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AFTER the SOLAR DECATHLON: CREATING a NEW DESIGN-BUILD PROGRAM

Session Topic: Design – Build & Public Interest Design

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Abstract

In Fall 2011, the University of Nevada – Las Vegas School of Architecture's David G. Howryla Design Build Studio began development of UNLV's entry into the U.S. Department of Energy Solar Decathlon 2013, an international, university-based competition to design and build solar-powered housing prototypes. As a competition that requires collaboration between engineering, architecture, interior design, marketing, and communications, the Solar Decathlon is an effective tool for simulating teamwork on real projects.

The School of Architecture's intent was to use the Solar Decathlon as a catalyst for creating UNLV's Design Build program. The project allowed the School to use support for the project to acquire tools & equipment essential to creating the house, and for upgrading the school's shop facilities. The projects completed immediately following the Solar Decathlon utilized both digital fabrication and prefabrication. This is significant because the School intends to leverage both of these competencies, developed during the Solar Decathlon, in order to further the School's craft-based pedagogy. Due to the Design Build Studio's success in developing the Solar Decathlon house, there has been significant interest from multiple parties in using the program's offsite-construction experience to create projects that will benefit from these lessons.

After the Solar Decathlon: Creating a New Design-Build Program

In Fall 2011, the University of Nevada – Las Vegas School of Architecture's David G. Howryla Design Build Studio began development of UNLV's entry into the U.S. Department of Energy Solar Decathlon 2013, an international, university-based competition to design and build solar-powered housing prototypes. As a competition that requires collaboration between engineering, architecture, interior design, marketing, and communications, the Solar Decathlon is an effective tool for simulating teamwork on real projects.

Design build education is an ideal pedagogy for developing a designer's skills. Teamwork, workmanship, and understanding are necessary to form the synthesis needed to create compelling projects. Technique is derived from the Greek *techné*,

which means 'the rational method involved in producing an object, goal, or objective;' Aristotle describes craft as itself also *epistémé* or knowledge as a practice grounded in an 'account' – something involving theoretical understanding.¹ This blending of workmanship and understanding is critical to a student's development of a coherent design process. Students must learn to develop a working method that advances their ability to synthesize complex pieces of data into a coherent whole.

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UNLV Design Build Studio's Approach to the Solar Decathlon

When the Design Build Studio began work on DesertSol, Team Las Vegas' Solar Decathlon entry, the Studio determined that the operative principle was that wasn't a solar project first; it was a *house* first. This was a critical determination, as it strongly informed all following decisions. While it was essential to the success of the project that all of the engineering systems be innovative, the engineering systems should support this mission, rather than the other way round. Team Las Vegas determined that it was imperative to design a credible, serious project that celebrated the uniqueness of our location, climate, and culture, without resorting to clichés or predictable, 'safe' responses. The following passage from Juhani Pallasmaa's *The Eyes of the Skin* had a particularly profound impact on the design team:

In recent decades, a new architectural imagery has emerged, which employs reflection, gradations of transparency, overlay and juxtaposition to create a sense of spatial thickness, as well as subtle and changing sensations of movement and light. This new sensibility promises an architecture that can turn the relative immateriality and weightlessness of recent technological construction into a positive experience of space, place and meaning.²

Good architecture creates a sense of place and inspires memorable experiences. Thoughtful consideration of comfort, scale, light, and sensory experience distinguish a home from a simple shelter – these are the qualities people look for in a well-designed custom home. Phenomenological considerations like these are as relevant now as ever – perhaps more so, with society's preoccupation with the virtual environment; people need a release from the stresses of contemporary life. This philosophy of foregrounding the body's sensory experiences has formed the basis of the Design Build Studio's work since its inception, and will continue to inform future projects.



Figure 1: DesertSol Exterior
Source: Kevin Duffy 2013.

Engineering Collaboration: Opportunities and Challenges

As mentioned previously, a design-build project is an ideal opportunity to expose students the opportunities and challenges of collaboration. Learning to work with engineers is an essential skill for every designer, and creating the Solar Decathlon house demonstrated the challenges inherent in this process.

Working with engineering students for the first time posed unique challenges and opportunities. The

greatest initial challenge architecture students encountered was learning how to communicate effectively. As communication improved, the architecture students began to slowly realize that engineers solve the problems they are asked to solve; in other words, it is essential that the architecture students carefully formulate their questions, in order to receive useful input.

The engineering students' biggest initial hurdle was that in the early stages, it is virtually impossible for architecture students to give them solid, determinate information with which to begin designing. An example was the determination of the roof pitch, which required analysis of solar insolation, optimal angle of incidence for PV collectors, daylighting and cross ventilation. The engineers asked repeatedly which determinant was most important, while the architecture students asked how much flexibility or range of variation was tolerable for each determinant. The engineers initially found talk of ranges, instead of optimized values highly problematic.

The reason architects need ranges like this is in order to determine whether there may be an angle that satisfies the majority of these interrelated design determinants. This turned out to be true in the case of the roof angle, as well as several other key design elements.

Engaging in design-build projects like the Solar Decathlon are an excellent means of teaching the value of collaboration, communication, and the need for effective documentation and transmission of design intent. Even if the participants never again pick up building tools, the experience becomes embedded in their memory, forever changing the relationship between design, drawing, and construction.

Design – Build Precedent Research: Learning From Successful Programs

As the UNLV Design Build Studio began transitioning away from the Solar Decathlon project, research was conducted on effective design-build programs. Investigating these programs was essential to formulating an effective strategy for the Studio. Two programs in the West, as well as one of the most successful programs in the United States, Studio 804 at the University of Kansas, were studied closely for insights into their success. Finally, the undergraduate studio at Kansas was discovered to share many of the goals and processes UNLV began implementing following the Solar Decathlon.

Studio 804 receives no funding or support from the university; it is entirely funded by the projects they build. The Studio is set up as a 501c(3) nonprofit corporation, and is open to graduate students through

a competitive selection process. The program started by designing and building single-family houses, using construction loans to fund the projects; sale of the houses would support the following year's effort. As the program developed a track record of success, they began designing larger projects, such as the 5.4.7 Arts Center, the Galileo Pavilion, and most recently, an addition to the School of Architecture at the University of Kansas.

On public projects, Studio 804 bids for the design-build project in a similar manner to how a commercial design-build firm might approach the process. The primary difference is that in most cases, Studio 804 helps the client develop the program and scope of work, and then they are hired to design and build the project.³

Studio 804's model was investigated as UNLV transitioned away from the Solar Decathlon, due to their exceptional critical success. However, this model could not be implemented, due to strict anti-competitive regulations in Nevada stating state agencies cannot be perceived as taking business away from commercial contractors. This limitation proved decisive in determining how a successful design-build program could be established at UNLV. However, the logistical organization, exceptional craft, and commitment to sustainable design were particularly noteworthy, and serve as an exceptionally effective precedent for what is possible for a thoughtfully organized and committed program.

As a regional example, the Drachman Design-Build Coalition at the University of Arizona School of Architecture was investigated. Mary Hardin, Director of the program, was particularly generous in describing the administrative requirements for developing their program, also organized as a 501c(3) nonprofit corporation.

I began by incorporating as a business entity in 2004. [In Arizona], one has to fill out forms of incorporation that can be found on the website for the Arizona Corporation Commission. It requires writing Articles of Incorporation and By-Laws. It will also require an annual fee and an annual report, filed on line.

I hired an attorney to help set up the new corporation as a 501c(3) non-profit. Having the non-profit corporation status allowed us to get donations of land from the City of Tucson. We [were able to receive] donations and [donors] could get tax write-offs. Most importantly, it

allowed the university to extend liability coverage to us (faculty who participate as licensed professionals and medical coverage for students).

501c3 status also lets us take out construction loans as a business entity. I take out a construction loan for each house, and then pay it back when each house is sold. The donated land serves as the collateral for the loan. I have [received] loans from the Tucson Industrial Development Authority and the Pima County Industrial Development Authority. These are groups of bankers tasked with making loans to worthy community outreach projects. Most cities have an IDA, because banks are required to loan 3% of their loan funds to community projects.⁴

The University of Arizona's program operates in a manner analogous to Studio 804's, with the primary difference bring a focus on affordable housing. This variation may be workable in Nevada, as the clients have to demonstrate need through the community outreach organizations they work with. This population is not currently served by the housing industry, so a case could be made for UNLV's involvement not being a competitive violation. Careful thought went into considering this option. Assisting an underserved community is highly compatible with the Design-Build Studio's mission. The primary reason this path was not taken was that while providing a house is life-changing for the family that receives it, the impact on the community as a whole is limited. By focusing on public projects, the Design Build Studio can effectively utilize limited resources to benefit more people in the state.

Another successful Western design-program is the University of Utah's Design Build Bluff, founded by Hank Louis in 2000 as a nonprofit corporation. Louis stepped down in 2013, with Jose Galarza taking over.

Hank Louis was heavily influenced by the precedent set by Rural Studio founder Sam Mockbee. He made contact with the Navajo Nation, and began working with them to identify families in need of assistance. Working on the reservation offers several advantages, most notably a radically simplified permitting and regulatory oversight process. Their focus has been primarily on single-family housing, with funding coming from nonprofits and charitable foundations. The program was also established as a 501c(3) nonprofit corporation, but has since been reorganized into an arm of the university, giving them greater oversight of program operations.^{5, 6}

During research on Studio 804, I was introduced to the work of Dirt Works Studio, the third-year undergraduate design-build studio also held at the University of Kansas. Projects include a trailhead and other improvements for the Kansas Biological Survey and other public clients.

Unlike the other programs discussed here, Dirt Works is a required course for third year students. In addition, this program is funded through the public projects brought into the program by its coordinator, Chad Kraus.⁷

Dirt Works is in many ways organized most similarly to the UNLV Design Build Studio; the focus is on public projects and the studio is a component of the University of Kansas School of Architecture, rather than a separate entity. The primary difference is a focus on rammed earth and other (primarily) site-building strategies, rather than the offsite construction emphasis of the Design Build Studio.

Construction Technology Revisions – a Pedagogy of Teaching Technology Develops

A recent PBS program about researchers trying to recreate an ancient Egyptian chariot, demonstrated just how sophisticated the design was; the ancient builders really understood the nature of the problem at hand. The design was a careful refinement of material properties, production and craft techniques, demonstrated an understanding of the body, and an exceptional understanding of creating something fit for purpose. It underscored that there was nothing primitive about ancient people's response to technological need. If anything, contemporary people are far more primitive than they were; student design projects are often far less thoughtful regarding their responses to need and particularly to materials.

Students today generally have no understanding of materials. They are not necessarily to blame; material properties and building methods have been eliminated from their experience and education. Everything they encounter in daily life is designed to give the appearance of being effortless, seamless, and without resistance. Needless to say, when students first encounter real materials, they are confronted with real failure, often for the first time. It is deeply frustrating for them, as they have never experienced this feeling before, and have no idea how to respond to it.

In response to this, the Design Build Studio pedagogy emphasizes making very early in the design process, often from the first week, building details of small components to study ideas, full-scale mockups of places where human interfaces are most critical, or where complex conditions are difficult to represent.

The Fall 2014 studio exercises, described later in this paper were particularly effective for the third-year students enrolled in the course, especially regarding tectonic joints and the interface with the human body.

Hands-on exercises have been incorporated into the revised construction technology sequence, now taught by the Design Build Studio Coordinator. This was done to address the aforementioned issues with material understanding, as well recognizing that only a small number of students are directly impacted by the design-build program. It is very difficult for students to really understand concrete, for example, by reading about it, watching a lecture, or even videos showing the processes of creating and placing it. Actually doing it, even on a small project, will fundamentally alter their thinking.

The construction technology course sequence is typically taken in the third year, with the design-build studio offered during the fourth year. This enables the design-build studio to build upon the knowledge gained in the construction technology course. The intent is that construction technology gives all students the basic foundations, terminology, construction theory, means & methods, and helps students to understand some of the reasons why construction materials & systems are selected and used.

The construction technology sequence has been organized as two components; lecture and exercises. The lectures discuss construction systems and how building assemblies are constructed. The exercises in the first semester focus on assisting students in developing a deeper understanding of the basic properties of materials. To this end, the exercises do not have specific constructional/representational content; they are explorations of material properties and how designers can develop the materials' expressive opportunities, but driven by the materials themselves, rather than conceptions imposed upon the materials.

There are three exercises; a wood/tectonic exercise, a casting/stereotomic exercise (usually, but not limited to, concrete), and a third exercise in which students must integrate tectonic and stereotomic materials. The integrated exercise also requires students to take a critical position regarding materials, tectonic strategies, and conceptual approaches to construction detailing.

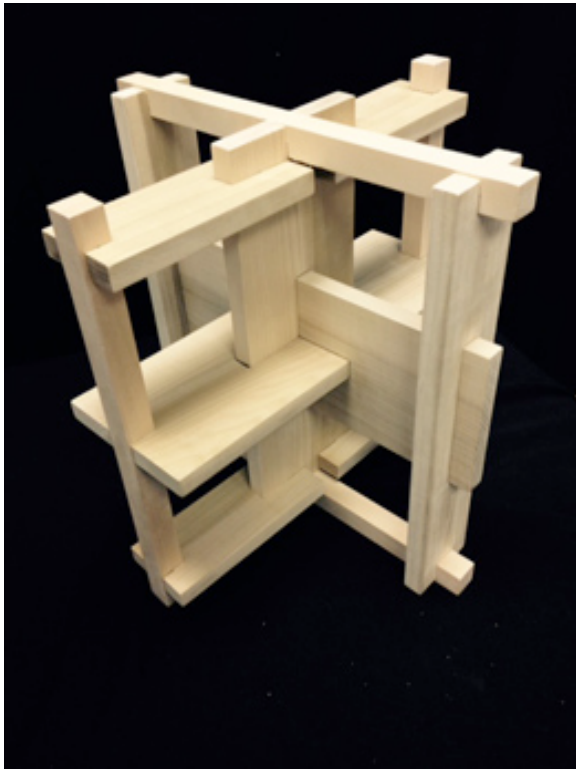


Figure 2: Construction Technology I Wood Exercise
Source: UNLV Design Build Studio 2014.



Figure 3: Construction Technology I Mixed-Material Exercise
Source: UNLV Design Build Studio 2014.

The key to these explorations leading to designs driven by materials themselves, instead of the more common conception (among students) of imposing a preconceived idea onto the materials is to require students to begin building and making at the project's outset. They cannot be allowed to design it first, and then try building it; in the case of the casting project, their first casting was due a week after the project began, giving the students little time to over-think the design before getting to work. Those that had spent time designing before building have been forced to reconsider their design approach, given the high failure rate of first castings.

During the second semester, the students are required to build upon the knowledge gained from these exercises in order to build a series of full-scale construction details. The details are again intended as critical exercises, in that the students must clearly articulate a position regarding material/tectonic and detailing strategies, and how these approaches underscore a comprehensive architectural theory.

This foundation is essential for students entering the Design Build Studio, but is also highly relevant for students pursuing a more traditional architectural education. In discussions with and studies of the work of exceptional architects, virtually all of them have stressed the importance of a clearly-articulated approach to construction and detailing; in fact, many of them have stated that this is essential to making good architecture possible. If architecture students do not develop an appreciation of the importance of this subject, they will not be successful in their pursuits, and if educators do not instill this appreciation in students, it will slowly disappear from the profession. If this happens, detailing will be left to contractors, who have very different agendas than architects, and architecture as a profession will become increasingly irrelevant to the building industry; this trend would lead in time to the demise of the profession.

The rise of construction management, interior design, signage/exhibit design, envelope consultants, and many, many others have been the result of architects willingly giving away authority/responsibility. If architects instead embrace their traditional role as master builders, they can regain the respect of society, save their profession, and have more control of the process of their buildings' realization. Rick Joy once said that if architects simply focused on doing a good job, many of the problems the profession faces would take care of themselves.⁸ He was referring to the lack of fees, lack of respect for the profession, and constant conflict with contractors (and sometimes owners). Will Bruder used to tell his staff regularly that "an owner will never ask for less than 100% of your creativity,"⁹ and he meant this in many ways, not

the least of which is that architects have a responsibility to do the best, most complete work they can.

A key component of doing the best, most complete work possible is to use all of the tools at our disposal, as effectively as possible. This requires a careful understanding of the most basic components of architecture, its language, its words. The words are composed of materials, the sentences written in a building's tectonics and detailing. Learning how to speak is the first step towards writing poetry. Learning the building art's material language is the first step to creating architecture.

Once this approach to the construction technology sequence has fully permeated the School of Architecture's program, it will have positive effects on the students' design work. Students entering the Design Build Studio will be in a much better position to design and build their projects, having been immersed in this more hands-on approach. All of these lessons are intended to make students better architects. Architecture drives the creation of real things, real places.

After the Solar Decathlon

After the team returned from successfully participating in the competition, the fourth-year students that joined the team in August 2013 needed a project to give them something of their own for their portfolios, but also to utilize the energy of the Decathlon to making a meaningful intervention in the School of Architecture.

The project was to design and construct a gathering space at the midpoint of the School of Architecture studio corridor. The project created a "room" that breaks up the extension of the corridor, allowing visitors to perceive the corridor more as a north review space and a south review space, with the project mediating between these two spaces. It was designed and constructed in two months, with numerous of refinements during the iterative design/construction process. One essential learning outcome of this iterative process was that the students gradually began to understand that virtually any problem has multiple solutions; the right one is the solution that is consistent with their design intentions.

Students were explicitly challenged to utilize both digital and conventional construction processes in the creation of this project. It was essential that the students learn to use each method appropriately. Digital technology is just another tool that offers opportunities to find and solve problems. It would be a mistake not to take full advantage of emerging technologies, but designers must not succumb to tool fixation. Helping students to develop an

understanding of the appropriate methods for the task at hand was a fundamental goal of the studio.



Figure 4: Fall 2013 installation
Source: UNLV Design Build 2014

In Spring 2014, the studio explored another intervention in the School, which was prototyped during the semester; final construction was scheduled for the Fall 2014 semester. The intent was to transform the graduate studio critique space/staircase into a multimedia presentation space. The intervention was to serve as a gathering space for students, as well as providing seating for presentations. This project was shelved, due to resistance from the university's building department to having students building the project, even with professional oversight. This was despite initial support from the department's director. The project was still highly instructive, as students were exposed to the occasionally byzantine regulatory processes under which professional architects must labor.

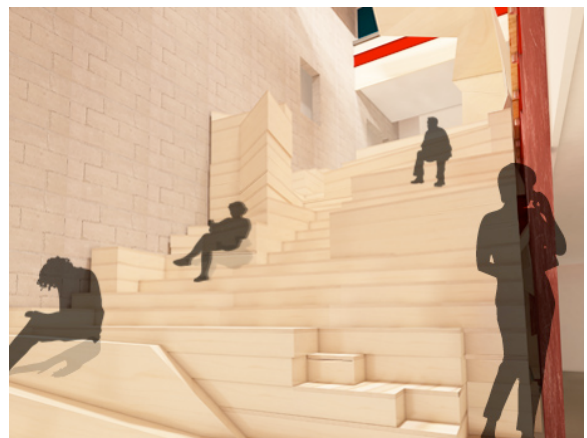


Figure 5: Spring 2014 installation proposal
Source: UNLV Design Build 2014

The Fall 2014 Design Build Studio was unusual in that for the first time, it was scheduled as a third-year studio, meaning that the students were concurrently enrolled in the construction technology sequence. There was significant concern initially, as the students would apparently be less experienced than previous students, as well as less knowledgeable regarding construction materials and techniques.

The concerns, while accurate, turned out to be far less problematic than expected. The students were highly conscious of their lack of experience, and while apprehensive, eagerly embraced the challenge of learning the processes necessary for completing the project.

The project was to design and construct another gathering space within the School of Architecture's studio corridor, to supplement the installation completed during Fall 2013. The intervention provided for student gatherings, such as study groups, as well as providing surfaces for reviews/display of drawings and presentation boards. The primary design task was the development of a module that can perform multiple functions, with one side of the two-sided unit accommodating seating, while displays could be hung on the other side. The installation had to be built in accordance with all applicable building codes; two critical design determinants were that the modules must be movable/self-supporting, and must be no taller than 5'-9", due to local fire codes.

The design solution utilizes a plywood frame, with a hand-laid plywood skin applied to the seating surface; the opposite side was clad in hot-rolled steel panels, allowing drawing mounting via magnets. The project was interesting in that it required a highly iterative design development process, as did learning the processes necessary to construct the modules. The plywood skin was an excellent example of this, as well as being a component that utilized both digital and conventional construction processes. The mold necessary for laying the plywood skin was cut on a CNC router, while actually laying the veneer flitches (1/8" luan) into the mold required a slow process of heat/steam bending. The bending process necessitated a great deal of patience; rushing the heating or bending resulted in veneer failure. Students developed a feel for when the veneer was relaxed enough for bending following the heating process.



Figure 6: Spring 2014 installation
Source: UNLV Design Build 2014

These projects, while relatively small in scale, utilized both digital fabrication and prefabrication. This is significant because the Design Build Studio intended to use both of these competencies, developed during the Solar Decathlon, in order to further the School's craft- and sensory-based pedagogy.

Since completion of the Solar Decathlon house, there has been significant interest from multiple parties to utilize the Studio's offsite-construction experience to create projects that would benefit from these lessons. Despite the team's tremendous success, translating this interest into viable projects has taken significantly more time and effort than expected. The Design Build Studio's faculty coordinator vetted interested parties, as well as actively searching for projects that fit the program's mission.

UNLV's School of Architecture serves the functions normally associated with land grant universities. It is the sole architectural program in the state, and its mission is to work for the benefit of the people of Nevada. The Design Build Studio's mission includes assisting the state's residents in connecting to the natural resources, wildlife, and ecosystems. In January 2015, the Design Build Studio began work on a project for the Nevada State Parks Division, a box office for the Lake Tahoe Shakespeare Festival. The Festival is an annual event at Sand Harbor State

Park, Lake Tahoe, Nevada. The project, while small, is in a highly public environment, and serves as an opportunity to showcase the Studio's capability to work in diverse environmental conditions.

Representatives of the State Parks Division have expressed an interest in developing a long-term relationship, with the Design-Build Studio developing projects across the state. Future projects are anticipated to include guest cabins, ramadas, viewing platforms, and other projects that enrich visitor experiences at the parks. This relationship is an ideal partnership, leveraging UNLV's prefabrication skills and social/environmental focus while meeting the Parks Division's needs. If the first project is successful, this partnership will be the catalyst that creates a sustainable future for the Design Build Studio.



Figure 7: Lake Tahoe Shakespeare Festival Site
Source: UNLV Design Build 2015



Figure 8: Shakespeare Festival Ticket Booth
Source: UNLV Design Build 2015

Why Prefab?

The Design Build Studio has determined that offsite-constructed design build projects are an appropriate venue for exploration for several reasons. One of the most obvious reasons is that it allows students throughout the school to see the work produced. This is a primary component of the Studio's pedagogical approach. All students, not just those working in the design-build studio (capped at 15 students) can see the progress and understand the reality of construction processes. As stated previously, The Design Build Coordinator teaches the Construction Technology sequence, which all students in Architecture and Interior Architecture must take, and by having the ability to take students outside, a 60-second walk from their classroom, every student in these programs can be exposed to examples and processes directly related to their coursework. Additionally, due to this proximity, it will be possible to offer seminar courses open to students throughout the curriculum that allow them to perform focused exercises, such as digitally-fabricated components, furniture design, and other activities that may support the completion of the projects. The simplified logistics, from a student perspective, effectively lower barriers to greater student involvement in hands-on learning activities.

In addition, the desire by the aforementioned clients to build in highly environmentally sensitive locations makes prefabricated construction an ideal method of construction. Prefabricated buildings, particularly those largely constructed offsite and trucked/craned into place, enable dramatically smaller construction footprints. Excavation is typically much less than conventional construction, and the reduced site storage and staging areas can further mitigate environmental impacts. This makes it easier to meet sustainable design guidelines such as the USGBC's LEED Sustainable Sites Credit 6.1, which states that construction should stay within 40 feet of a building's perimeter, within 10 feet of sidewalks, and so forth. Tolerances such as these are much more easily maintained with this construction methodology.¹⁰

Finally, prefabrication greatly facilitates project management, enhances jobsite security with minimal financial outlay (the School of Architecture has a secure building yard adjacent to its shop facilities), and if performed carefully, can dramatically reduce material waste. Offsite construction also makes the permit/review process simpler, as the building is reviewed solely by the State of Nevada's Modular Housing Division; sitework and utility connections are reviewable by local governments. These expedients/observations, while significant, are not the primary reason for offsite construction. Instead, offsite construction offers the possibility of offering clients the possibility of purchasing their building and

land separately; instead of having to build new buildings every time our mobile society requires people to relocate, the owner can buy one building and relocate it. By decoupling land from building, it offers an alternate paradigm, one that may result in less waste, greater energy efficiency, less destruction of sensitive landscapes, and greater quality control.

CONCLUSION

Creating a new design-build program is a challenging and rewarding task, which takes a long-term commitment from both faculty and administration.

Despite tremendous success in the Design Build Studio's first effort (second place in Solar Decathlon 2013), the process of transitioning toward a sustainable program has been a slowly evolving process. Educating the community and potential clients about the Studio's capabilities, identifying funding sources, and resolving the regulatory hurdles have been ongoing challenges. The program will continue to work to resolve these hurdles, as the Design Build Studio offers an unparalleled educational opportunity for the students enrolled in it.

Notes:

¹ Parry, Richard. "*Episteme and Techne*." The Stanford Encyclopedia of Philosophy (Fall 2008 Edition), Edward N. Zalta (ed.), URL=<http://plato.stanford.edu/archives/fall2008/entries/episteme-techne/>.

² Pallasmaa, Juhani. *The Eyes of the Skin: Architecture and the Senses*. John Wiley & Sons: West Sussex, MA. p 32.

³ Rockhill, Dan. Personal conversation, March 2014.

⁴ Hardin, Mary. August 12, 2014 email describing University of Arizona Design Build Program.

⁵ Louis, Hank. Personal conversation, July 2013.

⁶ Galarza, Jose. Personal conversation. October 2014.

⁷ Kraus, Chad. Personal conversation, March 2014.

⁸ Joy, Rick. Personal conversation, Fall 1999.

⁹ Bruder, Will. Personal conversations, December 2000-February 2009.

¹⁰ Smith, Ryan. *Prefab Architecture*. John Wiley & Sons: Hoboken, NJ. p 238.