A 21st Century Approach to Trans-disciplinary Sustainable Design Education

ROBERT FLEMING
Philadelphia University

Why is teaching interdisciplinary design so important in the 21st century? After all architects and designers have succeeded quite well in mitigating the span between, form, on one end, and, function on the other. In the academies the struggle between form and function is well documented with accreditation requirements forcing a nod towards function while the overwhelming focus on formalism dominates most programs. All would be well, but the realm of design expectation has now been expanded to include the demand of an ethical response to the otherwise creative outcomes. Ethics are expressed, at minimum, via the LEED Rating System, and, at maximum via triple bottom line expectations that includes social responsibility. The difference here is the shift in our larger society towards sustainability as defined through the triple bottom line of enterprise, environment and equity. The clarity and power of this triad has propelled organizations (clients) to recalibrate their mission and vision statements and in turn require the expression of an elevated consciousness by architects and designers who shape built environment projects.

This design **consciousness** requires that buildings must now "perform" thereby minimize or better yet, eliminate their impact on the environment, reduce their demand for fossil fuels and increase their ability to provide for higher level human functioning. The added complexity of design deliverables requires integration between the professionals that, at one time, were able to navigate the typical design project in relative isolation. But the need for a more **integrated** and higher performing built environment projects has demanded a more **inclusive** approach to design that requires a level of collaboration and respect between professions rarely witnessed in history. Perhaps the Bauhaus and Taliesin are examples of modern day interdisciplinary practices but even then, the engineer and builder played subordinate roles in the process. Engineer Adler and architect Sullivan, pairing up in the late 19th century perhaps better reflect the current day alliances between disciplines because of the balance between performance and aesthetics. If performance based design requires an interdisciplinary team, then the rules of engagement must also change to accommodate a multiplicity of views and approaches. Integrated design charrettes featuring multiple stakeholders and multiple experts is now gaining momentum as the lynchpin of the integrated project delivery process. This new method of building design prizes **co-operation** over competition, and so the leap from the adversarial relationships between architect and builder and the hierarchical relationships between architect and engineer are now replaced with a collaborative relationship built upon mutual respect. Today, even construction managers are brought in early to the process, not just to control costs, but to share their wisdom early in the process. The desire to receive information from builders, engineers and project stakeholders early in the design process features new project process **alignments** which moves engineering optimization, value engineering, and end-user input much earlier in the process. In the 21st century the professional landscape is changing dramatically as designers, engineers, builders and architects are making the leap from exclusivity to inclusivity; From adversarial models of practice to cooperative models, From linear transfer of information between team members to non-linear, front loaded, digital information sharing; and from built

projects that meet aesthetic and functional goals to built projects that feature increasing levels of integration leading to higher environmental performance and higher levels of equity. As a response, this paper will explore important aspects of each *intention* in the proposed framework with a specific focus on how interdisciplinary work forms the centerpiece of a new approach to design education. In addition, specific examples of how each of the five intentions is placed into operation in a functioning graduate level sustainable design program at Philadelphia University will be interwoven into the discussion.

While the end game of interdisciplinary integrated design is apparent in the professional world, the movement forward remains slow at best. James Cramer writes in a recent issue of Design Intelligence, "Sadly according to our latest research, sustainable practices are not yet in the mainstream of architecture and design." He goes on to cite "lack of inertia", "denial", "resistance", "anemic leadership", "poor self-confidence", and "confusion" as reasons to explain the slowness to pursue sustainable design. Indeed, any wide spread change is going to be met with such responses. After all design practice is already demanding, let alone, the addition of significant additional burdens. When seeking answers to such problems, the focus is rarely placed upon the academies. Institutions of higher learning have come to reflect the 20th century bifurcation of the design, engineering and construction professions through the development of vertical educational silos, making it difficult to cross disciplines and explore non-linear design processes. In addition, many schools are built upon a competitive model of education that prizes grades and other external stimuli to spur effort, making it difficult to explore cooperative models of education so necessary for a successful interdisciplinary experience and in turn more difficult to reach the levels of integration that many academics desire but few achieve. Part of the problem lies not in desire but in operation. Esmail Baniassad, Chair of Architecture at Chinese University of Hong Kong writes that, "The challenge of sustainable design education lies not in our recognition of the need for a change in our values. It lies in how to take it beyond a mere change in our verbal vocabularies. The challenge is to go beyond intentional to operational." However, operation, or action without an effective framework can often end in unfulfilled learning objectives. The Framework of Intentions shown below in figure 1, expresses an approach to sustainable design education built upon: An ethical foundation (why are we designing?); Inclusiveness (who is involved in expressing design consciousness?); Cooperation (how can the interdisciplinary process work effectively?); Alignment (when should different aspects of the design process occur?); and finally Integration (what will the end the educational process result in?). The choice of integration as the goal of sustainable design education is supported by Mark Dekay's "Integral Theory" and/or Sim Van Der Ryn's "Emerging Integral Epoch" as ways to better understand and pursue sustainability at a deeper, more meaningful level. The now culturally accepted Triple Bottom Line while useful in explaining the philosophic goal of integral sustainability leaves few, if any clues as to how to attack such integration in a design education setting.

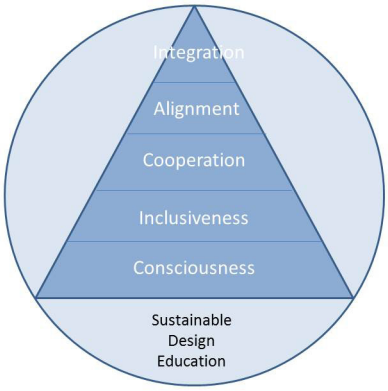

Figure 1. Proposed Framework of Intentions for Sustainable Design Education

INTENTION: DESIGN CONSCIOUSNESS

The notion of consciousness in design is not new. In the 1960's and 1970's architects and designers worked hard to pursue educational strategies that prized social awareness and energy efficiency. So, it would be inappropriate to argue that sustainability is a new consciousness for the design professions. However in the current pendulum swing towards ethical design as expressed through the integrative ideal of the Triple Bottom Line, the once polar opposites of economic progress and social/environmental progress have been released from their dialectic relationship allowing academics in the built environment to teach a more unified conception of design that balances the demands for

ethics with the more typical aspects of form and function. However, the question arises: where might students learn the origins, philosophies, ethics and frameworks of sustainability? It's unlikely that the already overburdened design studio can take on such an additional lofty subject, which leaves the design professor attempting to integrate sustainability into the studio with a thin intellectual backbone – making it easy for students, and yes, some faculty to abandon deeper explorations of sustainability in the studio.

In the graduate level Sustainable Design Program at Philadelphia University is offered as a case study, design consciousness is expressed via an introductory three credit course that is organized into two sections, the first dealing with the philosophies, ethics, and ethos of sustainability followed in the second half that explores how the ideals of sustainability are expressed practically in the built environment. While first half of the course is lofty and macroscopic, the second half is followed by detailed descriptions of sustainable design methodologies including specific coverage of the LEED rating system, the Living Building Challenge, commissioning, overview of energy modeling and more. The idea is to connect the larger themes of sustainability down into the methodologies needed to enact those themes. This course is offered at the beginning of the Program, thereby laying the ethical groundwork for future courses where the now established design consciousness can be re-encountered in later courses. This course may offer a model for a similar approach in undergraduate programs.

The required Sustainable Design Studio in the case study features students, faculty and guests (clients) to develop mission, vision and value propositions also known as Touchstones for a project. Subsequently the students go through an intense building/site programming process that is used to interpret the project's functional requirements with other ethical requirements that include, but are not limited to energy use, environmental material performance that express the larger Touchstones of the project. This is followed by the development of design directives that are meant to translate the non-physical aspirations of a project into specific design goals. In turn a series of strategies are identified to guide the design team. An example is shown in Table 1 below.

Touchstone	Water is a precious resource and should be protected, conserved and celebrated
Environmental goal setting and programming	Achieve a water neutral project as per the Living Building Challenge requirements
Design Directive	Develop roof forms to channel and direct water to cistern locations
Identified Strategies	Install rain garden's near entry of building, cistern rain water for use in toilet flushing

Table 1. Sample Design Studio Ethical Implementation

The same process is used to better understand and position issues of site response, energy performance, material purity and building layout. The educational strategy described above is designed to insure that the ethical foundations of a specific project as developed collaboratively between students, faculty and invited guests are followed through at all levels of the project. The student's projects are evaluated against the project touchstones, so the design review process is tied back to the ethical and moral foundation of the project.

INTENTION: INCLUSIVITY

If design consciousness forms the ethical backbone of sustainable design education, then the principle of inclusiveness forms the functional backbone. The choice of the word inclusivity expresses the need to build a broader vision of interdisciplinary work that includes a learning environment that is welcoming to students and faculty of varying ethnic, gender, and cultural backgrounds. This is critical as the quality of the collaborative experience must be equitable for each student.

In terms of discipline diversity, our tendency as humans is to streamline, simplify and optimize our processes. We do this on the pretense that time and money will be saved, convincing ourselves that a reductionist view via division of labor will lead to better projects. But design of the built environment is a messy process, fraught with stops and starts, entanglements between consultants, misunderstandings between clients, a desire to remain profitable and endless arguments with builders.

The emergence of the Integrated Delivery Process will, in theory, begin to address the fragmentation of the process and reduce the adversarial dynamic between disciplines. The professional environment is pre-disposed to pursue emerging delivery methods not because firms love change but more out of the need to constantly evolve practices to remain competitive. In the academies, however, the same kinds of pressures do not exist. Accreditation bodies ask for collaboration and interdisciplinary teaching and learning but not as a central theme to compliance. The accreditors understand very well the structural limitations placed upon programs making it difficult to pursue wide scale collaborative multi-disciplinary projects. Couple that with reticence among many faculty members to engage in such projects due to philosophic objections, or disinterest. Those faculty members who do want to collaborate are faced with a series of structural barriers including class schedule, credit allocation, room assignments, teaching load limits and so on. Lastly, the allegiance to one's discipline, protection of academic territory, and control issues constitute significant barriers to interdisciplinary learning.

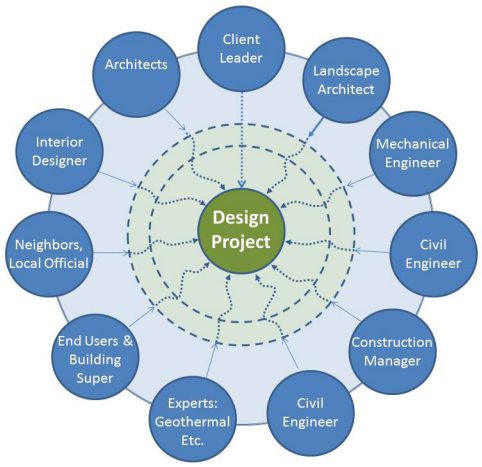

Figure 2. Inclusive Model of Design - Dashed lines reflect vetting interactions coordinated by experienced facilitator

WHO DESIGNS?

Why not begin to model in the academies the behaviors needed for success in a more integrated non-hierarchical design processes of the future? The figure below reflects the stakeholders present at a typical sustainable design charrette in the professional world. The operational challenge for the academies is to simulate this process so that students can begin to understand that everyone designs, or at least plays an active role in shaping design.

As a starting point in addressing some of the problems above, one could begin by exploring the participatory design process, in which stakeholders play a role in determining the design of a project. For example a school a teacher may provide a design proposal that could improve the functioning of project while also saving money. A builder may suggest an innovative yet cost effective idea to achieve specific design intent. While the role and impact of stakeholders is well documented in the participatory design process, traditional design projects also feature a wide array of designers in the broader sense. The difference is simply nomenclature. For example, an engineer who "calculates" and "specifies" a structural system is not considered a designer and yet his/her decisions impact the aesthetic sensibility of a given project. An engineer who develops a plan for the layout of ductwork, plumbing and electrical systems ultimately may impact a design developed without consideration of mechanical requirements at the beginning. The contractor who value engineers a project is "designing" through the alteration of material selection, the reduction of design complexity or the flat out removal of formalistic elements. The client that decides the height of a building based on return on investment is impacting the form and massing of a building. The cost estimator who overprices a certain window type in favor of a less expensive model is "designing" the building. If sustainable design by its very nature is collaborative and cooperative, then the traditional design studio is severely limited in its ability to deliver what is needed.

WHO OWNS THE DESIGN?

In the case study, the Program originators decided to characterize the program as "trans-disciplinary" as in transcending the disciplines to a new non-hierarchical model of teamwork. In this case students come into the program from all disciplines right from the beginning expecting to interact across disciplines. This side steps the typical barrier of inter departmental collaboration. The sample of students that come to the program includes architects, interior designers, civil engineers, mechanical engineers, landscape architects, planners, carpenters, and non-built environment professionals including develop-

ers, business owners and educators. The philosophy of the program is not to establish a "fabric" that students "fit into" but rather feature a dynamic culture that shifts with each incoming class. Students are encouraged to find comfort in their differences and draw upon their unique life experiences in the development of design projects. This plays out in the organization of student teams that always include non-designers and designers, and a mixture of built environment disciplines. A typical team might include a civil engineer, architect, interior designer and an anthropologist. The typical ten-week design studio project features a two-week "independent study" where students split off after the major design aspects of the project have been reasonably resolved. They work as individuals in consultation with their team and the faculty. Students are not required to work on something within their discipline but are allowed to work on something they are less familiar with. For example, an interior designer will work on landscape design or an engineer may focus on life cycle costing of the proposed building.

At the same time the teaching faculty must reflect the core values of the program and therefore are also diverse and also interact through the integrated design process. Studios are always combined to create a student group of 24. The typical ratio of 1-12 is split into four half positions and sometimes into 6 (1/3) positions depending on faculty availability. The typical makeup this *cohort* model is an architect, engineer, landscape architect and a professional from a sustainable design firm. That person's discipline varies. The faculty typically serves as charrette facilitators on one day each week – working with the students to attack a given problem. On another day they may serve as experts, providing specific lectures on technologies or design strategies for projects. On the third day they may meet with groups helping to review ideas or design proposals. Non- designers are brought in as "guest lecturers" but often come in to interact on design charrettes. For example, a branding consultant comes in each semester to work with the students on the communication aspects of their project.

INTENTION: COOPERATION

If interdisciplinary collaborative design forms the functional basis of the new educational model then a strong focus must be placed on the ground rules of interaction in such complex educational settings. The ethical underpinning of the curriculum demands that an equitable learning environment be established. A focus must be placed on how students interact with students and how faculty members interact with students and each other. In the Sustainable Design Studio submitted as a case study, the first two weeks of studio is dedicated communication, facilitation and mentoring skills, sublimation of ego, mutual respect, and acceptance/celebration of differences supporting a collective problem solving approach are the key aspects of a cooperative learning environment. Without these, collaboration can be either painful as control drama play out, or learning objectives may become unfulfilled as some students are marginalized in the process by those who take control. Faculty must be constantly aware of the group dynamics and constantly seek to make sure the process remains inclusive and useful to all participants.

In the sustainable design program offered as a case study, design presentations form the intersection when all parties come together to discuss the work. The spirit of the process involves a focus on collective problem solving, which includes invited participants. In this way there is a sense that "we are all in this together," and that the outcomes of the day's activities will ultimately be judged against the project's touchstones, goals and design directives established earlier in the project. In the table below, a sequence of typical events in the Sustainable Design Studio are outlined as a means to better understand the cooperative process.

Utilization of space can reflect a cooperative process. Figure 3 illustrates the layout of breakout sessions in a typical design charrette to encourage cooperation and collaborative problem solving. In this case the jurors and faculty have been reimagined as participants, experts and facilitators. Notice the level of engagement between each student and with the expert participant or faculty member.

Figure 4 (shown below) illustrates the layout of a "vetting" session at the end of a design charrette. In this format ideas are presented and vetted to determine the "best" concept or approach to solve a pre-defined problem. The level of engagement is high. Notice the seated location of the Participant/ Expert. They are part of the mix and not dominant in either physical position or in dominance of time speaking. The note pad on the right is used to record comments within the framework.

	Cooperative Sustainable Design Studio	Remarks
1	Professor works with the students to define the project and problem and develops a charrette workbook that will be used as a basis for design throughout the project	Professor and students are on the same team focusing on a very specific problem such as an RFP for a development site
2	Each week a different aspect of the design problem is addressed through a team oriented integrated design charrette. Appropriate team members are invited who represent either the client's point of view or a discipline specific expert that is appropriate for that week. Participants sit at tables with student teams and work on solving problems. Solutions are vetted in the larger group. (See Mid-review below for vetting process) The Facilitator's job is to make sure everyone is heard and that cooperative environment is maintained.	The pin-up or review is replaced with an integrated problem solving process. Student teams are encouraged to develop multiple solutions, including bad ones in order to explore the full range of possibilities and also to explore different student's ideas
3	Each student team presents project	At the end of the process, students present their work for "vetting." Multiple ideas are narrowed down in an equitable process (see below).
4	Student facilitator asks for clarifying questions. Team answers questions. Then "Pros" are collected by the student facilitator from participants, faculty and students and written on newsprint or typed onto a laptop and projected. "Cons" are collected by the student facilitator from the Participants, faculty and students. "Next steps" are collected by the student facilitator from the participants, faculty and students and written The Focus is on problem solving rather than entreating the participants.	Notice that arbitrary comments must now be contained in a zone of responses that can be digested and used later by students. The physical arrangement of the review space differs from a traditional critique - faculty and participants do not sit in front thereby expressing a sense of non-hierarchy in the process. See figure 4.The easel and newsprint recording of comments reassures students and participants that their voice has been heard and also helps to provide structure to the vetting process.
5	Overall wrap up: reflections from participants, faculty, students	Typically, everyone, including invited participants leave invigorated because the process is life affirming and uplifting. A sense of cooperation has been engendered.

Table 2. Case Study- Cooperative Model of Interaction

In one specific studio project the students and faculty worked in teams to try and understand education in the 21st century and make proposals for different types of schools that the studio would work on during the semester. The team generated concepts for charter schools, private schools, colleges and

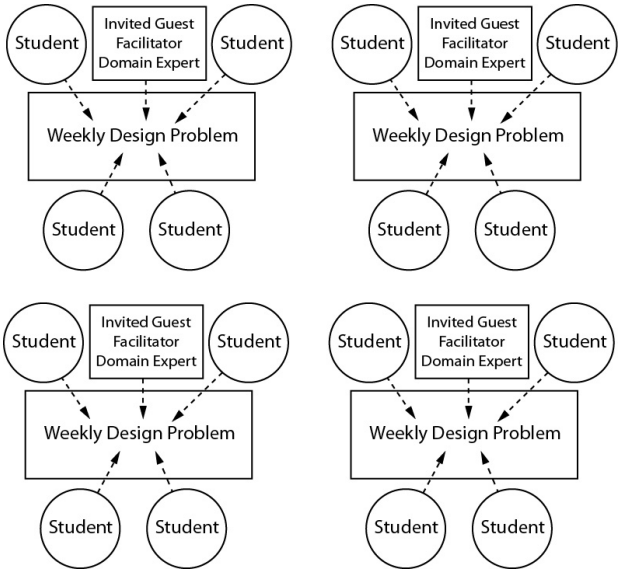

Figure 3. Typical Physical Layout of Collaborative break out sessions

public schools with different age groups and educational foci. In the following class, students realigned themselves into new teams based on which school project they wished to develop. This works to underscore that the design process is not about ownership of ideas but rather about pursuing ideas and concepts that are interesting to each person. In addition grades are immediately presented as unimportant, so students shift from trying to get a good grade to trying to solve a problem. In subsequent weeks, an established team will welcome a visit by other teams to help them tackle a specific aspect of their project. So, they may borrow a landscape architect to assist them with their site approach. It's also important to understand that the integrated design process seeks multiple answers for problems that are then vetted through a consensus-based process. This is why it's important to have an experienced sustainable design person on the team who has facilitation experience. Over the course of the semester students from each team are encouraged to take over the facilitation process in order to gain valuable experience.

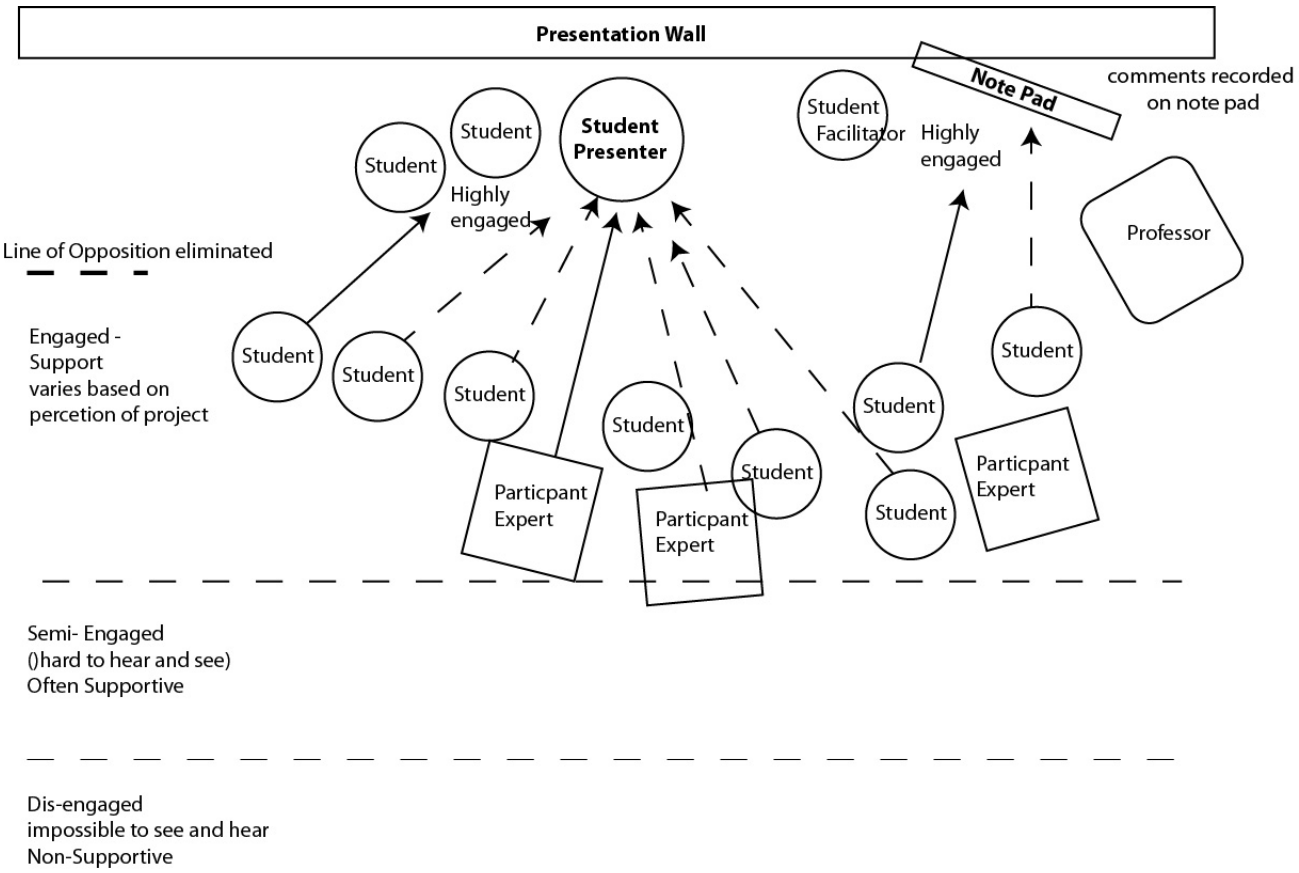

Figure 4. Arrangement of "Vetting Process" that replaces design juries

Step	Design Studio Process	Re-aligned Design Studio Process (Note – all disciplines present at all phases)
Charrette **1**	Develop ethical goals for the project	Development of guiding principles, mission & vision statements (Charrette Facilitator + Client rep)
Charrette **2**	Drive the ethical goals into the project's organization	Tangible goal setting including budget, energy goals, building/site program, third party metrics, active mechanical systems requirements (Construction Manager, Engineer)
Charrette **3**	Understand place before design and then work together to locate buildings based on environmental performance, and local context	Inventory/analysis – Site response (Landscape Architect)
Charrette **4**	Synthesize ethical goals with tangible realities of a given site	Development of design directives
Charrette **5**	Front load mechanical requirements before generation of form	Strategy identification, passive/mechanical/site strategies (Mechanical Engineer)
Charrette **6**	Form emerges as response to information gathered and design directives	Performative Design – form generation, theory/ concept development if applicable, early schematic energy modeling (Architect, Engineer)
Charrette **7**	Location of rooms/spaces to increase building performance and reflect a response to the local context	Spatial organization/concept in support of performance (Sustainable Interior Designer)
Charrette **8**	Aesthetic treatment	Aesthetic treatment/resolution of forms and motifs (Architect, Interior Designer, Landscape Architect)
Charrette **9**	Life Cycle assessment and energy modeling for project	Project optimization (wall sections, details and materials selection) to support performance goals (Construction Manager)
Charrette **10**	Develop communication strategy that connects ethical foundation through to the final project	Graphics + Project Documentation (Final energy modeling, PV array sizing, cistern sizing, life cycle costing/material analysis (Energy Modeler/Engineer)
Charette **11**	Sharing of ideas	Open House

Table 3. Re-aligned design studio process to optimize ethical, inclusive, and cooperative design process

INTENTION: ALIGNMENT

The premise of this Intention is centered on the idea that the design process does not necessarily need to be so linear in nature. In the typical professional design process, engineers, interior designers and builders are brought in very late into the process. At that point the architect has solidified his/her position on their project, so collaboration at that point is difficult. Instead, all disciplines must be involved in the process from the start, on equal footing. Once again, the integrated design process creates a learning environment where the various disciplines can interact in an equitable and effective manner. The faculty/facilitators are keys to the process, as they must recognize various control dramas. In the diagram below, a different set of disciplines is leading each week, but all disciplines remain involved in each step. For example interior design students get the opportunity to work on site issues. Architects get to consider the organization of mechanical systems to optimize both aesthetic and energy performance.

INTENTION: INTEGRATION

Clearly architecture and design schools have produced generations of professionals adept at creating thought provoking, intriguing, beguiling and poetic expressions through their work. Design faculty members use metaphor, profound insight, transformation, composition, and formal manipulation of elements in order to teach students to create evocative forms, spaces and images that constitute a possible (but not probable) built environment. This realm of the poetic, bolstered by theoretical discourse, although flawed in its superficiality remains a critical part of the educational process. Beauty is an essential aspect of sustainability and can never be sacrificed in the educational process. However, its elevation to the top of the pedagogical food pyramid creates enormous problems for those seeking to educate young designers for the emerging context of integration in our society.

Design integration must go beyond merely identifying various sustainable technologies. For example, students in traditional programs will point to a drawing that represents solar panels or a green roof but rarely do they understand the quantitative aspects of the impact of the technologies. In the case study students take a Sustainable Systems course, which is taught by engineers and requires the following as a sample:

Baseline Establishment	Strategy Development	Metrics
Calculation of base electricity demands for the proposed project using EQUEST software	Calculation of proposed building's electricity demands after application of passive and active strategies	Sizing of PV panel arrays to account for remaining electricity demands to reach net zero energy status
Calculation of rain water catchment based on roof size and local precipitation levels	Selection of water technologies based on environmental goals set early in the project	Calculation of cistern size and run off reductions to meet third party metrics
Calculation of available daylight in a given location	Identification of daylighting and shading strategies	Calculation of daylight received in building to meet third part metrics

Table 4. Case Study- Integrative Tasks required in the Sustainable Design program

Students repeat the above calculation process from their Sustainable Systems course in their proposed project in the subsequent Sustainable Design Studio and present all calculations as part of their final presentations in order to meet a LEED Platinum rating, Living Building Challenge or Net Zero energy standards identified early in the programming process. This requirement forces students to consider the performative aspects of the project in conjunction with the aesthetic impacts. Students quickly realize just how much roof space is required for net zero energy and are often unhappy about the aesthetic impact. This is when the ethical component comes into play as students are asked to weigh the relative benefits of solar power versus the aesthetic impact of the

building and come up with design resolutions to the problem. Aesthetic treatments for a studio project come very late in the process with the premise being that good designers can more easily discover aesthetic solutions to fixed problems rather than try and force performance based technologies and strategies into a formalistic design solution. In the most recent iteration of the Sustainable Design Studio, the mechanical engineering lecture was moved to the very front of the design process to insure that mechanical room location and primary duct runs are developed to be as efficient as possible. Then the spatial, organizational and aesthetic process unfolds.

CONCLUSION

The typical counter argument to the pedagogy offered in the Sustainable Design Studio revolves around the position that the performative design process sublimates the imagination and creativity of design students, which, in turn, will doom society to a plethora of high performing, yet uninspiring architecture in the future. But the ethical underpinning of design in the 21st century demands a break from tradition, a departure from over wrought formalistic design solutions that are thought provoking and beguiling but offer little sustenance for a world in need of healing and a culture in need of new and powerful equitable social alignments. In the academies, the call for a new, more integrated pedagogy buttressed by ethics, enabled by trans-disciplinary design, imbued with cooperation and realigned for optimal results may lead to a fundamentally new approach to education that could lay the ground work for the next generation of built environment professions. Lastly, patience and temperance is needed, as the recent history of authentic sustainable design education is so raw and unrefined that the jury is still out regarding the ultimate impact of such programs. More work, more time and more exploration is needed to better understand the potential of such educational approaches.

REFERENCES

Altomonte Sergio, "Environmental Education for Sustainable Architecture," Review of European Studies, Vol 1, No 2, Canadian Centre of Science in Education, December 2009

Anthony, Kathryn, Design Juries on Trial: The Renaissance of the Design Studio, Van Nostrand Reinhold, NY, 1991

Boyer, E. and Mitgang, L., Building Community: A New Future for Architectural Education and Practice, The Carnegie Foundation for the Advancement of Teaching, Princeton, NJ, 1996

Cramer, James, "Sustainability Leadership: From Stagnation to Liberation," Design Intelligence, 2011 Green and Sustainable Design Survey Vol 17 No 4, July/August 2011

Dekay, Mark, Integral Sustainable Design: Transformative Perspectives, Routledge, 2011

Fraker, H. "Is Sustainable Design Still Marginalized in the Schools?" ACSA News, Vol. 30, No. 5, 2000

Ho, Cathy Lang, "The Future Belongs to Woodbury," Architect Magzine, March 2011, pgs 83-89

Lennertz, Bill, Lutzenhiser, Aarin, The Charrette Handbook, The Essential Guide for Accelerated, Collaborative Community Planning, American Planning Association, 2006

Leibowitz, Sandra, Ecological Design and Building Schools, New Village Press, Oakland California, 2005

Libby, Bryan, "Studio on Steroids," Architect Magazine, March 2011 pgs 54-57

Van Der Ryn, Sim, Design for Life: The Architecture of Sim Van Der Ryn, Gibbs Smith Publisher, 2005

Wheelwright, P., "Text and lumps: thoughts on science and sustainability", ACSA News, Vol. 30, No. 6., 2000

Wright, James, "Introducing Sustainability into the Architecture Curriculum in the United States," International Journal of Sustainability in Higher Education, Vol 4, No 2, 2009

NAAB National Architectural Accrediting Board, NAAB Conditions for Accreditation for Professional Degree Programs in Architecture. New York: AIA. (2010)