Lessons Learned from the Limited Design-Build Exercise

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"If we were to train ourselves to draw as we build, from the bottom up, when we do, stopping our pencil to make a mark at the joints of pouring or erecting, ornament would grow out of our love for the expression of method. It would follow that pasting over the construction of light and acoustical material, the burying of tortured unwanted ducts, conduits and pipe lines would become intolerable. The desire to express how it is done would filter through the entire society of building, to architect, engineer, builder, and draftsman."

Louis Kahn, "Form and Design", 1961[1]

This paper intends to examine the pedagogical benefits and limitations of a studio project that utilizes the design-build model on a limited scale, meaning smaller than that of an enclosed building. While this presentation is not intended as a historical survey nor as an analysis of design-build as an educational typology, it attempts to draw particular comparisons and contrasts of smaller exercises to their larger counterparts in this category. These points are illustrated by a case study project constructed at Kansas State University.

The crucial lessons of design-build are difficult to replicate through other educational means. Construction drawing classes may demonstrate materials and methods through readings and illustrations, but understanding the causal relationship between instigated design and resulting construction is best cemented by performing both acts; it is their relationship that allows the synergetic confluence of drawing and building that Louis Kahn poetically alluded to more than half a century ago.

If we consider that architectural education is primarily intended to prepare its students for professional careers of building design in market conditions, then exercises that introduce realistic *constraints* confronted during such "real" situations should be of prime importance. The negotiation of budget, schedule, building codes, and coordination issues is of crucial importance in the profession, but these skills are generally addressed inadequately in a classroom setting. The preference for many schools of architecture to employ some form of a design-build exercise is therefore well founded.

As a communicator and conduit of ideas between client, consultants, and contractors, the architect needs to hone practical skills of cooperation, organization, and creative improvisation. Rarely is a project built exactly per the drawings; field conditions, substitutions, value engineering, and change of opinion all play a part in the final stages of design in a project – that design that occurs at the end of construction documents and in the phase known as construction administration. Although this phase typically accounts for 20% or more of an architect's fee, it currently occupies virtually no time in the architectural pedagogy. Yet this subset of design is critical to the successful completion of a project. The architect has to make quick decisions about revisions that will allow construction to move forward on time and in budget, *without sacrificing design intent*.

Of all the educational tactics deployed in architecture schools, the design-build project is the exercise that can best facilitate student learning about this type of design thinking, and do so in an intense, active, and productive manner. The correlation between drawing and constructing each condition provides a clear and memorable learning opportunity for those involved.

The design-build typology in architectural education

Today, most architecture programs include some form of design-build exercise, recognized as a necessity in forging the link between abstract representation and final intended reality within the built environment. These range in scale from small follies to extensive construction projects. On the smaller end of the spectrum, the exercise of designing and building simple furniture from household materials, such as cardboard, is a common assignment, taking in the range of a week or two in its entirety.

Large design-build projects, such as the *Solar Decathlon* housing competition (sponsored by the U.S. Department of Energy), offer students the opportunity to participate in interdisciplinary, complex, high profile constructions. These, along with prototype housing and other prefabricated buildings, delve into many issues of design and construction, but are expensive in terms of their real-world timelines and financial outlay; an entire building can rarely be completed solely by students within the length of a semester, and always requires outside revenue or financing sources. Over the course of several semesters, design and building tasks are divvied up between multiple groups of students, often preventing an individual's sustained participation in the entire timeline of these projects.

Other projects, such as the summer program at Yale, or any number of post-Katrina rebuilding projects in New Orleans, require the students to be at the site while the project is ongoing, to the detriment of any other classes or activities.

The *ecoMOD* project at the University of Virginia and *Studio 804* at the University of Kansas are two well-known, successful examples of design-build courses that provide educational benefit for all involved. In addition, they test progressive, prefabricated, and sustainable technologies, as well as providing housing for underprivileged neighborhood families.

Many schools have also engaged in smaller ventures, which also offer amenities and public exposure. For example, the University of Virginia used a semester project to create outdoor seating and landscape elements directly outside of its architecture school. Students at Kansas State University have constructed room-sized “cubes” for the tornado-stricken town of Greensburg that demonstrate environmentally sustainable building techniques.

The design-build project can act as a laboratory for testing techniques in prefabricated construction. Because profit is not a factor, time-intensive prototyping in the school can aid the profession and society, by providing much of the front-end research into new material techniques and practices.

The practice of architecture is a social activity that requires spanning class, gender, generations, and personal differences. Students gain a sense of how communication is important to their future professional success. Since the crucial lessons of teamwork are generally not taught outright, scenarios that foster these skills are beneficial.

Design-build projects of all scales generate opportunities for social improvement and betterment of society through improving the built environment. They are opportunities to test discourse and reify ideals; building transforms the world.

Comparing scales of design-build projects

The scope of design-build projects can obviously vary in many ways (including complexity, use of technology, and cost) but scale tends to act as a significant determinant. Just as the area of a building is a primary factor in determining cost, the size of a design-build scheme is a significant determinant of the difficulty and cost of completing the project.

While this paper does not posit that the experiences and educational benefit of a limited exercise are equal or greater than those of a larger scale, it does attempt to demonstrate that smaller scale design-build projects can offer many of the same benefits to education of architecture students.

Certainly, the main advantage of larger projects is that they produce a high-profile “building” in every sense of the world, which will exist for an extended period (usually decades) and allow the type of publicity that schools find useful in connecting with alumni, donors, and potential students through journals, magazines, websites, and other publications. In addition, the students learn to deal with every manner of building system at full scale, preparing them for their professional careers.

The convenient access and small scale (including budget and schedule) of a design-build project fabricated in the school (rather than on site) make the proposition more accessible to all within upper level studios. Specifically, the tasks of this exercise can easily be entirely performed and completed within one semester, allowing other pedagogical objectives to be achieved in other studios.

The greatest contrast between large and small design-build projects may be their cost. A design-build house, prefabricated or traditionally engineered, requires at least a five-figure outlay to complete. Design-build projects with more complex engineering, such as the Solar Decathlon houses, each necessitate a financial investment of over one hundred thousand dollars. This type of capital requirement significantly limits the proliferation and accessibility of these programs at academic institutions. On the other end of the spectrum, a limited design-build project may be successfully completed for several hundred dollars, as demonstrated later in this paper.

Physical requirements of the space required for assembly are considerably less stringent for smaller design-build projects; consider the access and infrastructure required for transporting a 10’x10’ structure compared to that needed for moving a 400 square foot or larger building. Most architectural design studio spaces or wood shops located in architecture schools are large enough to contain one or more smaller scaled projects. In addition, transportation can be achieved with readily available pickup trucks and vans, as compared with the larger trailers and cranes required for buildings. Even for “prefabricated” buildings, a significant amount of the construction for larger design-build exercises takes place on site, which may be a significant distance from the school; this valuable time is detrimental to the other educational activities of the students.

Several forms of accessibility are at stake; a series of small projects allows a greater range of students to participate and complete such an exercise in their time at the school. In addition, it is easier for students to access and work on such a limited project within the context of their primary learning environment, rather than on a removed site.

Liability issues are increased when an occupied “building” is produced by the project. A smaller design-build project can instill many of the same lessons while lowering the exposure of the school and its employees.

While a larger project can, due to its complexity, expose students to a wider range of architectural building issues than a smaller scale design-build, not all schools can support such a project. For various economic, pedagogical, staffing, liability, or other reasons, a full-scale design-build effort may not be possible. A limited version of the exercise can extend many of the same benefits; students still negotiate the gap between the intention, representation, and constructed result. They necessarily need to work together in teams to complete the task, and an object is constructed from tangible finished materials, fastened by designed connections.

Case study: Multifunctional prefabricated unit

This project was completed in the Spring 2007 semester, at Kansas State University, under my direction. A small team of fourth year students designed and constructed a structure to be used in conjunction with the environmentally sustainable house under construction by the school for the Solar Decathlon competition. The unit, to be located adjacent to the house when on display on the Mall of the nation’s capitol in October 2007, was to provide informational displays, seating, shade from the sun, and local lighting for the duration of the exhibition.

In harmony with the materials of the Decathlon house, the design incorporated recycled wood from a local barn as cladding. It used digitally controlled routing to precisely shape the plywood fins of the sunscreen, and the entire unit was optimized for easy assembly, disassembly, and transportation to and from the site. The fins that comprised the upper half of the unit were bolted together, to allow disassembly and storage in the lower half of the unit.

The structure was constructed from typical 2x4 framing members, attached through a series of bolts, nails, and screw connections. It was designed and assembled so that the entire unit could be rapidly disassembled for transportation. The lower portion is essentially a wood case mounted on heavy-duty casters, allowing the unit to be loaded on and off the main house unit as it was towed across the country to the competition. The disassembled components that comprise the upper portion of the unit fit into snug compartments in the lower casing. There was an intention to inscribe complete assembly instructions for the unit onto the plywood boards that comprise the sun screen, using a digital CNC router, but this process was only partially realized; numbers that are engraved into the fins were intended for this purpose.

The entire project was designed and built by six students within the allotted time period of eight weeks, for a total budget of $300. Built mostly of wood, the manufacture of the unit utilized a range of technologies, from basic woodworking tools to a two-axis CNC router that was used to cut louver panels to specific shapes. These openings were precisely located according to simulation software, so that the sun would shine through each of the various openings according to the hour of the day. The recycled barn wood, with its original red paint and rustic imperfections, was attached to the frame as cladding.

The design-build process included meeting with the "client," which in this case was the Solar House team. Programming and strategic brainstorming was followed by the production of conceptual design options, models, and a series of renderings (see Fig. 1 example) to present to the Solar House team. Once feedback and suggestions were incorporated into the design, students produced construction drawings and a project plan for completing the unit by the deadline.

Rapid prototyping techniques available at the school were used effectively at a number of scales, from laser cut models, to routed full sized panels. The laser cutter was found to be a useful tool for testing digital routing techniques in miniature. Precise models could be produced to test the aesthetic of the full-scale rapid prototype pieces.

Internal reviews with the instructor and other members of the team were necessary to resolve details. The students organized meetings with potential donors to obtain required materials; a number of hardware items were donated by local businesses, allowing the project to be built within the allotted budget. Other students conducted research about available products and placed calls to suppliers, while continually budgeting and tracking costs and creating (and modifying) the project schedule. Finally, a push by the entire team to construct the unit resulted in its assembly within a matter of weeks. The formal presentation of the finished unit (see Fig. 2) to the client served as the official conclusion of the project.

The studio critic's role, after setting up the problem, was to guide the students through each step in the process -- this was essential, since students generally have not worked on a project from conception through to construction. In addition, the critic addressed legal and code implications and compliance, as well as obtaining permissions and limiting liability to the school.

The different strengths of each student, while being apparent in design studios, took on new significance, as individuals were each suited for various tasks. Those fluent with construction techniques (often not the strongest students in terms of abstract design concept and representation) took pride in building and teaching construction techniques to others in the class.

The feedback from the students was mostly positive. Early in the semester, a significant majority of the students in the course had expressed a desire to “build” something, and were enthusiastic to take on the project when offered the opportunity. By the end of the semester, their ownership of the project was complete, to the point where the instructor was notified and invited to events essentially as a courtesy. The group mobilized as a self-organizing team, and pride in creating the project was its cementing element. The students were especially satisfied to have actually built something that they designed at full scale, which was the first opportunity that they had to do so at the University. All agreed that much had been learned about the translation of idea to built form.

Negative feedback from the students was minimal, and mostly addressed the “unfair” distribution of the workload amongst the team members, due to differences in student motivation. The project was graded per team, not per individual, so pressure on each individual to excel came from other students on the team, sometimes resulting in bad feelings or conflict -- not unlike the environment of many typical design offices. What some of the students perceived as a problem with the scenario can actually be interpreted as a preview of professional practice. In addition, this problem is typical of any group work assignments given within academia or other environments, and should not be attributable to the design-build process itself.

This prefabricated wood project, designed and built by students, is just one example of a successful limited design-build project constructed within an architectural design studio. Although it employed a mix of recent technologies and traditional technologies, it admittedly achieved little that was ground breaking, as a typology. However, its educational benefits to those involved were extensive, and offered many of the same lessons of larger design-build projects on a significantly reduced scale.

Illustrations and photographs by the author and the students of ARCH606: Anthon Ellis, David Hildebrandt, Kelly Krob, Garrett Peace, Joseph Stock, and Luke Stricklin.

Fig. 1. Visualizations of the students' design.

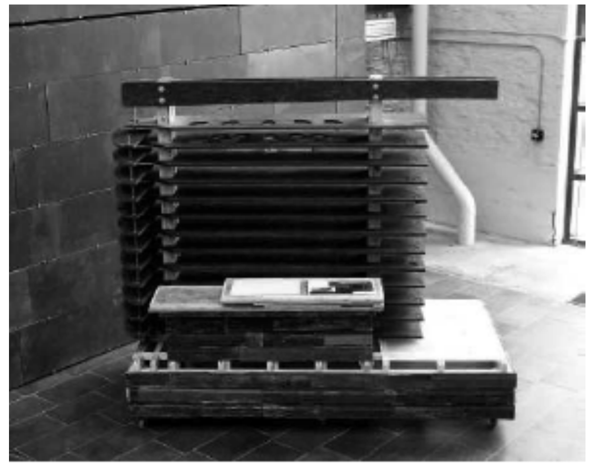

Fig. 2. The final product, as built.

Notes

[1] Kahn, Louis, "Form and Design" in AD, no. 4, 1961, pp. 145-54.