*Panel prefabrication,  modification: cut*

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# Design/Build: A Relevant Pedagogy for Architecture Education

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## ABSTRACT

The predominance of drawing as a mean to create and represent architecture, whether in an educational setting or in professional practice, has had a profound influence on the design process. Drawings are so much a part of that process that they can often be mistaken for architecture itself. But drawings are not architecture, rather they are tools to create and control.

Historically, drawings greatly contributed to the establishment of the profession of architect inaugurated by the Italian Renaissance. They became the means by which architects gained control over design and by extension over the construction process. Control of the design process eventually moved from the hands of the master builders to architects' pencils.

The long-held monopoly of drawings in architecture has perpetuated a structural disconnect between design process and the "making of things". The heavy reliance on drawings has lead to tendencies for abstraction, repetition, self reference and a diminished sense of genuine innovation.

Design/build as an alternative delivery method focuses on a more intuitive approach based on the creative powers of manual labor and the interaction of the designer with the material world. This methodology has the advantage to re-engage a generation of student increasingly invested in a world of virtual stimuli with the physical materiality of things and promote the creative value of Homo Faber. By "making things" students are designing. A hands-on approach would also meet the needs of a student body who responds well to active learning pedagogy.

This paper will present a series of recent furniture design/build exercises where students designed and built furniture and small building prototypes with limited reliance on drawings. We will discuss how subjects such as structures, material sourcing and construction detailing can be transposed from various courses and applied to design/build projects. We believe that a pedagogy based on physical experimentations could infuse energy throughout curricula no matter the course subject.

## KEYWORDS

*design/build, furniture, building prototypes*

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## 1. INTRODUCTION

In a world where the omnipresence of digital tools has created a general disconnect with regards to the physical world, a pedagogy based on design/build projects would help re-engage the current generation of students. In keeping with the concept of active learning the hands-on approach of making things would help students focus on a single task and allow them to learn by doing. Building concrete things would also invite students to care and respect the material world and value the transformative process of working with materials. Such experiences could help shape their future attitudes towards the construction process and help develop an interest for construction related activities in the field of architecture. Constructing such things as furniture or even small building prototypes would help students come to the realization that architectural drawings, whether a conceptual sketch or a technical detail, have practical implications. As a matter of fact detailing may be another area of architecture education to benefit from design/build exercises. The necessity for students to devise adequate connections in order to join a variety of different materials would provide a practical introduction to the concept of creative detailing.

In addition, the creative process of making things can be empowering in the sense that even though students may have various levels of technical skill, the final outcome of their project would not depend solely on their ability to hand draw or create elaborate digital or physical models. The relative simplicity and straightforwardness of using basic tools may give a fair opportunity to a broad range of students to carry out their design regardless of their ability to use representation tools. In fact, providing exposure to a more immediate and accessible process may be a source of motivation for students. Another benefit of physically making things would be to infuse an increased sense of responsibility and design ownership in projects whether the result of the work is a failure or a success. A built design tends to speak for itself and invites students to a certain objectivity when it comes to the quality of their work. The overall process would promote student engagement and physical activity as an integral part of the design process.

Because the outcome of design/build projects is a physical object with specific requirements in terms of structure, connections and craftsmanship such projects foster the development of problem solving skills as they are tied to the accomplishment of a practical goal. Due to the amount of work typically involved in designing and fabricating even a small piece of furniture, students often work in teams. As a result design becomes a collaborative process which brings additional value to the experience of making. Building something as a team also promotes peer learning. For example the overall process of building furniture in a shop as opposed to listening to a lecture or designing in a studio environment increases student engagement and empowers them to try new things and take risks. Even though there is a clear objective when constructing a project the overall success depends on the ability to apply ideas to materials and let materials and techniques confirm or contradict the validity of the original design intent.

The need to build something also requires an acute sense of time management on the part of the students to take into account such things as material procurement, modes of assembly, possible failures along the way as well as unexpected events. Time management and scheduling just happen to be highly valuable skills necessary to the successful delivery of any architecture project. Fabrication based projects present students with the opportunity to design, verify the validity of their design intent in the field, make changes during fabrication and oversee a construction process. Design and construction are no longer disconnected but integrated in a creative process where they inform each other.

## 2. THE DESIGN/BUILD PROCESS

The design/build process is not based on abstract thinking alone but rather on the ability of the mind to learn and synthesize from the actions of the body. In other words it is less about organizing ideas than confronting ideas to the reality of the fabrication process. The fabrication phase is always a crucial part of any project delivery due to the simple fact that no matter the design intent fabrication has a huge impact on the physical quality of the final product. It can be argued that in situations where fabrication is the result of a series of highly mechanized operations there is little room for creation in that process. In fact a creative fabrication process is possible only because there is an engaged individual at the center of a dialogue between the world of ideas and the world of materials. The typical delivery system for architecture projects in academia or in professional practice can be summarized in two main operations; representation and construction. These two phases are usually not concurrent as representation typically precedes construction. In contrast, a fabrication based delivery system will usually allow for ideas to be tested and verified against the laws governing the material world such as the ability to transform and connect specific materials. In terms of both process and outcome representation and fabrication based designs have significant differences. The design/build process can be generally described as a series of transformative manipulations where design ideas transform materials through an iterative process and are in turn transformed by the experience of working with materials.

## 3. THE NATURE OF BUILDING THINGS

There is something immediate and rewarding about making things with our hands and at the same time it is hard to explain what goes on while we are engaged in that process. While the act of physically transforming materials with tools relies on a specific set of technical skills it also relies on our intuition. The hand finds, the mind responds. For example our body knows to adjust its strength when applying a rasp to a piece of soft wood and we do not have to actively think about that specific act. Spinoza in his Ethics makes the following observation.

"No one hitherto has gained such an accurate knowledge of the bodily mechanism, that he can explain all its functions; nor need I call attention to the fact that many actions are observed in the lower animals, which far transcend human sagacity, and that somnambulists do many things in their sleep, which they would not venture to do when awake: these instances are enough to show, that the body can by the sole laws of its nature do many things which the mind wonders at."

The mechanisms involved when we are physically building something are difficult for someone to describe because they are not primarily controlled by the sole powers of our mind. The process of making belongs to the realm of our body and involves a more complex system of perceptions. While actively engaged in fabricating a piece of furniture we cannot simultaneously engage in elaborate thoughts. Instead we are focused on our perception while working. The act of making requires the focus of many of our senses and the moment we engage in abstract thinking we instantly leave that intuitive mode of operation. The fact that building with our hands engages our body and its intuitive processes opens the door to a creative realm unknown and inaccessible to our analytical mind.

Our goal here is to discuss a design methodology based on the value of physically making things. Just as the physical act of building something can lead to the acquisition of valuable technical skills it can also become the vehicle of a powerful design process. The introduction of hands-on design/build type projects where fabrication is conceived as a process rather than an end can provide a counterpoint to the abstract tendencies of architectural design and infuse energy throughout the architecture curricula no matter the course subject.

We will present and discuss a series of recent projects designed and built by students and outline a creative methodology which relies primarily on fabrication as a process rather than on representation. We will discuss how design/build exercises can be integrated in a variety of ways to courses such as Design Studios, Structures, Materials and Methods, Introduction to Technology and Environmental Systems. The design process in architecture typically relies on a series of representation tools as a means to create, organize and present ideas. Hand-drawn conceptual sketches, design development drawings, construction documents, physical and 3D models to name a few, have become a set of indispensable tools to navigate the design process of increasingly complex projects. These tools rely on a series of graphic conventions to represent things that are to be physically built in the field. They do belong to a world of representation which lies somewhere ahead and besides the physical world. Although representation is and will remain crucial to the production of contemporary architecture this paper focuses on an alternative design process which would introduce or re-introduce students to the physical world of materials, tools and craftsmanship. Despite the obvious disconnect between design and construction in terms of process and the fact that architects are not expected to build their own projects, architects are nevertheless expected to understand the properties of the various materials involved in construction as well as their modes of assembly. The process of simultaneously designing and building a project may reveal to students a physical world they may not be familiar with. The understanding of notions such as gravity, structural integrity and the need to provide adequate connections can be a source of limitations but more importantly a source of great opportunities.

## 4. CASE STUDIES

The following case studies present a series of recent design exercises completed by students. In some cases students were asked to design furniture using only a limited set of materials and connection techniques and find creative opportunities within these boundaries. In other instances they had to transpose a structural system to a different scale in order to solve technical requirements. They also looked at how construction details can influence design as a whole. Each exercise was typically very clearly structured and presented a specific set of educational goals with regards to design pedagogy.

### 4.1 MATERIAL BASED FURNITURE DESIGN

The premise for these exercises was to design and build a piece of furniture using a specific material or combination of materials. In this context students were expected to rely on an in-depth analysis of a material's properties (gypsum wall board, dimensional lumber or corrugated cardboard) in order to generate design ideas. The understanding of a material's properties allowed students to define practical strategies in term of structural systems, connections and finishes. The purpose of this type of exercises was to emphasize the importance of materials within the design process both as a limiting factor but also and more importantly as a source of inspiration.

#### *4.1.1 THE CARDBOARD CHAIR*

This design project was assigned within a second-year architecture studio and spanned over a two-week period. The purpose of this exercise was to design and build a chair using corrugated cardboard as the only available material. The chair was required to have a seating surface located at 18" above the finished floor and a back. The assembly of the various cardboard parts had to be completed by friction or with a custom-made water and flour based glue. Students had just completed the design of the semester main architecture project and the goal was to expose them to a different mode of design and production. A short lecture provided students with precedents of successful cardboard chair projects as well as an overview of the structural properties of corrugated cardboard. Following a short presentation, students spent approximately 2 hours brainstorming design ideas which they presented in sketch form at the end of the class session. Students worked in teams of two and were responsible for obtaining enough cardboard to build their chair. Once their conceptual design was approved by the faculty, students built their chairs with limited supervision. Access to commercial-grade band saws at the school of architecture workshop allowed students to cut several layers of cardboard at a time. The assembly of the various pieces was completed in the studio space.
The assignment was successful in the sense that all teams were able to build a chair within the time frame imposed. The overall design quality of the chairs seemed in line with the level of work displayed in the studio's previous assignments. Nevertheless some of the weaker students seemed more involved and performed better on this particular project when compared to previous representation based

architecture projects. The less successful chairs lacked a true structural concept based on the physical properties of the material assigned. As a side note students managed their time efficiently and were able to obtain enough recycled cardboard to carry-out their design.

Figure 1.

*Cardboard chair by second-year student*

## *4.1.2 THE DRYWALL CHAIR*

This assignment was undertaken in an elective course titled "Making Furniture and Up-Cycling" and involved third-year students. It was developed during a 3 week period.
Students were asked to design and build a lounge chair using a combination of ½" sheet of gypsum wall board and 2"x2" nominal size-lumber with drywall or wood screws for assembly. As the final assignment of an elective class the purpose of this project was to design and build a chair using construction materials which typically produce large amounts of waste. The construction of the chairs would present an opportunity to divert waste through upcycling.
The drywall chair project was preceded by a week-long exercise during which students built a replica of the famous Red and Blue Chair designed by Gerrit Rietveld in 1918. The constructive concept of the Red and Blue Chair, a combination of timber frames supporting two planes was to serve as inspiration for their chair design. Students built the original Red and Blue Chair using ½" veneer plywood for the seat and back and 2"x2" and 2"x4" nominal lumber for the frames. From that point students were given two choices. They could design their chair based on the structural concept of the original Red and Blue Chair (plans supported by a frame) of define a concept of their own choosing. An obvious challenge was to address the limited resistance of a ½" sheet of gypsum wall board in flexion. Therefore designs were to take advantage of the shear properties of gypsum board as a sheathing material and the ability of wood to perform well in flexion. In order to obtain a successful solution the two materials had to work together.
The proposed requirement to combine wood and gypsum wall board in a meaningful structural system produced projects that were either quite successful or quite weak with very few "in betweens". One of the successful designs proposed to create two shear planes supporting 2"x2" pieces of lumber which in turn carried the seat and back surfaces of the chair. Another strong proposition combined gypsum wall board and wood to create the equivalent of a wood

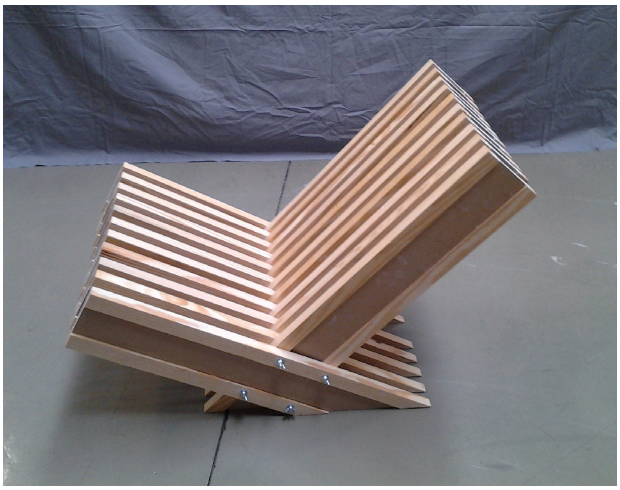

Figure 2.

*Drywall chair by 3rd-year Student*

I-beam using the sheathing material in lieu of ½" OSB (fig. 2). This was especially interesting as a creative solution combining the two materials together. A third chair more closely inspired by the original Red and Blue Chair proposed a system of light frames supporting 3 planes.
In some of the less successful projects students planned to use ½" drywall as if it were ½" plywood only to realize they had to come back and add additional support to the drywall in the form of several layers of gypsum board or wood framing.

### *4.1.3 THE LIMITED RESOURCES CHAIR*

The purpose of this particular assignment was to design and build a chair using as only resource one 8 feet long 2x4 wood stud. The chair seating surface was set at 18" above the finish floor and the chair was required to have a back. The time frame proposed to complete this project was two weeks.
Building a piece of furniture with a limited amount of resources became an opportunity to provide a real example of what it means to be efficient in terms of resource availability. This exercise was also an opportunity to break the monotony of a lecture-based class. Students started the assignment by submitting an axonometric sketch including material notes and a detailed list of all parts with dimensions.
The submission of these drawings was required to help students verify the feasibility of their design on the basis of their limited resources. Design proposal were reviewed by faculty and marked-up if necessary, after which students built their chair in the school of architecture workshop.
Although students produced an initial document indicating design intent it was made clear to them that designs could be modified during the fabrication process as a result of specific problems or opportunities. This project was initially received with some level of skepticism by students although they quickly turned that apprehension into a desire to successfully complete a challenge. Students were given a presentation on traditional and contemporary wood joinery in the hope that they would apply these principles to the fabrication of their chair.
Unfortunately and due to the relative short schedule of the project no one was able to incorporate such involved connection details. Assembly of the various wood pieces was accomplished either with wood glue alone or a combination of wood glue and brad nails. Everyone was able to build the basic structure of their chair given the limited resources allowed. Approximately half of the final chairs built were structurally sound while the other half presented major structural weaknesses in term of the overall structure itself, bracing or connection quality.

## 4.2 STRUCTURE BASED FURNITURE SYSTEMS

The scope of this assignment given to fourth-year architecture students consisted in designing and building a bench based on the structural principle of a bridge truss. The time allowed to complete this project was three weeks. This exercise challenged students to design a truss system composed of cables and bars in order to allow a 12"x96" piece of ¾" plywood to span 8 feet and successfully support four people. The bench seating height was set at 18" above finish floor. Students were given a choice to use either a Fink or Bollman truss to achieve the required span.
This project had a very structured set of requirements so that opportunities for creative design lied in the specific definition of a truss system, its size, spacing of its components and connection details. A series of connections between various elements (cables to bars, cables to bench top, bars to bench top and bench legs to bench top) was identified as critical to the success of the project. Following a presentation of the project requirements to students, the class met at a large home improvement store where faculty pointed out possible materials and assembly systems available. Following the "materials and methods" shopping trip each team was asked to produce an axonometric view of their bench with material notes along with a complete kit of parts and projected budget. After review of these documents students spent the rest of the allotted time building and refining their design in the workshop at the school. Class meetings occurred in the shop from there on.

Figure 3.

*Limited resource chairs*

Some students expressed disappointment about the perceived lack of design freedom associated with this project. They argued that design, in their opinion, had to be shape forming. Despite the very structured guidelines of the assignment the final benches were all different. Each team provided a unique interpretation of the original truss concepts with solutions involving various level of prefabrication.

Notable challenges during construction included the adequate termination and tying of the tension cable ends using crimp sleeves and a crimp tool. Although all teams understood how the cable ends were to pass through a sleeve and create a loop they had to find out how to effectively crimp the sleeve in order for the cable to be firmly anchored. All built benches demonstrated a good understanding of the original truss system and the level of craftsmanship was high overall. Variations in the size, spacing and connections for each truss system resulted in the fact that the rigidity and weight carrying capacity of each bench varied. The very structured nature of this assignment seemed to explain, at least in part, the high quality of the work produced by students.

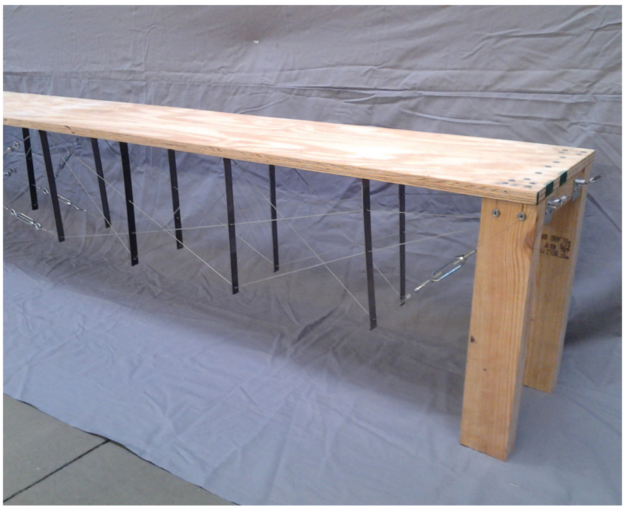

Figure 4.

*Truss bench example*

## 4.3 A PREFAB OFFICE/STUDIO

The overall goal of the Prefab Office/Studio was to design and build a small structure using a custom prefabricated insulated panelized system. The physical scope of the Prefab Office/Studio was determined by the fact that it had to be designed and built in one semester within a lecture type course, in this case Materials and Methods and fulfill the required course content. Another requirement of this project consisted in the fact that the small design/build structure had to be fabricated and assembled inside the School of Architecture. Prefabrication was therefore selected as the project delivery method.

The project itself consisted of an 8' x 16' prefabricated structure and included an 8' x 8' enclosed office/studio adjacent to an 8′ x 8′ covered patio. To the exclusion of the floor system the overall structure was built using a prefabricated panelized system. Power was provided by means of a photovoltaic system in order for the pavilion to operate off grid.

This project was an integral part of a Materials and Methods course offered to third-year students at Florida A&M University School of Architecture and Engineering Technology (SA+ET). The project presented an opportunity for students to test and apply the knowledge acquired during the course in the form of a design exercise. This assignment was also conceived as a practical introduction to construction documents, creative detailing and project scheduling. The overall goal was to empower students to plan an entire construction process and understand the critical importance of construction as a means to inform design. In terms of overall planning the structure was prefabricated in the shop at the SA+ET and then assembled in one of the school's large indoor atrium. Ultimately the structure would be taken apart and reassembled on a permanent site.

### *4.3.1 PROJECT DESIGN REQUIREMENTS*

The project was first presented to students as an assignment with a series of broad guidelines. The main design challenge consisted in developing a prefabricated system that would bring the building program to a successful resolution and address issues such as cost, construction efficiency and sustainability. The panelized system had to be light enough to allow installation without heavy equipment and be built with a minimum of material waste. The stated goal of this project was to design a small structure consisting of an enclosed space (office/studio) and a covered porch. The enclosed space should function as an office/sleeping area whereas the porch would provide an outdoor extension to the enclosure and a place to relax. The dimension of the overall project should be governed by the dimensions of standard building components in order to minimize waste. The prefabricated panels should be built with standard wood framing materials, sheathing and receive a layer of rigid insulation on their exterior surface. The final exterior finish material would then be applied over the rigid insulation. Openings should be designed in order to fulfill a variety of functions such as bringing natural light, providing views to the outside and allowing natural ventilation. A small photovoltaic system installed on the roof would power interior and exterior LED lighting as well as power receptacles inside the office space for up to 6 hours. In order

Figure 5.

*Panel prefabrication*

to function both as an office and sleeping area the interior layout must include built-ins and movable components.

### 4.3.2 DESIGN SOLUTION

The final design presented here was not the work of a single student but the result of combining successful solutions proposed by a number of students. Based on the need to create small but usable spaces with modular dimensions the overall footprint of the project was defined as an 8′ x 16′ rectangle. The porch and office/studio spaces were respectively 8′ x 8′ so as to provide two similarly sized spaces with different qualities. In addition to the overall footprint of the project being 8′ x 16′ the height and dimensions of the prefabricated panels was determined in order to conform with standard material dimensions. The prefabricated wall panels where actually 4′ wide by 8′ high on the high side of the shed roof and 7′-4″ high on the low side. This arrangement provided that no wall dimension would be over 8 feet. The roof panels were built in modules of 2′ x 10′ so they would create a 1 foot overhang on all sides. Final wall and roof panel dimensions well also driven by their weight considering that assembly was to be executed without heavy equipment.
The interior space was designed to function both as an office and sleeping area. The desk surface placed against the north wall could pivot downward and the space would then function as a meeting room. Another panel could also pivot down on the east wall and be used as a meeting table. A bed on wheels would be moved on the floor from its storage position against one of the wall to provide sleeping arrangements.

### 4.3.3 PROCESS

The goal of the design phase was for students to identify the technical requirements of using a panelized system and develop a design scheme which would successfully integrate all construction components.
Initially students developed a variety of design propositions for a small prefabricated structure. They produced dimensioned plans, elevations, sections and an axonometric view. These propositions ended up presenting a variety of sizes, layouts and roof shapes but did not always take into account the necessity for these elements to be prefabricated with standard material sizes and assembled without special equipment. Given the first series of design propositions developed by students the overall size of the project was then defined as an 8′ x 16′ rectangle with an 8′ x 8′ porch and 8′ x 8′ office/studio. It was also decided that the roof shape be a shed with a 1:12 pitch to simplify construction and allow for easy installation of the photovoltaic system. A second iteration of the design was then produced by students which presented major improvements over the first draft. All design propositions were reviewed and successful components from a number of designs were combined to define the final building. Up to that point in time the documents produced were typical architectural drawings aimed at describing the shape and dimensions of the structure but not its modes of assembly. Once the design was finalized students developed a set of construction documents describing each prefabricated panel and building component along with its mode of assembly. The drawings produced included plans and elevations of the overall structure and individual panels, two sections and an exploded axonometric view presenting the overall assembly and connectors.

### 4.3.4 PREFABRICATION

The goal of the prefabrication phase was to build all wall and roof panels with a high level of precision in a controlled and safe work environment. All prefabricated panels were built in the shop at the School of Architecture. Students were assigned a team and worked in the shop at set times set aside from regular class hours. The wall panels built in 4 foot wide sections were constructed with 2 x 4 framing and ½″ OSB sheathing placed on the outside. Rigid insulation was placed on the exterior side of the panel over the OSB sheathing. The dimensions of the modular panels assumed assembly to be executed by two people. Door and window openings where precut in all wall panels. In addition to conforming to the overall dimensions of the structure, the 2′ x 10′ roof panels were sized so one person could lift them while another person would receive them and install them. Roof panels where constructed using a 2 x 6 framing system covered with ½″ OSB sheathing and rigid insulation. Assembly of all prefabricated panel components was achieved using screws rather than nails to allow for future disassembly.

### *4.3.5 ASSEMBLY*

As planned, assembly was carried out by 2 people as a way to verify the assumptions made during the design phase with regards to panel size and weight. Prior to

Figure 6.

*Assembly layout*

Figure 7.

*Project close to completion*

the assembly of the prefabricated panels students built a floor system composed of ¾" tongue and groove OSB boards screwed onto 2x8 floor joists at 16 inches on center. The perimeter of the floor was built with two 2x8 on which heavy duty casters were installed in order to move the structure during and after construction.
Once the floor system was installed, wall panels were screwed directly onto the floor sheathing and rim joists. Temporary bracing was used to ensure safety during the assembly of the wall panels. Following the wall panel assembly, two 4x4 posts were notched at the bottom and bolted onto the floor structure. 2x8 beams were then installed to support the roof structure above the covered porch. Roof panels were finally anchored to the top of the walls and beams to complete the basic structure. The overall assembly of the overall structure took approximately five hours.
The phases of design, prefabrication and assembly were completed during the course of a single semester. The installation of the exterior cladding, roof panels and interior built-ins is currently being carried out by graduate students.

### 4.3.6 OBSERVATIONS

When the project assignment was presented to students there was a clear emphasis on the fact that they were expected to integrate construction methods within their design proposition. The first design iteration did not prove very successful with regards to construction informing design. This may have been due in part to the lack of construction knowledge and experience of the majority of the students enrolled in the course. Another factor contributing to the difficulties encountered by students may be related to the delivery method of the original assignment which was presented verbally and graphically. Even though the pedagogical goals were clearly laid out in the assignment students struggled with the concept of basing their design on a set of specific materials and construction methods. In that regard a preliminary and short hands-on exercise may have helped clarify the expected outcome of the design phase.

A more structured and detailed set of design guidelines was then developed with the definition of overall dimensions and the decision to use a shed roof for practical reasons. The refinement of the program seemed helpful to the majority of the students. Following the relative failure of the first design attempt students were much more successful at incorporating construction processes in the second design iteration. The environment in which students worked at the SA+ET, a large and fully equipped shop, provided a setting that proved safe and conducive to team work. Due in part to good work conditions the overall craftsmanship of the construction was relatively high which proved key to the assembly of the prefab modules. The majority of the students involved in the project did not have prior construction experience and this project became an opportunity to demonstrate that building skills and knowhow can only be acquired through the physical act of making.

Another positive outcome to be noted about prefabrication was the fact that it allowed a large number of students to work at the same time on a number of building components, therefore increasing efficiency and production output.

The assembly phase of any prefab project is usually preceded by a bit of anxiety and anticipation as the validity of design and construction quality are about to be tested. The actual assembly of all prefabricated panels was successful and validated the overall design and construction planning although the installation of the roof panels proved a bit harder than expected and required the help of a 3rd crew member at certain times. Assembly of the structure was completed by a crew of 2 people in 5 hours.

## 5. CONCLUDING THOUGHTS

Fabrication based design projects such as the ones we presented may be typically undertaken in a design studio environment. Nevertheless these exercises, due to their scale and scope have the potential to be integrated in courses typically taught in a lecture format. Furniture is large enough to physically engage students but remains at a scale that is manageable by individuals or small teams of students over short periods of time. Therefore furniture making projects can be developed as short assignments ranging from a week to a month. Although the projects outlined in this paper were mostly introduced in elective and design studio courses they would seem particularly well suited for architecture courses such as Materials and Methods, Structures, Introduction to Technology and Environmental Systems. Projects like the cardboard and drywall chair would benefit a Materials and Methods or Structures course and provide an opportunity for students to become more familiar with material properties and invite them to consider the use of materials as a source of inspiration. The Limited Resource Chair which deals with design in a context of specific limitations may be relevant for an Environmental Systems course. The truss bench exercise, as a structural system applied to furniture would also be a good fit for a Structure course. The Prefab Office/Studio project with its emphasis on assembly and connections would provide an appropriate introduction to creative detailing within a Materials and Methods course. Other skills like construction management and the acquisition of good craftsmanship would prove valuable to students as part of their overall architecture education.

Design/build projects have an important place in the current active learning environment as they invite students to gain knowledge through the invigorating process of resolving a series of concrete challenges. The inherent qualities of a design/build process could provide balance to the virtual tendencies of most areas of human activity including architecture education. Design/build projects would also give students confidence based on tangible things as opposed to the sometime false confidence of resolving issues graphically. These types of projects can provide an opportunity for students who are struggling with a represenation based design process. We are by no means suggesting that hands-on projects should replace the current tools used in architecture education but we want to recognize their value in terms of pedagogy.

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