived to simulate an emerging paradigm shift in architectural design and project delivery, the Integrated Project Delivery (IPD) process. An important tenet of IPD is cross-disciplinary collaboration, and this process, at its best, provides for a more integrated, resolved and cost effective final project. However it is often marred by conflicts during collaboration – often, miscommunication is the cause of conflicts between team members, with reports of different disciplines "not speaking the same language". The fact is that different disciplines tend to use similar terminology in very different ways. Therefore the "common language" sought for this project is not that of a specific discipline, but rather a collaborative dialog to set common project goals as a solid foundation for individual and disciplinary exploration. For this project the teams of four students provided an atmosphere for collaboration and an opportunity to set project-specific goals based on different personal perspectives: students reflected on experience that they brought to the class, as students / Penn State residents and from their disciplinary training in architecture, integrative arts and engineering. They also brought newfound knowledge to the discussion based on explorations of what defines "sustainability" for the built environment and research into one of four categories of sustainable development: Sustainable Sites, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality (IEQ). Thus the students were asked to represent themselves as "experts" on a particular subject while balancing the many, sometimes conflicting, personal and cross-personal viewpoints

The students utilized various resources in order to prepare for the collaborative charrettes, including "A Handbook for Planning and Conducting Charrettes for High-Performance Projects" (Lindsey et al., 2012) and "Integrative Process (IP): Design and Construction of Sustainable Buildings and Communities" by the American National Standard Institute (ANSI, 2012). These manuals provided guidance on collective decision-making and served as appropriate references for ideas and the development of the student projects.

Figure 2. Representatives from the Housing & Food Services and the Office of Physical Plant conversing with students in the ARCH 412 seminar class during the strategy development charrette

A brief description of the collaborative charrettes is provided below:

Project Charrette 1: Kickoff

- Charrette concept and facilitator role introduced, project and participant description provided;
- Teams of 4 people formed; and one "expert" in each of the four categories – Sustainable sites, Energy and Atmosphere, Materials and Resources and Indoor Environmental Quality - identified
- Initial team goals established and documented in collaboration with representatives from OPP and HFS.

Project Charrette 2: Goal-Setting Charrette

- Project goals and objectives confirmed
- Specific issues related to sustainable design strategies relevant to the future of Green Dorms in general and Trippe Hall in particular identified
- Strategies and project intentions coordinated between team members.

Project Charrette 3: Strategy Development / Decision-making Charrette

- Most appropriate sustainable 'good, better, best' design strategies evaluated and identified
- 'Big picture' items relating to process, education and community outreach identified
- Guidelines and conceptual design sketches illustrating examples of implementation of strategies developed;
- Coordinated visions for how sustainable strategies will work together established;
- Overview report on strategies to be implemented and rationale for inclusion outlined.

Public Project Presentation

- Project and team goals introduced;
- Participants educated about the sustainable design strategies included and the rationale for selection;
- Full-project report submitted, integrating all charrette reports and project documentation.

During each charrette, one of the four team-members acted as a 'charrette facilitator', whose responsibilities included:

- Establishing the desired outcomes for the charrette;
- Maintaining motivation and encouraging participation from the team members;
- Keeping track of time to assure that all goals are met;
- Recording discussions and decisions during the charrette; and
- Coordinating a charrette report summarizing discussions and documenting outcomes and decisions.

ANALYSIS OF THE OUTCOMES

Over the course of this collaborative design process, we realized that the sustainable design strategies suggested by the ARCH 412 students that contributed to the majority of energy consumption reduction in the projects of the ARCH 441 students were those that needed to be implemented in the early stages of the building design and construction. A schematic breakup of the major sustainable design strategies that we considered are plotted over the anticipated time frame of the building design process in Fig. 3:

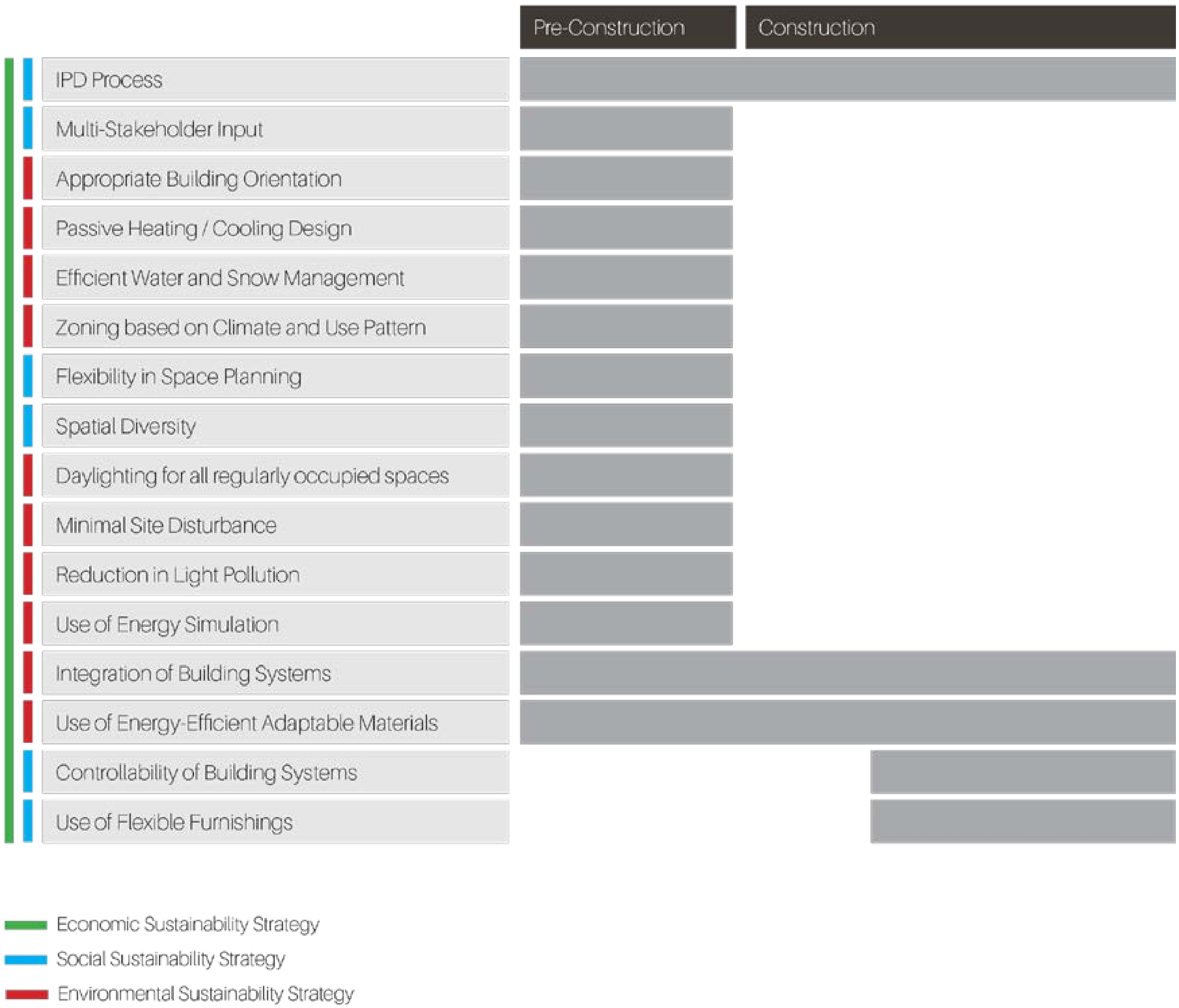

Figure 3. Sustainability strategies considered by student teams plotted over the building process timeline

Throughout the Trippe Hall design charrettes, it became clear that the most time-intensive part of our design would be the schematic design stage, as it involved multi-stakeholder consultation at an early stage in the project. If we construct a time-effort curve based on the previous diagram, with the ‘effort’ (sustainability strategies) on the vertical axis and the building design & construction timeline on the horizontal axis; we identify the pattern shown in Fig. 4:

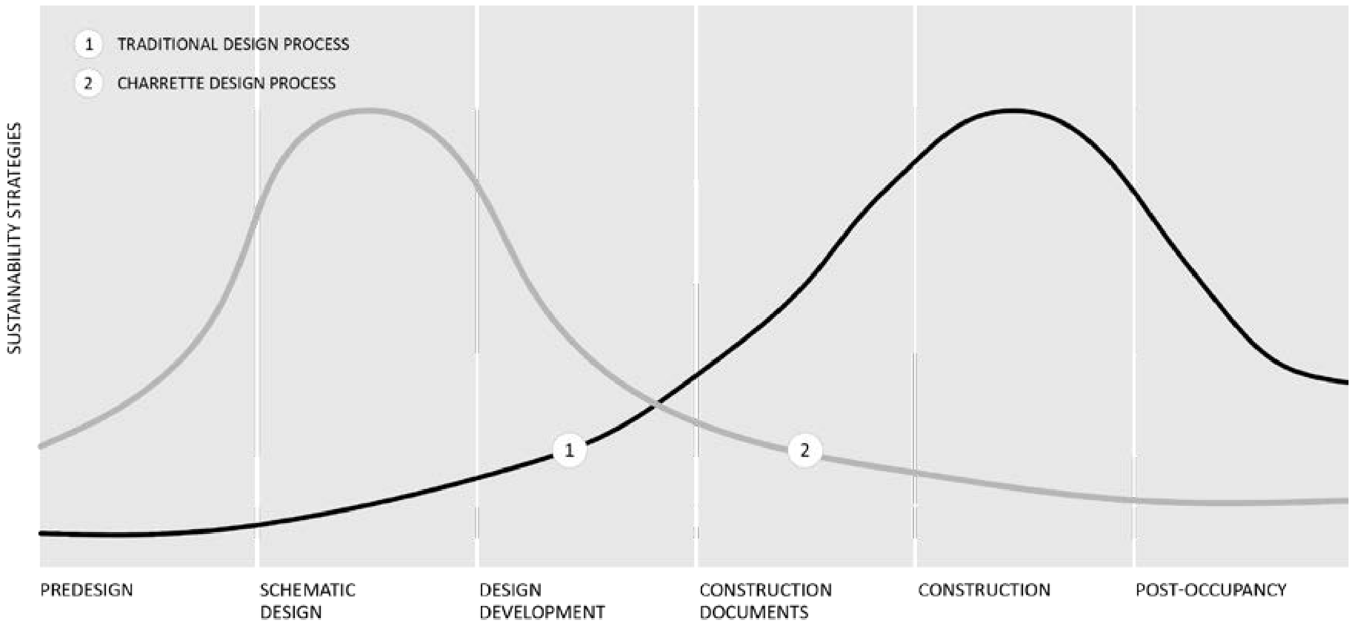

Figure 4. Time-effort curve comparison between a typical sustainable building design process and the Trippe Hall charrette design process

The darker line in Fig. 4 represents the time-effort curve for a typical building, in which the majority of the time and effort is spent in the construction stage of the project. The AIA published the following graphic (Fig. 5) in their publication 'Integrated Project Delivery: A Guide' (2007):

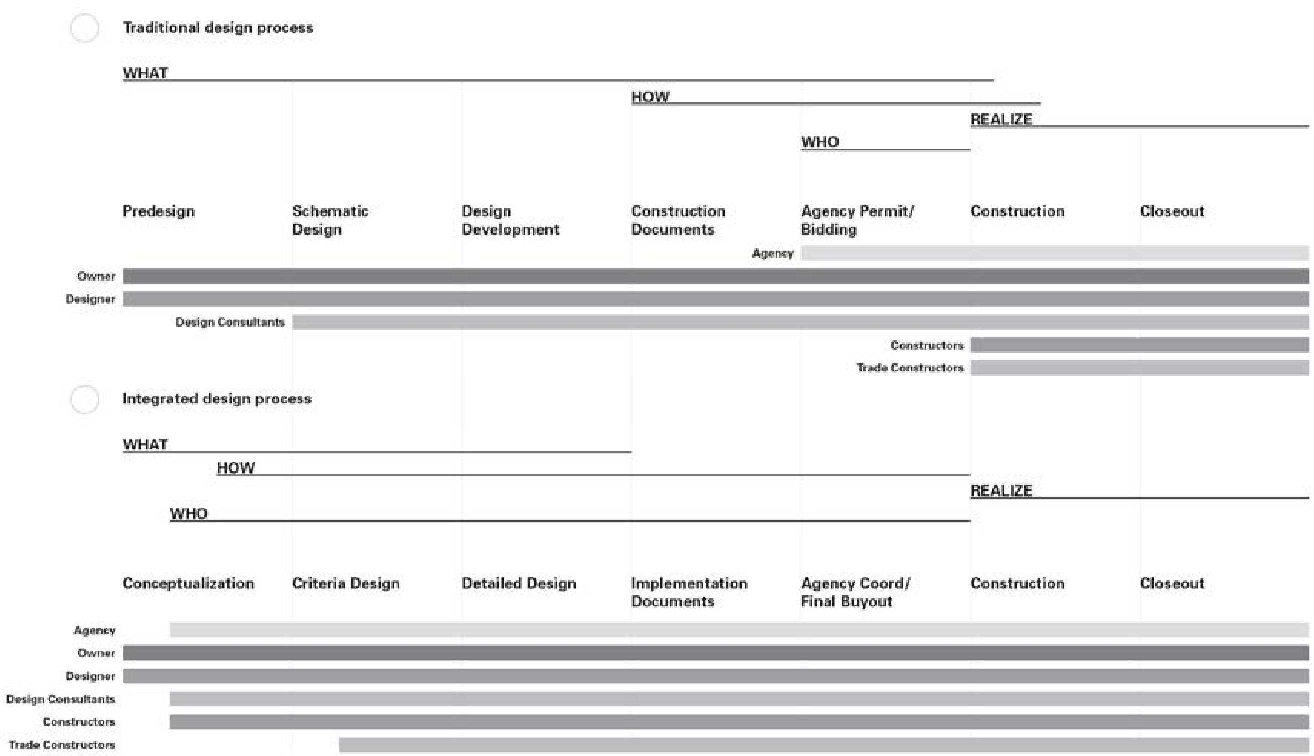

Figure 5. Comparison of traditional delivery to integrated delivery methods showing the shift in effort to earlier phases of the project (AIA California Council, 2007)

Translating the data from Fig. 5 into what has now become known as the MacLeamy curve - in which the cost and the ability to change is plotted on the vertical axis, while the building design-construction timeline is mapped on the horizontal axis - the following diagram (Fig. 6) is generated:

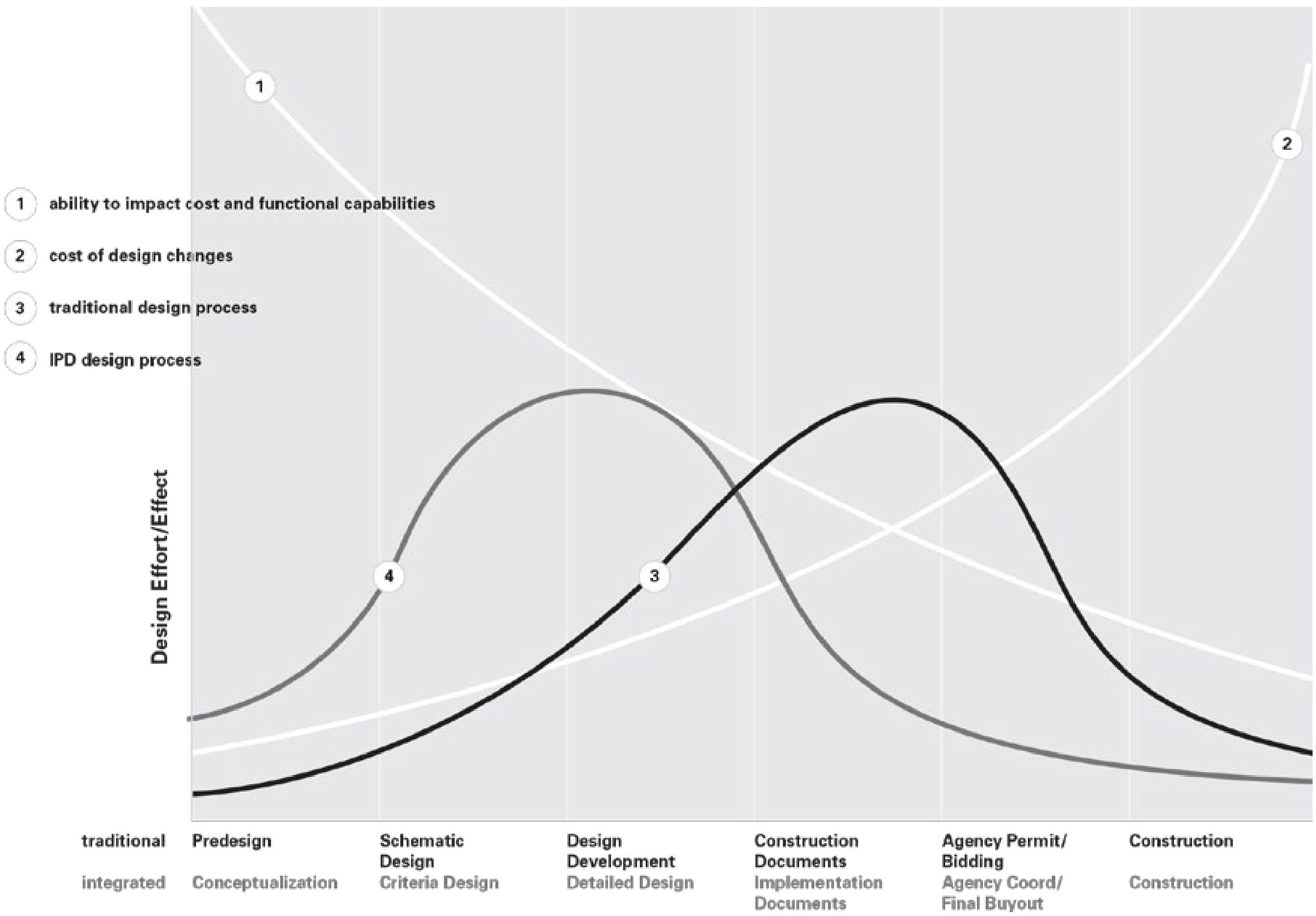

Figure 6. The MacLeamy curve: Time-effort comparison of a traditional and IPD design process illustrating the benefits of early decision-making – opportunity to influence positive outcomes maximized and cost of design changes minimized (Source: Integrated Project Delivery: A Guide, AIA California Council, 2007)

From this, we notice that the time-effort curve for a sustainable design process (as exemplified by the Trippe hall design process) and the IPD process are strikingly similar - there is a shift in the curve from the typical emphasis on the implementation phase of the project to the conceptualization phase, which has been proven to have a major improvement in building quality metrics (El Hasmar, 2012).

Therefore, it makes sense to consider sustainable design in a holistic manner from the very beginning of the building design process, as it has a greater ability to impact cost and a minimized cost for design changes. However, a quick look at green building rating systems (in the case below, LEED-NC) suggests that the graph with the same parameters may, in fact, look like the graph shown in Fig. 7:

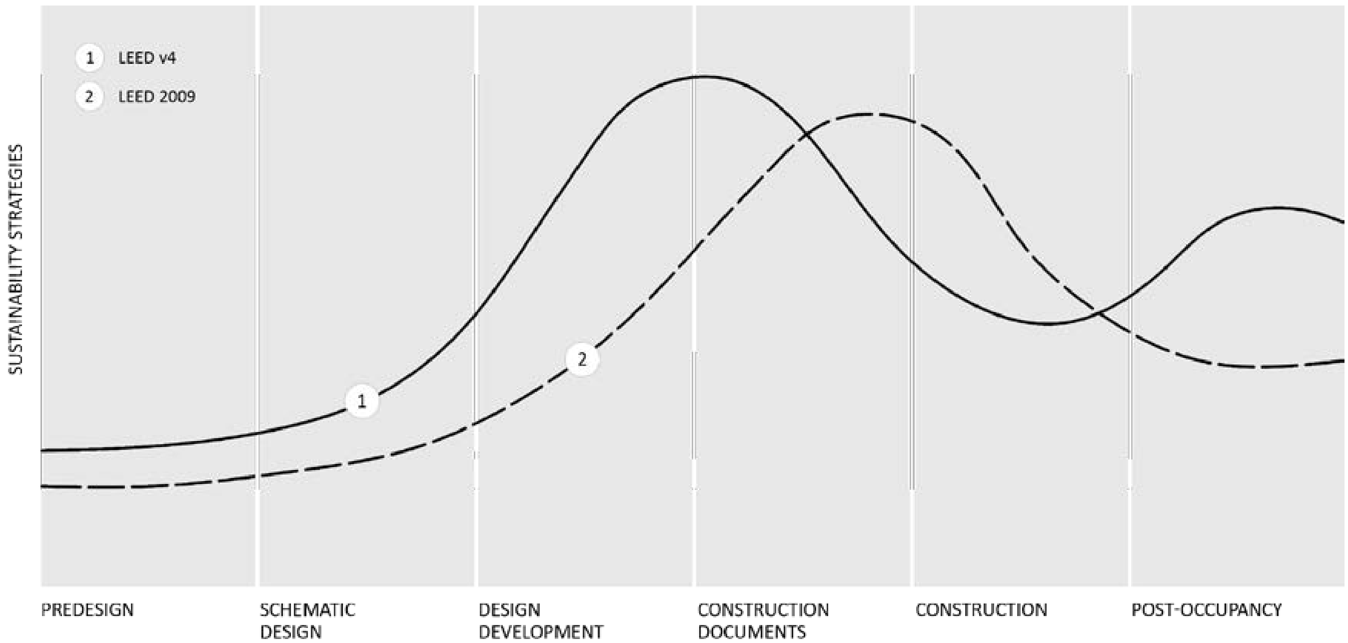

Figure 7. Schematic comparison of time-effort curves of LEED v4 and LEED 2009

The second, smaller 'bump' in LEED v4 is a more recent, welcome addition of the post-occupancy phase of energy-efficiency in a project – because energy-efficiency or sustainability needs to be considered over the entire life-cycle of the building, and not just through the end of the construction process. An emphasis on energy-efficient post-occupancy strategies is also particularly important for University projects like Trippe Hall, as in this case, the same 'client' is involved in multiple projects and the 'lessons learnt' can be applied by OPP and HFS in future projects. However, the crucial thing of note in the graph above is that there is little emphasis on the design phase, and most of the credits focus on the construction-related aspects of sustainability. In retrospect, this is not surprising; as these rating systems essentially focus on the 'tangible' aspects of sustainability – quantifiable aspects such as Energy Metering, IAQ assessment, etc. This analysis perhaps provides the answer to the observation made earlier in the Introduction about the absence of the intended 'fundamental shift' in the reduction of energy consumption in buildings – there is a lack of focus in current evaluation systems on the most critical aspect of a 'green' building project; the pre-design and design phase.

Some of the sustainable post-occupancy strategies considered in the Trippe Hall design charrettes by the ARCH 412 and ARCH 441 students are shown in Fig. 8:

Figure 8. Post-occupancy sustainability strategies considered by student teams during the charrette process

Therefore, by incorporating these strategies into our initial time-effort representation of the Trippe hall charrette design process; we posit the time-effort graph of the 'ideal sustainable building' to be as shown in Fig. 9:

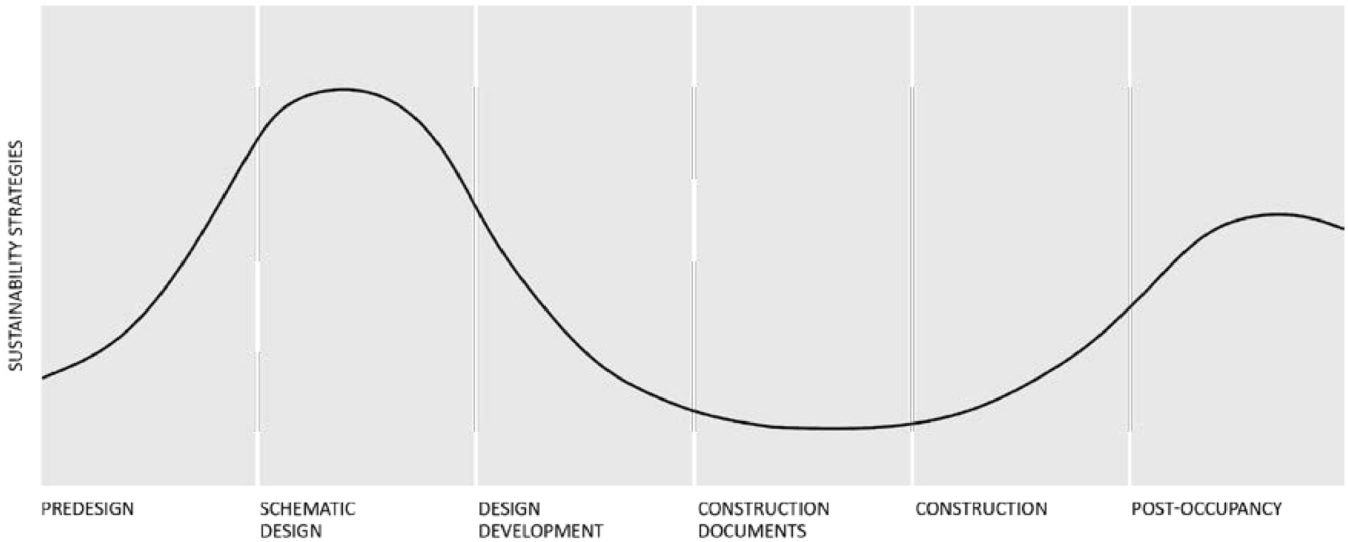

Figure 9. Projected time-effort graph of an 'ideal sustainable building'

This would be the case for a sustainable building designed in a holistic manner; which shows a clear, primary emphasis on strategies employed in the design stage and a secondary emphasis on the post-occupancy phase. For this IPD / Collaborative design + Sustainable design process to become popular in the industry, it needs to be proven that the area covered by the graph in Fig. 9 (time x effort, a loose interpretation of which is money) is lesser than that of a typical comparable building. It can be postulated that this is a very realistic scenario, as data is available to support this claim individually for both the IPD process and the sustainable design process - while there are numerous sources to make the case for sustainable buildings from an economic perspective, Asmar and Hanna (2012) prove quantitatively that IPD systems result in higher quality projects at no significant cost premiums

The following factors make the case for a collaborative process in the design and construction of new buildings:
Procedural symmetries: As shown in the preceding pages, in terms of their procedure, a collaborative design process and the sustainable design process are a natural fit – the factors of time and effort are emphasized in the same initial stages of the project. Both these processes require close collaboration, but the benefits of this are immense - for example, in the traditional linear design process, the input of the mechanical or lighting engineers are not taken into account by the designer when deciding the orientation of the building, even though they have the expertise to weigh in on the topic.
Cost savings: A marriage of these two design processes would pass on greater savings to the owner - while the collaborative process would save project costs by reducing the number of design changes in the later stages of the project and encourage lean construction (cost reduction during building construction); the sustainable design process would help reduce energy consumption and maintenance costs (cost reduction over the life cycle of the building post-occupancy).
Quality: In a survey of quality performance metrics of IPD projects that included structural and mechanical systems, the number of deficiency issues and the cost of warranty and latent defects, it has been shown that there are significant benefits over traditional delivery systems (Asmar and Hanna, 2012). Aspects of sustainability such as safety of materials and finishes, creation of demand-response systems, occupant satisfaction measures etc. will only

serve to enhance the quality of the building over not just the construction process (as a result of the collaborative process), but also the life cycle of the building (because of the sustainable design process).

CONCLUSIONS AND THE WAY FORWARD

The latent potential for designers that employ the combination of these two processes is immense in the construction sector, which consumes approximately 40% of energy, but has a time-effort-material wastage of 57% compared to just 26% wastage in the manufacturing sector (NASFA, 2010). In an era where specialization is considered to be key, it may just be that integration of these diverse processes in a sustainable manner is the way to go in the construction industry.

While the specific strategies of sustainability do not change as they are tangible aspects and are well documented; the way we implement them, in other words, the process, is the key. The impact of this demonstration project has already begun to take shape; as the Request For Proposal (RFP) document of the Trippe Hall project specifically mentions the work of the students and the Sustainable Housing Initiative:

"…this project has been selected to support an important initiative that combines student's classroom experience with the University's commitment to energy efficiency and environmental sustainability. Two classes, one in Architecture and one in Architectural Engineering, have used this project to research sustainability strategies and develop a "Living Green" presentation and report that will inform future residence halls. We expect this project to "raise the bar" and go beyond LEED to comprehensively address the social, economic and environmental aspects of sustainability and set the standard for future projects of this type. It is our intent to integrate these classes in the design/build process and hope that as you respond to this request you consider how this can be done. We also understand that this ambitious goal must be accomplished within the constraints of our typical process and cannot impact schedule and budget. Going forward, the SHI intends to collaborate with the University and its facilities management organizations in initiating a dialog with the designers of Trippe Hall."

Process, and the success of the project outcome is ultimately only as strong as the collaborative 'actors' impacting the decisions. The process of interaction in this project, which was initiated as an independent study by faculty members (research), developed by students in a classroom environment (academia), and involved the development of a 'real' building (industry) shows the potential of universities to act as initiators of positive change in collaborative environments. The civic issues embedded in this campus 'living laboratory' project are multifaceted and potentially informative for the future of the architecture, engineering and construction (AEC) industry in general, and particularly design professionals.

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