

Constructing Design in the Studio: Projects That Include Making

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1 INTRODUCTION

What is Design/Build? In the profession design/build refers to the arrangement that replaces the traditional trio of Architect-Client-Builder with a single contract between an Architect-Builder and a Client. In design education it refers to an approach that combines the conceptual, studio-based model of instruction with a tangible, real, and physical process of making. Design/Build is an activity that brings the reality of constructing and making into the design process. It is a method in teaching that, like its professional counterpart, is gaining acceptance throughout the world.

1.1 ORIGINS OF DESIGN/BUILD IN ARCHITECTURAL EDUCATION

In the past all architects were directly involved in the building process. The master-builder of the guild era was the forerunner of today's project architect. Yet for various reasons, the role of architect as craftsman and builder gradually evolved into a more specialized, professional role of *designer*. Changes in the education and training of architects were a key factor. Significant was the transition in America from a training procedure based on shop culture to the system of university or school education that gradually replaced it. (Pfammatter, 2000) Focusing more on theory and design, the architect pulled away from close involvement in the building process, yielding more responsibility to the professional contractor. This was reinforced in the twentieth century in USA by the development of professional contractual regulations that established the role of the architect as an intermediary between the client and the contractor (builder).

In architectural education the Bauhaus attempted to restore the connection to building through a rigorous program that placed greater emphasis on the process of design and its relationship to making. Through the curriculum established by Walter Gropius and his diverse team of artists, craftsmen and designers, the Bauhaus re-established the critical relationship between the designer and the medium: the materials of construction, the processes of forming and fabrication, and the constraints these place on the design. In a sense, the Bauhaus was the first Design/Build program of the twentieth century. The adoption of its principles abroad was not immediate and traditional Beaus Arts programs continued in most schools of architecture through the first half of the century. The exceptions, Gropius at the GSD at Harvard and Mies at the Armour Institute (IIT) in Chicago, together with Frank Lloyd Wright's Taliesin, which pre-dated both schools, were important models that influenced architectural education throughout North America.

Speaking to the conference of the Association of Collegiate Schools of Architecture (ACSA) in 1959 Walter Gropius defined his approach with a list of ten statements concerning architectural education. Several have direct bearing on the relationship of making to an architect's education. For example, item number 5 states: "At the start, basic design and shop practice combined should introduce to the students the elements of design, surface, volume, space color, and simultaneously the ideas of construction, of building by developing three-dimensional exercises to be carried out with materials and tools." And number 6: "In succeeding years

of training, the design and construction studio, supplemented by field experience during summer vacations, will coordinate further experience with the broadening of knowledge.” (Carpenter, 1997) In his advice to the meeting of design educators Gropius defines a new culture of design education that places critical importance on the involvement of students in the process of building and making.

In the late fifties, R. Buckminster Fuller created a new pedagogical innovation, the visiting professor workshop. Invited to leading design schools throughout the USA, Fuller led hands-on full-scale construction projects involving him and students in dome building. The inventor of the geodesic dome, Buckminster Fuller continuously researched and tested the variations of dome geometry and construction with the aid of interested architecture students. For the most part these were hands-on, instructional demos, designed to promote the advantages and beauty of lightweight construction. The Fifties in American design education was a period of intense belief in the principles of functionality, especially the role of structure as a form determinant and a basis for aesthetic value.

At the University of Pennsylvania, beginning in the early sixties, another engineer-instructor was influential in the teaching of design. Robert Le Ricolais and his students at Penn created one of the most advanced structural experimentation labs for any design program at the time. Working primarily with steel wire, bars, tubes and pieces of plate, Le Ricolais and his students designed, built and tested radical new concepts in structures that challenged the status quo. Working in a small shop with limited equipment, the physical models built by the class tested theories of long-span braced frames and pre-stressed trussed beams. Since the primary purpose of these structures was to test theory rather than model an actual bridge or building design, they can be considered as full-scale constructions, and as such, early design/build works.

1.2 DESIGN/BUILD & COMMUNITY SERVICE

In the period of the sixties politics and social responsibility created a near schism in architectural education between schools that continued to emphasize formal content in design and those adopting a new position of community activism and social relevance. The former continued the exploration of the classic modern formal vocabulary

of architecture (epitomized in the work of Richard Meier, for example), while the latter embraced an inclusive approach that championed new programs, social issues, and humanitarian service. Regardless of orientation however, both schools of thought recognized the potential educational value of student-built projects and several leading programs introduced design/build studios into their curricula.

The most acclaimed of these programs and possibly the first was the Yale University Building Project. Charles Moore, then the head of the Yale School of Architecture, began the program in 1967 with a project to design and build a community center in New Zion, Kentucky. Moore saw the project as an opportunity for Yale students to make a contribution to society by building for the poor. At the same time Moore realized that a design/build project would likely offer students their first hands-on construction experience and also allow them to participate in the complete process of an actual building design. Today the building project continues and is now embedded in the curriculum as part of a required three-course sequence for all first year graduate students. (Carpenter, 1997) Approximately forty students participate with five teaching assistants serving as project managers. The assistants introduce the project and coordinate the budget and schedule. The Building Project is partnered with Neighborhood Housing, a non-profit agency in New Haven, and together they create single-family houses for the poor in New Haven.

While Yale University created the building project partly as an outreach program for community development and partly as a design/build opportunity for students, the Cooper Union School in New York City initiated a design/build project as an investigation of the “elements of construction”. Although recognized as one of the foremost formalist schools of the sixties, Cooper Union’s design approach was closely aligned to the role of tectonics in generating form. A project for a park pavilion with an elevated deck and an innovative polyester-resin shading canopy was designed and built by a team of six students and their instructor. Erected on one of the campuses of the Cooper Union, the modular wood-framed construction involved site surveying, setting foundations, welding steel connections, milling lumber, and assembling the modular components. (Franzen et al. 1999)

1.3 RE-EMERGENCE IN THE NINETIES

The difficult financial times that most universities experienced in the seventies resulted in cutbacks in funding that affected many design/build programs that were just getting underway. Yale University itself scaled back their building project program choosing local sites and smaller projects in order to minimize the cost. Also during this period much of architectural design education was engaged in the rhetoric of post modernism that tended to explore historical and theoretical influences largely through the medium of drawing and paper (i.e. cardboard) modeling.

One of the first attempts to restore hands-on building experience in studio education was led by Steve Badanes who, with collaborators John Ringel and Jim Adamson founded the design/build practice known as Jersey Devil. Badanes and Jersey Devil's approach to design/build was primarily shaped by their reaction to conventional practice, which positions the architect as a designer outside the actual process of building. As Donald Schon pointed out in his classic study on design education; "Sometimes he makes a final product; more often he makes a representation, a plan, program, or image of an artifact to be constructed by others". (Schon, 1983) Educated at Princeton in the early seventies, where the design culture was dominated by the neo-modernist formalism of the New York School of the Five Architects, Badanes and his partners sought an alternative practice that would reconnect architecture with the process of making and establish a true collaboration between artisans, builders and clients. Key to their approach to design and practice is the idea that the architect must be involved in building the work and that the work is adjusted, altered, fine-tuned in response to conditions encountered in construction. (Piedmont-Palladino and Branch, 1997) This has led to their unique approach of living on the site of their projects through completion of construction.

In 1988 Steve Badanes began his involvement with design/build education at the University of Washington in Seattle, with a studio project called *Stairwell to Nowhere*. Designed and constructed by 12 architecture students in a spring studio taught by Badanes, Stair to Nowhere is a simple wood-frame folly for Gould Park, a flight of steps with no function other than serving as a sitting place, like the front stoop of a traditional Victorian house. Projects

in successive years have included children's playhouses, park pavilions, garden structures and the like. These projects are developed with community/client input and are funded by small grants of \$2000 - \$5000 from the city Department of Neighborhoods. Projects encompass site analysis and planning, project design, working drawings, materials procurement, fabrication and scheduling. The program continues to this day as the Howard S. Wright design/build studio chaired by Steve Badanes. It is an elective studio open to grad students in architecture and to undergrads that have a dual major in architecture and building construction.

Badanes emphasizes the collaborative aspect of building and in contrast to earlier methods of selecting the winning scheme to be built by jury or voting, he now insists that all decisions through construction be made by group consensus. This he says fosters a shared responsibility and greater enthusiasm during construction, as well as resulting in more egalitarian designs. With regard to the benefits of direct contact with construction, Badanes writes: "Design/build projects allow students to move past schematic design. Issues that never come up in the classroom arise on the job site. Structure, detailing, design issues, and construction strategy are all debated in the hands-on atmosphere of three-dimensional reality." (Carpenter, 1997)

One of the more charismatic leaders of design/build education, the late Samuel Mockbee established the Rural Studio at Auburn University with a group of twelve students in 1992. Mockbee's objectives were multiple. First, he believed that the profession has an ethical responsibility to the poor. In architectural education this means engendering a "moral sense of service to the community". (Dean, 2002) In practice it involves transporting Auburn students 150 miles to an impoverished county in rural Alabama where they live for one or two semesters and continue their architectural studies in the field. Here they work with the county Department of Human Resources and the Hale Empowerment and Revitalization Organization, connecting with clients and choosing a suitable project to design and build. Recycling is a second characteristic of the work of the Rural Studio. Even before setting up the studio, Sam Mockbee in practice with Coleman Coker from 1977, had established the precedent of low-budget construction using found materials and volunteer labor. His first charitable

effort was a 1000 square-foot dormered dogtrot house built for \$7000 for a destitute family of nine. By doing it he “learned that small projects like that were doable by ordinary people”. (Dean, 2002) This principle has long been the basis of the success of Habitat for Humanity, the house-building program for the poor established by former President Jimmy Carter and the Carter Foundation.

Many of the structures scattered throughout Hale County, Alabama and built by students in the Rural Studio make use of salvaged or donated materials. In part this is a response to limited resources but it also is an extension of Mockbee’s own attitude towards recycling and waste. The philosophy seems infectious. There have been projects incorporating used railroad ties, old bricks, donated and scavenged lumber, rubber tires, license plates and more. One of the more celebrated works, Mason’s Bend Community Center, incorporated 80 Chevrolet Caprice windshields obtained from a scrap yard to create a stunning glass-shingle roof membrane. These kinds of bricoleur-collage efforts result in an architecture that is modernist in form and yet strangely contextual with the local vernacular.

Since the nineties, the interest in design/build education has grown. In 1997 author William Carpenter estimated there were approximately ten programs in North America offering a of design/build project. Now many programs are initiating projects either as one-off studios or on a regular basis. There are many different options for introducing design/build projects into a design curriculum. One approach is a visiting critic studio. University of Virginia has invited outside practicing architects to lead a design/build studio for a semester. (Wade, 2004) This resulted in the design and construction of an outdoor *classroom* on the campus grounds. Another possibility is to provide the experience as part of a regular summer internship program by cooperating with design/build practices. The University of Nebraska as well as the Philadelphia School of Architecture & Design University incorporates this strategy.

Many programs throughout the USA have joined with Habitat for Humanity to offer an opportunity to students for hands-on construction. The architecture program at the University of North Carolina at Charlotte has an ongoing structured, design/build studio led by Professor John Nelson that now partners with Habitat for Humanity. Each year in the fall

students select a client and site and begin design for a new house. Connecting design/build experience with research on alternative building practice is another viable possibility. Professor Mary Hardin of the University of Arizona has led several successful design/build studios to explore improved methods of constructing rammed earth wall buildings. Her research funding combined with support from Habitat for Humanity has made it possible to build innovatively within the financial constraints of housing for the poor.

2 DESIGN/BUILD IN THE CURRICULUM

Many of the design/build programs that have been discussed and that constitute the mainstream of design/build approaches in academia today focus on the high end of the scale, that is, an actual building. The funding for this kind of exercise is often difficult to obtain. Some institutions have partnered with municipal government offices (e.g. University of Washington’s collaboration with the Department of Neighborhoods) or NGO’s like Habitat for Humanity and received support. Others search for private sponsorship and donations of material resources and loaned equipment. Unable to acquire the funding some programs downsize the project to match the budget. All in all the organization and financing of a design/build endeavor discourages many administrators and department heads who would otherwise be sympathetic to the educational benefits.

2.1 RESISTANCE AND LEARNING

The architect’s education has traditionally been composed of a sequence of projects and exercises that use surrogates in the form of drawings and models that are abstract in nature, to learn and to test assumptions about physical objects in the real world. This affords a virtually unlimited freedom to explore speculatively. Hypotheses are tested through discussion and critique (e.g. the design jury) where the many experiences and insights of the participants are brought to bear on a design problem encouraging a range of ideas and debate. Representations—the drawings and models—while more specific than a verbal description, are still abstractions and open to the kind of interpretation and searching inquiry that is essential to achieve formal clarity.

However surrogates have their limitations. *Learning by doing* is based in the belief that knowledge,

to have real meaning, must be a way of dealing specifically with actual stimuli and situations. (Dewey, 1910) Our initial thoughts, concepts and knowledge about the world begin with meeting the resistance that must be overcome to get somewhere, achieve a goal, or make something. Human activities evolved to solve problems of all sorts and human thought is the instrument of these actions, where ideas arise from experience and are plans of action to engage within the world. The act of making things inevitably leads to a series of encounters, each demanding decisions and further plans of action, the critical component of any creative act. Thinking is not merely a passive activity formulating and appointing concepts to perceived reality. The mind is constantly determining relations, likenesses, differences, and trying to understand underlying, hidden structures and connections.

The actions involved in making things demands explorations and questioning of the thing being made and the process by which it is created. Making is preceded by idea and invention and vice versa in a reciprocal process that constantly turns back upon itself because every act of construction has ramifications involving processes, materials and even tools. And the way in which they are used involves a creative activity, composed of many interlocking events that parallel the intellectual evolution of a thing.

The process of thinking and making described here is the essential quality that drives design/builders to stay close to the work through its entire construction cycle. For Steve Badanes the nature of the site as well as the nature of the materials talks back to the designer/builder offering opportunities for development and refinement. These opportunities are absent in a design practice or design studio that limits the creative process to dealing only with the abstracted, surrogate forms of representation and not the materiality or process of making afforded by direct involvement in creating the physical object.

2.2 WORKSHOP STUDIO: ALTERNATIVE TO THE DESIGN/BUILD STUDIO

Introducing the process of making in a comprehensive way in design education today is feasible with the implementation of the concept I'll refer to as the *workshop studio*. The workshop studio provides the context for critical discussion about the intention, design and actual making of things (and ultimately, buildings). It is not a single studio but rather a com-

ponent of workshop design activity spread across the curriculum. At the most basic level it requires only hand tools and lumber. At its most advanced stage it encourages familiarity with the full range of shop power tools and machines, and experience working with a wide range of materials.

In the beginning year of the design studio sequence the workshop studio can introduce basic fabrication skills; the use of hand tools to cut and connect wood, plastic, and metal with some degree of precision. Projects may be at various scales but their complexity is constrained. The use of proscribed components—a kit of parts—is frequently employed. In the middle studio years this parameter is lifted and students begin to define the components themselves and discover ways to fabricate them. Machine tools are introduced to increase the range of possibilities. Finally, in the upper years, the workshop studio expands the scope of projects to include a broad range of design-build projects from furniture design to habitable structures. The student at this point has acquired the knowledge and skill of shop-work technique that allows access to a wide range of machines and shop fabrication processes as well as the use of portable power tools for on-site work.

This workshop approach describes a plan for a graduated sequence that distributes skill levels, fabrication techniques and construction details across the design curriculum to the place that is most appropriate. It is an alternative to the traditional design/build studio that may occur only once in a student's educational experience. It is also an attempt to provide workshop learning to all students at each year level.

To achieve this some shop facilities are required. It is unfortunate that some architecture schools have never acquired a student shop while others make do with sharing a facility that is primarily designated for building maintenance and repair. However, the lack of a well-equipped machine shop need not be a barrier preventing some introduction of the workshop approach. The common denominator throughout is that the process of making something with actual materials, whether the elements of an abstract formal problem or a full scale functional object or environment, involves decisions about fabricating and joining that transcend the limitations of working with the particular materi-

		Intention	Type	Material	Fabrication	Tools	Scale	Comments	Schedule	Examples
1	R	Introduce workmanship and craft. Proper use of hand tools.	Modular Assembly	MDF Modular dimensioned elements	Dimensional stock MDF cut to precise rectangular shape & glued	Miter-box handsaw and clamps	Visual study model 30cm x 30cm	Kit of Parts Construction focused on modular assembly	1 week	- Cube object study - Parallel wall study
2	P	Direct contact with construction materials and methods.	Hands-on Demos	Various (wood, brick, concrete, etc.)	Various (connecting, laying, forming, etc.)	Various (hand-tools)	Full scale (varies)	Hands-on exercises with real materials. Led by a building trade instructor	1 day	- CITA - Geodesic Yurt
	P	Introduce simple bolted connections and precision of assembly.	Kit of parts design/build object.	Small dimension lumber 1 x 1, 2 x 2	Stock lumber cut to length, holes drilled, bolt/screw fastener	Hand saws, handheld power drills, screw drivers, wrench	Full scale 1m x 1.5m	Small mobile furniture piece designed using limited range of components	2 weeks	- Presentation stand
3	P	Design/build structure for performance test. Instruction in use of small machines.	Structural prototype for testing	Various (lumber, wire, plywood, rigid foam, sheet metal, plastic)	Simple cutting, fastening Hot wire cutting	Hand tools Small machine tools. Hot wire cutter	Prototype or behavior model at 1:10 or 1:5	Structure or component assembly load tested	2 – 3 weeks	- Composite beam - lessRoof - Roof module - Portable bridge
	R	Use of hand tools and small shop machines to form non-rectangular complex shapes.	Design project model studies.	MDF	Stock MDF cut to length, laminated stock MDF formed and shaped	Light machine shop tools: scroll/band/chop saws, drill press, sander	Visual form model at 1:100 or 1:50	Solid wood design study models exploring wall and plate systems	1 – 2 weeks	- Wall design study - Plate design study
4	P	Introduces working on site with portable hand tools and machines. Ground attachment.	Constrained on-site design/build project	Small dimensional lumber 1x1-2x2, plywood, wire, metal fasteners	Stock lumber cut to length, holes drilled, bolt/screw fasteners	Hand tools. Power hand tools (battery or generator powered)	Full scale 3m x 3m and greater	Kit of parts approach to a project with size and time constraints	1 – 2 weeks	- Sun shade pavilion - Lookout tower
	R	Use of hand tools and small shop machines to fabricate more complex shapes.	Case Study model: unit-bay frame structural study	MDF, basswood, plexiglass, small-scale steel rods, etc.	Various small element cutting and shaping. Glue & small connectors	Light machine shop tools: scroll/band/chop saws, drill press, sander	Visual form model at 1:100 – 1:50	Design studio model revealing building systems. Some abstraction of detail required.	3 – 4 weeks	- Tectonic case study
5	P	Advanced fabrication with various materials and using full range of shop machines.	Furniture, sculpture or small installation	Hardwoods, MDF, metals with various materials and connectors	Unrestricted	Unrestricted (with training in proper use and safety)	Full scale	Ergonomic and functional considerations. Joinery critical.	5 – 10 weeks	- Chair design - Concrete sculpture
	P	Involves planning, transportation of materials and full range of performance issues.	On-site Design/Build Project	Standard or experimental materials and assemblies	Standard or experimental building construction practice	Unrestricted (combines shop fabrication with on-site work)	Full scale	Site-Client-Budget constrained. Encompasses full range of issues in a built work.	15+ weeks	- Bridge too far - Habitat for Humanity

Figure 1: Workshop studio chart

als at hand or the available tools. Every workshop studio problem becomes a learning activity and a potent analog for situations encountered in actual building design.

2.3 THE WORKSHOP PLAN AS A GRADUATED SEQUENCE OF ACTIVITIES

The workshop studio chart (Figure 1) outlines a series of design exercises or projects that involve some degree of making the object. The chart identifies certain constraints for each project related to materials, fabrication methods and tools. It also comments on the nature of the project, an approximate scale or size of the work, and an estimate of time required. In general, the scheme is based on four principles:

1) The project must have appropriate limitations defining the scope and complexity of the work. These parameters should take into consideration the design abilities and skill level of the stu-

dent, the overall cost of materials and the amount of time estimated for completion of the project.

2) The knowledge of workshop procedures and the skills needed to use various tools are to be developed progressively over time. An important consideration is to insure safety in the use of higher-level machine tools.

3) The content of a workshop project should relate to the studio design curriculum for the given term in which the project is proposed. For example, in the proposed chart, Year 3 studio curriculum of the second term emphasizes building technology, specifically structures. A design/build project for this studio should relate to structure; e.g. the design and testing of a structural component.

4) A workshop project may be collaborative in nature or individually pursued. There should be opportunities for both types of activity at various levels to build cooperative working skills.

2.3.1 FOUNDATION OR YEAR ONE

Foundation year curriculum is interdisciplinary (architecture, graphic design and multimedia) and studios are divided between analytical drawing and design. Typical problems are abstract and explore basic principles of composition and form. A typical problem at this level would make use of a kit-of-parts approach. Rectangular modular elements defined by the brief are used in the exploration of form. This type of formal exercise requires precision and the preparation of the kit-of-parts is an important skill building activity. Using prescribed dimensional thicknesses of MDF students use hand-cutting tools (miter box and crosscut saw) to create the required set of elements. Basic operations besides measuring and cutting involve checking elements for square, sanding and later, gluing elements together using clamps. Shop facilities are generally not accessible to beginning students so hand tools are used on workbench tables in a second shop area used for assembly.

The idea of a set of pre-configured elements assembled into a formal design refers back to the Nine Square Problem that was developed by John Hejduk in the early sixties at the Cooper Union. (Franzen et al. 1999) The Cube Project shown here (Figure 2) is one such example. Abstract in nature, the elements do not correspond to real building components (frame, infill panel, etc.), as did many of the elements of the Nine Square Problem. Hence, once the kit of design elements is fabricated, the role of construction is super-ceded by pure investigations of form.



Figure 2: The Cube Project

2.3.2 YEAR TWO

Beginning in year two, the principle of *design to build* is introduced. The concept is straightforward and implies that the process of making the object is considered and informs the design. An example of a project of this type is the *Presentation Stand*. This is an object that is designed by the student to act as a display structure during end of semester reviews for drawings and models. Here materials are restricted to small pieces of dimensional lumber and operations are limited to length cutting and simple bolt connections. Multiplication, transformation, and rhythm form the basis for design decisions. Yet, even at this basic level of construction, initial decisions about joining will have important consequences on the overall form, and vice versa.

Constructing the presentation stand coincides with an introduction to the wood shop and to safety regulations. In year two the use of machine tools is partially restricted. Cutting is accomplished with hand miter saws and drilling is done with hand power drills. Again the kit-of-parts approach, instead of stifling creativity, has the opposite effect, channeling creative energies towards design solutions enhanced by a deeper understanding of the limitations of the material, the method of joinery, and the variations in form presented by manipulating geometry and pattern.

In year two students are introduced to materials and their applications. Traditionally courses in materials and construction have used construction site visits to involve students indirectly in the activities of building construction. An alternative approach is to provide a hands-on demonstration workshop in which students construct something using actual building materials. Edward Allen adopted this approach and described it in an unpublished paper entitled "Hands-On, Half-Day, Hundred-Buck Construction Projects". In some urban centers construction training institutes or private material production factories will offer opportunities for student groups to gain hands-on experience with various material and construction processes.

2.3.3 YEAR THREE

Third Year studio introduces building technology: structure, enclosure, and passive controls. Continuing the use of wood models for the investigation of space and form, the problem referred to

as *Wall design study* and *Plate design study* in the Graduated Workshop Scheme Chart (see Figure 1) uses MDF and wooden dowels to construct precision form models based on designs that explore basic short-span structural system types. Similar to the kit-of-parts approach used in foundation year on the Cube Project, various elements of the project (floor and roof plates, front and side exterior walls) are created in advance. The student then modifies the universal floor plate to his/her own design. Openings are cut in the elevation for lighting and the floor plates are cut to correspond to double height spaces.

Although these models primarily address formal issues, there are many aspects of fabrication that must be addressed by the student as the design proceeds. Precision cutting of openings in the MDF planes require learning wood shop techniques associated with an intermediate level of shop machine tools: band saw, drill press and chop saw. Non-rectilinear design elements in the projects present special challenges that must be solved on an individual basis. In the process the lesson is learned that complex form usually requires special fabrication techniques, in the model as well as in the actual building.

Another type of building exercise that complements the focus on structure in year three is the design and testing of a structural component, such as a composite beam. This tends to be an assignment with more freedom in that various materials can be used and there are no restrictions on shape. Performance criteria of least weight tends however to exert a moderating influence on the more successful designs.

An alternative to this type of engineered component testing that more directly supports a studio agenda is the roof module project. In this problem a set of parameters are given for the design of a 1:1 scale component assembly that must span a given short distance (range of 1.5 – 3m), be constructed from a limited set of materials, and incorporate natural lighting control (a shading device to prevent direct sunlight penetration). In addition the structural design goal is maximum efficiency, measured by the strength to weight ratio. The projects are load tested during the final review. One of the materials included in the prescribed kit is insulation foam. Although foam has little strength to

contribute to the design, it can be used effectively as a bracing material enabling greater efficiency in the design of any compression struts. These projects generally follow a schedule of about 3 weeks: one week of precedent and technical studies, one week of design and development, and a final week of construction. (Figure 3)

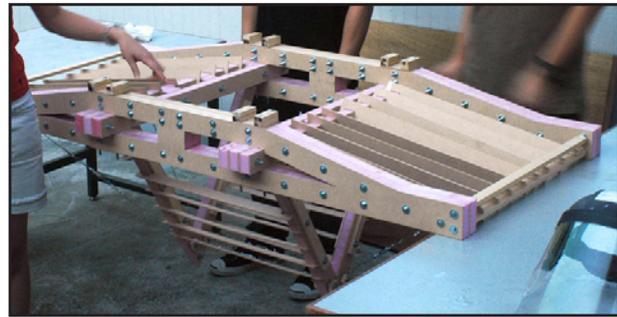


Figure 3: Roof Module Project

2.3.4 YEAR FOUR

The fourth year involves the study of more advanced building technology, namely enclosure systems and environmental controls. Together with building structure these issues are typically explored first through case studies and then in a design project. The case study offers many opportunities for making that involve workshop skills and techniques in fabrication. In particular, the *construction* of a unit bay building systems model (Figure 4) of a precedent case study challenges the student or student team to rethink connections, clad surfaces and supporting structures in order to represent them at a relatively small scale (e.g. 1:50 or 1:100). Problems encountered in making the model are often eerily similar to problems faced by architects and engineers in actual building design. How to fabricate and assemble long span curving three-dimensional trusses presents different challenges to the model maker than the builder yet both scales require creative solutions to achieve a satisfactory end result.

Due to the variety of projects in the case studies each model tends to present different fabrication issues that must be solved on an individual basis. Often it takes more than one attempt at making a particular component or piece before an easier or perhaps more precise method of fabrication is discovered. Problem solving takes place in the

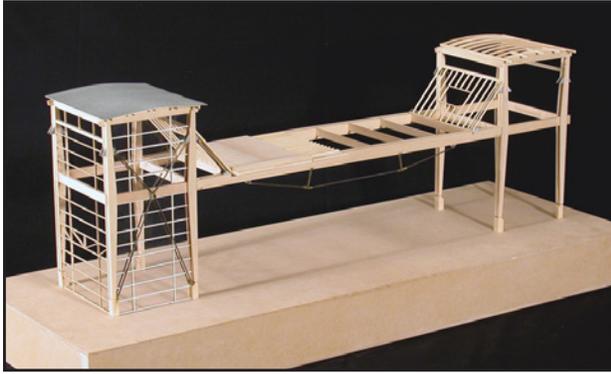


Figure 4: Unit bay building systems model

workshop (on site) while confronting the physical materiality (and properties) of the object to be formed. These types of learning experiences are memorable and inform students about conditions of construction or making that are often neglected or missing in conventional conceptual/schematic design studio work.

From time to time a short-term, collaborative team building exercise is a worthwhile digression from a semester long studio project. With good planning and some imagination interesting design/build exercises can be devised that last a week. Using a limited set of materials of prescribed dimension and amount creates an equal playing field for a competition between design teams of 4 to 8 students. The program must be explicit; the inclusion of performance criteria and a means for testing usually focuses design thinking and provides a method for evaluating proposals. The cost a kit-of-parts package for each team is dependent on available funding. This type of exercise demands team cooperation. Compromises must be made to establish consensus or the project stalls and everyone loses. Each member of the team must assume responsibility for a part of the overall design. In the end the spirit of teamwork and collaboration becomes as important a learning experience as a successful design project.

2.3.4 YEAR FIVE

By year five most students have acquired a good knowledge of shop practices and can use most machine tools available in a workshop. If the opportunity presents itself a team of 12 or more students are capable of designing and constructing a modest residential building in 15 weeks with the guid-

ance of a professional builder/instructor and the collaboration of a client or agency. This has been demonstrated in many schools that have adopted this approach in the past ten years. Participation in the building of a house from design through interior finishes can be a transcendent experience for a young architect. However most schools cannot manage the staffing and/or funding for a design/build studio of this scale. Nonetheless, similar benefits are gained through the design and construction of smaller scale structures such as pavilions or waiting shelters. (Figure 5)

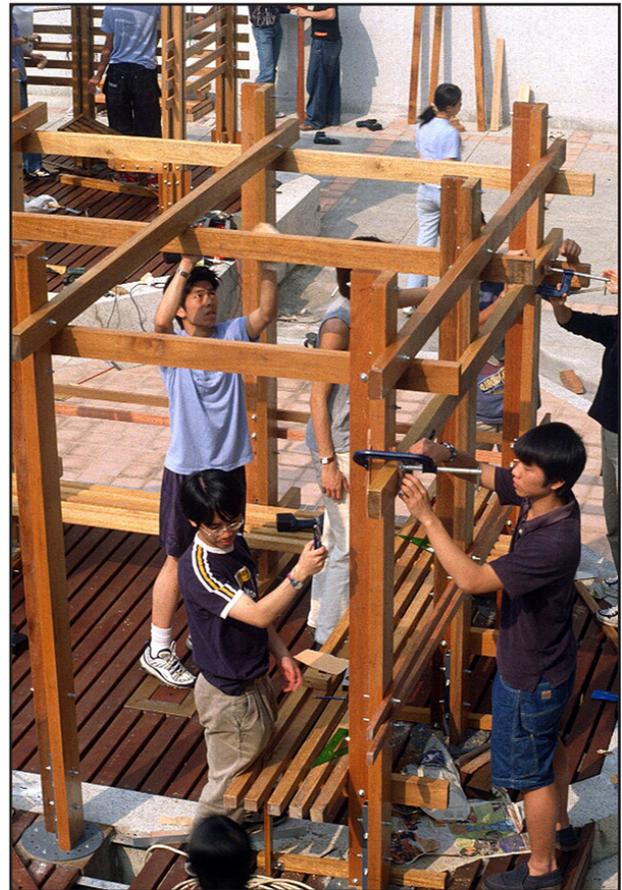


Figure 5: Sunshade Pavilion

Furniture design poses many of the same issues as a larger work including material selection, fabrication, joinery, and structure. Generally affordable, a furniture design is small and yet it can elicit some of the most creative design solutions of any constructed object. A furniture design is an individual problem and a challenging design/build project even for an advanced student.

3 CONCLUSION

The popular image of a student design/build project is a group of 10-15 students on an open site framing a small, low-cost house. This is an ideal that while attractive for the educational benefits it offers, does not easily fit into many school programs constrained by budgets and curricula that resist change. Fortunately, as argued in this paper, it is possible to introduce mini-design/build exercises and projects at all levels of a design program. Lessons learned in shaping, forming, connecting real materials at the scale of the model, furniture piece, or small pavilion translate to similar problems encountered in full-scale building design. The advantages of a distributed and graduated sequence of workshop activities is a more comprehensive introduction of hands-on construction experience due to the lesser demands of these projects on time, funding, equipment, and skill. All can get involved in the process of making and benefit from the exposure to real sites, real clients, real budgets and of course, real construction.

ENDNOTES

- Carpenter, William. 1997. *Learning by building: design and construction in architectural education*. New York: Van Nostrand Reinhold.
- Dean, Andrea Oppenheimer. 2002. *Rural studio: Samuel Mockbee and an architecture of decency*. New York: Princeton Architectural Press.
- Dewey, John. 1910. *How we think*. Boston: D. C. Heath Publishers.
- Franzen, Ulrich; Perez-Gomez, Alberto and Shkapich, Kim. 1999. *Education of an architect: a point of view, the Cooper Union School of Art & Architecture*. New York: The Monacelli Press, Inc.
- Pfammatter, Ulrich. 2000. *The making of the modern architect and engineer*. Basel: Birkhauser.
- Piedmont-Palladino, Susan and Branch, Mark Alden. 1997. *Devil's workshop: 25 years of Jersey Devil architecture*. New York: Princeton Architectural Press.
- Schon, Donald A. 1983. *The reflective practitioner: how professionals think in action*. New York: Basic Books.