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Constructing Understanding: A Developing Strategy for Teaching Introductory Construction Courses

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Abstract: In "Being and Time," Martin Heidegger states that the nearest kind of association one can have is not merely through perceptual cognition, but rather by handling, using, and taking care of things. As he noted, "we do not come to know a hammer by staring at it, but by grabbing hold of it and using it." Undergraduate students in any school of architecture, especially those in their first and second years in the program, are inundated with countless new learning experiences and avenues of thought. Frequently missing from those experiences, however, are moments in the curriculum that allow the student to connect their generated abstractions to the actual built environment through critical acts of making. In an age of increasing focus on digital technologies and virtual architecture, these developing students also need to be introduced first hand to the physical consequences of the lines they draw on paper. By introducing acts of making into the curriculum alongside their digital counterparts, students are given the capacity to achieve a deeper understanding of their projects and of the architecture they will come to design in the future. This research paper presents one strategy for teaching introductory building construction that allows the developing architecture student to begin to cultivate understanding between the sketch, the drawing, and construction throughout the design process. Working at multiple scales, this strategy encourages these students to have a more intimate relationship with the materials of design and construction both from a technical view of construction and a poetic understanding of architecture as an assembly. Haptic connections with actual construction materials provide a tangible basis of knowledge that has the potential to inject the unseasoned architecture student with a valuable, but often forgotten, connection to materiality and the sensory potential of our built world.

Keywords: Building Construction, Critical Making, Hands-on Making, Representation, Experiential Learning

Introduction

Architects draw lines. They draw lines on paper; they draw lines on the computer screen. They draw lines at the first client meeting; they draw lines while working in the field with the contractor the week before the project is slated to open. In his book, *The Thinking Hand*, Juhani Pallasmaa illuminates the dialogue that occurs between a seasoned architect and his or her project throughout the design and documentation process. He states that the "architect is not focused on the lines of the drawing, as he is envisioning the object itself…or occupying the space being designed." (Pallasmaa 2009, 59) For Pallasmaa, during this process the architect mentally migrates into the project, into the structure of these drawn lines. He believes this transfer of consciousness constitutes a "fully haptic and multi-sensory reality of imagination" which brings the architect into a more intimate relationship with the project at hand. (Pallasmaa 2009, 59) While Pallasmaa's agenda with regards to this line of inquiry is focused on a comparison of the drawing hand to the computer-aided model, it also provides an access point to a discussion of how architecture students come to understand the symbolic meaning embedded in the lines they are taught to draw. If a mature architect should have the ability to inhabit the lines of his or her drawings, how does the immature architecture student begin to develop the ability to do so?

One logical place to begin to teach students to make these connections between the drawn line and the built work is in the realm of building construction education. This paper outlines a developing strategy for teaching the second year students in The School of Architecture at Southern Illinois University about introductory building construction. Through the investigation

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of a single family residence from a variety of viewpoints and at several different scales, these students have been afforded the opportunity to explore architecture through haptic connections with the built environment. While working through a series of three projects, these novice architecture students are introduced first-hand to the physical consequences of the lines they draw on paper.

Representation

Virtually everything an architect produces is an abstraction, a representation simultaneously of both the generative ideas and images in his or her head and the yet-to-be-built construction. Sam Ridgway, in "The Representation of Construction," outlines the history of the use of representation to document architecture prior to its physical realization. He defines representation as "the presentation of one thing (the signified) in or by another (the signifier)." (Ridgway 2009, 268) Ridgway adds that not only do architects generate representations, the buildings themselves are interpretations or representations of the architect's construction documents and the other "artefacts" that precede the construction of the work by the contractor. (Ridgway 2009, 268) Navigating this environment of representations is a daunting task for the introductory architecture student. Not only do these students have to learn the fundamentals of architectural design, but each student needs to start to develop a grasp of how these representations inform the parties that will actually be performing the work in the field. For, as Pallasmaa suggests, the craftsmen who implement the work at the jobsite act as the "designer's surrogate hands in the execution of the work." (Pallasmaa 2009, 63)

In order for these neophyte students to be able to make the connections between these layers of representation, each needs to understand through direct and active experience these "surrogate hands." Most critically, these architecture students need to be working hands-on with building materials and assemblies so they can learn the processes and the procedures required to assemble architectural systems. They need to understand the characteristics of these building materials as well as their capabilities. An architecture student can read about wood in a book and memorize some listed facts, but if one were to give that student a 2x4 and ask him or her to create something from it their learning curve has the potential to increase immensely. For Matthew Crawford, in *Shop Class as Soulcraft*, practical knowledge is based on the experience of an individual. "It can't be downloaded, it can only be lived." (Crawford 2009, 342) In the past, this learning typically occurred during a mandatory apprenticeship at a construction site, but this is generally no longer the case. (Pallasmaa 2009, 65) The beginning architecture student needs to live the construction of architecture, not just read about it. This process is best achieved through a course structure that includes a significant thread of experience-based learning objectives.

Experience

Experiential learning has its roots in the philosophies of John Dewey, Kurt Lewin, and Jean Piaget. In his book *Experiential Learning*, David Kolb outlines the common characteristics of experiential learning shared by these three founding fathers. The first trait presented is that experiential learning should be conceived of as a process, not an outcome. In experiential learning theory, ideas are assumed to be malleable and are formed and continuously reformed through one's individual experience. The outcomes of a learning experience or exercise, in the context of this philosophy, are secondary to the primary learning experience of the process of idea generation. (Kolb 1984, 26) Citing Jerome Bruner, Kolb adds that "the purpose of education is to stimulate inquiry and skill in the process of knowledge getting, not to memorize a body of knowledge." (Kolb 1984, 27) For the unseasoned architecture student, it is critical that process is reinforced as the fundamental basis for learning how to create architecture. In most architecture

courses the product carries very little educational value; it is the process of getting to that result that builds the architect's body of knowledge.

The second of Kolb's characteristics of experiential learning is that the process of learning is continuous and grounded in experience. According to John Dewey, "…the principle of continuity of experience means that every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after…" (Dewey 1938, 35) Each step through the semester should be designed to allow the students to reflect on intermediate results, generate iterative solutions, and enrich the critical thinking undertaken at every step in the process. Each task should be critically informed by that which has come before and result in the development of new knowledge to be brought with to the next step in the design process. Within the context of teaching building construction, Kolb adds a qualification to the theory of continuity. He poses the question that if learning is indeed a continuous process grounded in experience, then most of our learning is actually relearning. (Kolb 1984, 28) The students in introductory construction have lived in wood frame structures and seen them being built and, consequently, have ideas on the topic regardless of their level of articulation. In response, the learning environment must be structured to allow for the implantation of new ideas as well as the modification or growth of existing ones.

In his book *Making Learning Whole*, David Perkins expands on the notion of continuity by proposing that the first principle of learning is to make sure that the students "play the whole game." He states that the majority of learning exercises found in typical educational situations do not allow the student to get past the initial disorientation of new knowledge and into the "game" itself. For Perkins, key "threshold experiences" - a place in the exercise where the students begin to gain clarity – are sparsely utilized. He likens this experiential void to learning about a puzzle without actually being able to touch the pieces. Perkins continues by stating that it is not just about playing the game, but about making the game worth playing. Facts and figures are bits of information that make sense within the context of a larger learning experience. But without putting that data or information within a context, no clarification exists for the user as to how these ideas fit together. (Perkins 2009, 9-10) This argument is critical to consider when creating a level of understanding about architecture in the novice architecture student. In order for understanding to be properly gained, these students must be allowed to have a whole learning experience about architecture. They must be challenged to not just memorize the facts, but to take those facts and apply them to the practice of architecture. In introductory building construction courses where there is an exploration of building construction that spans from drawing, to modeling, to full scale construction and back again students have the potential to gain this type of whole learning experience.

Course Structure

Building Technology I: Wood is the first in a series of three construction-based courses taken by the architecture students at Southern Illinois University during their tenure in the undergraduate program. Traditionally, all three courses center on the creation of a small set of construction documents for a given building that escalates in complexity from one course to the next. This introductory course focuses on wood construction while the other two involve the creation of buildings constructed from concrete and steel. In this first iteration of reworking the pedagogical framework for *Building Technology I*, the goal was to provide the second year class with a variety of different perspectives into building construction. Renzo Piano has described his working process as a circularity: "you start by sketching, then you do a drawing, then you make a model, and then you go to reality – you go to the site – and then you go back to the drawing." (Sennett 2008, 40) From this cyclical process, he and his colleagues are able to attack a given design problem from numerous angles, providing an ever-changing perspective on the problem. Much like in Piano's office, this course focused on breaking down the aforementioned layers of

representation by having the students sketch, draw, model, and physically build. Through a series of three projects, these students explored the gamut of making explored in the practice of design and construction. David Perkins encourages the use of problem-based learning that is somewhat "messy." Based on his research, problems that lack perfect answers or a strict connect-the-dots path encourage the students to seek out information. (Perkins 2009, 33) Explorative exercises that ask the students to utilize different mediums and perspectives without providing direct answers generate a learning environment that allows the students to critically think through these problems and develop a strong working process.

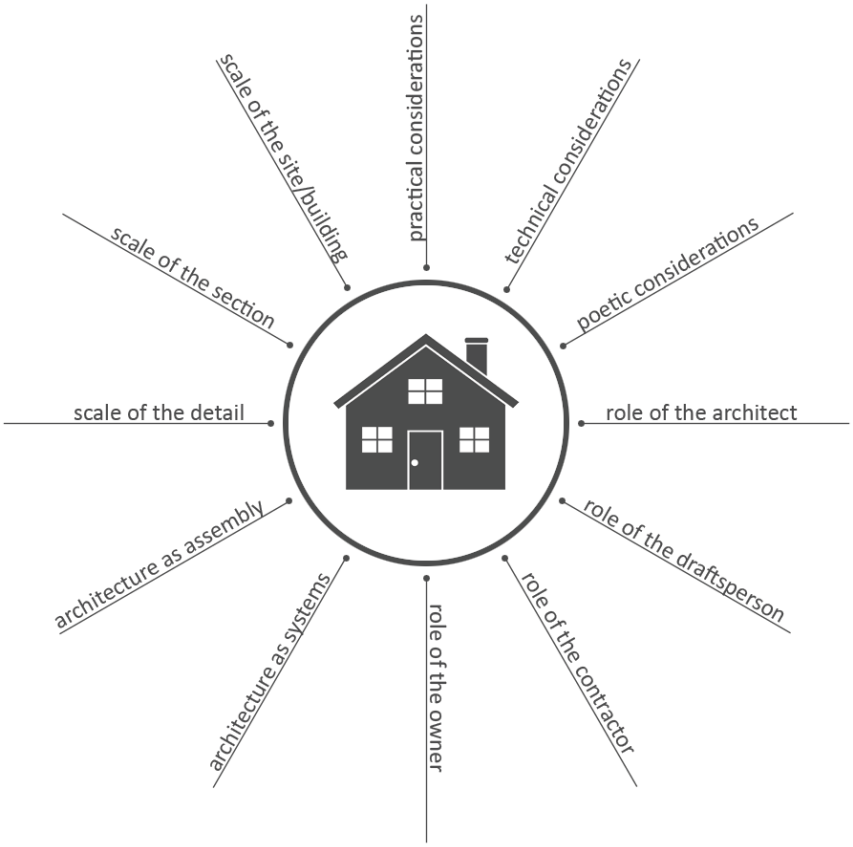

Figure 1: Perspectives Diagram

Within the context of this course, however, the goal was to provide more diversity than just the medium of exploration (Figure 1). Through the project structure, the students were asked to forego their role as a student and don the hat of the architect, the draftsman, the contractor, and the client. Facilitating these various roles allowed the students to better identify and understand the delineation of roles in their future endeavors in the AEC industry. The projects were also configured to allow the students to consider wood light frame construction at multiple scales. This strategy allowed the students the opportunity to make connections between the detail, the section, and the whole in the exploration of architecture. The effect of "zooming in" on a section of a building also typically provides a deeper exploration of the subject at hand. And finally, these novice undergraduates were asked to look at the poetic and technical aspects of the construction of a building. In separate, but intertwined problems and readings, the students were given the opportunity to poetically explore the qualities, abilities, and limits of wood as a material for design and construction in addition to the technical documentation of a building. This clash of perspectives forced the students to think about the materials of construction with

much broader seeing, yet deeper penetrating eyes. Through these strategies, each student in *Building Technology I: Wood* was provided an opportunity for growth through the exploration of the tasks presented via different perspectives and points of view.

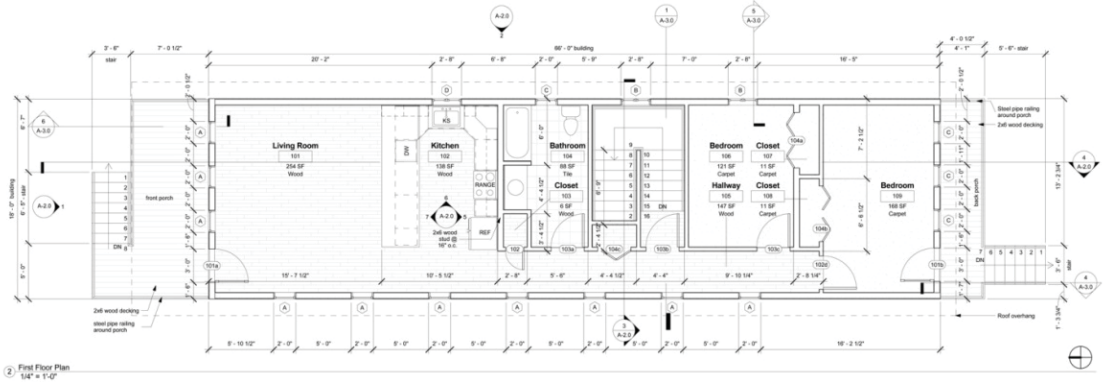

Figure 2: R. Musial - Project 1 Floor Plan

Projects

In the first project of the semester, the students took on the role of the production architect and created a simple design for a single-story *shotgun-esque* style two-bedroom, one-bathroom home for a narrow site in Cairo, Illinois (Figure 2). This project was the largest scale of the three and the fundamental basis for the entire class. Although the students were relegated solely to the use of Revit for the majority of the project, the initial design was conceived by each student with layers of trace and a pencil or pen. Two weeks into the semester, the students took their designs and began to translate them into Revit. As most of the students had never used the program before, it was incredibly difficult at first for the majority of the class to grasp what it was they were telling the computer to generate. BIM (building information modeling) was an ideal platform for this project as the lines from the design sketches have to be "built" in the computer as families and components. This transformation from a single line to a component marked the first level of understanding of representation in the course. A single sketched line became a 2x6 exterior wall with interior and exterior finishes, a thickness, a height, constraints, and relationships to other components. It became part of an assembly. The students did not yet understand how the pieces were assembled, but their minds started to open to the realities and possibilities of construction.

Over the course of the semester, the students generated three sets of drawings: a schematic design set, a design development set, and a construction document set. All three sets were composed of four sheets and the exact same drawings, but each set added complexity to these drawing and greater depth of understanding for the student. Early in the semester, an opportunity arose which significantly increased the student investment in the learning process of this project. It was at this point that the program's relationship with a new YouthBuild program in Cairo, IL was initiated. Amongst other responsibilities, one of the homes the students were designing in this class would be converted into a full set of working documents and built in Cairo by the students studying in the YouthBuild program. Despite the intense workload of the project, the students appreciated the learning experience. At the beginning of the semester the students took an introductory survey given by the instructor. One of the questions asked the students to rate their interest level in learning through a BIM based project. The 42 students who responded to this voluntary survey averaged a rating of 4.4 out of 5 with 4 being 'interested' and 5 being 'very interested.' In a similar exit survey, the students raised their average rating of this question to a 4.6. In a separate question asking about the effectiveness of this project, the average score was a

4.8. This project, although relatively typical for this type of course, allowed the students to develop a thorough understanding of the basic tenants of residential wood light frame construction.

However, in order to provide a more complete learning experience for the students, a more immediate investigation was needed. The second project of the semester began to fill in some missing information and provided the most powerful learning experience of the semester. In this project the students, in groups of seven, played the role of the contractor. Each group was provided with a section drawing from their architect (the instructor) of a single story residence and asked to build a full-scale mock-up of a four-foot length of the depicted wall. This problem jumped up the scale and looked at a portion of a house very similar to the one they were concurrently working on in project 1 in more depth. First, the students were asked to analyze the drawing and develop a materials and parts list of everything they would need to build the wall. They then took the list to the local hardware store and created a cost analysis outlining the funds necessary to construct the wall. And finally, the groups had to create a digital storyboard of the step-by-step process required to actually assemble the wall (Figure 3).

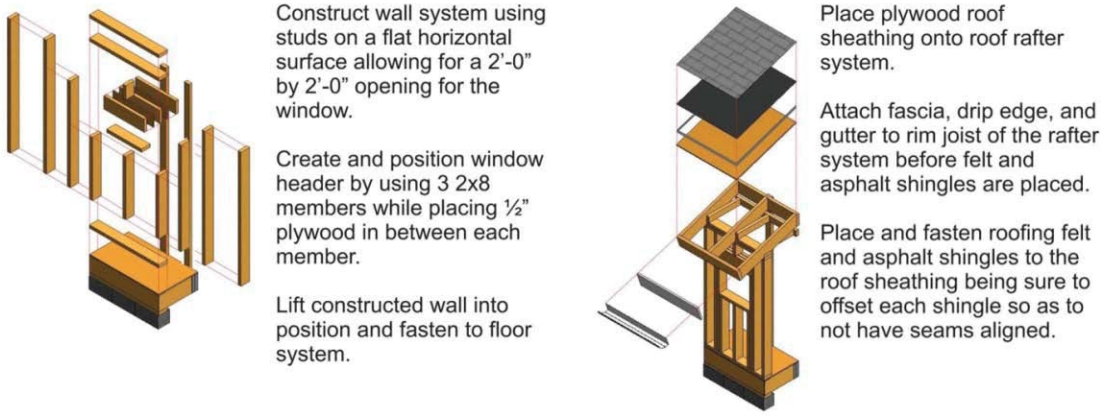

Figure 3: Group 5 (Ollmann, Behl, Mauerman, Ouellette, Thomason, Andersson, Young) – Project 2 Storyboard Samples

Once all of the elements had been signed off on by the "architect" (after further iterations), the groups built the walls at full scale in a massive one-day event in the courtyard of the architecture building (Figures 4|5). Most of the students had never built anything approaching the scale of this construction and many had very little experience with power tools. In his essay "The Nature and Art of Workmanship," David Pye discusses the role of the workmanship of certainty and the workmanship of risk with regards to crafts and the built environment. While not approaching the level of his discussion with regards to automation versus hand-crafted goods, this dichotomy played a major role for the students at this moment in the course. The notion of the workmanship of risk is embedded in the fact that the hand has the ability to err and an error in the craft generates the need to perform considerably more labor to fix the issue or perhaps to start over all together. (Pye 2010, 342) The students in this course were thrown from a situation of relative certainty with their Revit models in problem 1 to a situation of relative risk with the physical constructions of this problem. It is very easy to fix an issue with a wall in Revit; there is very little risk involved in placing a wall in the model and adjusting it later. The full scale construction did not afford this ease of modification. As an aphorism from Kurt Hahn so elegantly states: "A ship is safe in the harbor, but that is not what ships are made for" (Perkins 2009, 115). This group of students had left the safety and familiarity of the textbook, the lecture hall, and the laptop for a more exploratory learning experience.

Figure 4: Project 2 Build Day – Left the Groups in Various States of Construction; Right N. Bosman and D. Ojo Cut a Birdsmouth Notch.
Photographs by R. Swenson

Potentially the most important experience of this project for the students was understanding what all of the lines, symbols, components, and hatches from their generated documents actually represented. Again, connections were made as the elements were brought together and assembled: first digitally in the storyboard and then physically in the construction. Lines became real; they were hammered, screwed, sawn, and anchored. Like the other two projects in this course, project 2 was highly process driven. And much like the first project, the student's surveys indicated a strong interest in this project and its method of delivery. In the initial survey the students averaged a score of 4.6 when asked about their interest in learning through full-scale building; and again, the average increased to a 4.8 in the exit survey. In addition, the effectiveness of project 2 earned an average score of 5.0 out of 5 in the exit survey. Per the Matthew Crawford quote outlined previously, the students lived this project and through all the mis-cuts, bent nails, gorged siding, band-aids, and slivers, they started to learn how to navigate through the representations generated in the practice of architecture.

Figure 5: Project 2 Build Day Site - Left at Midday; Right at Completion.
Photographs by Author

The third and final project of the semester asked the students to contemplate a single detail. As Peter Zumthor states in his book *Thinking Architecture*, "Construction is the art of making a meaningful whole out of many parts." (Zumthor 2006, 11) In Zumthor's professional work, "…every join, every joint is there in order to reinforce the idea of the quiet presence of the work." (Zumthor 2006, 15) In order for the students to gain a full understanding of the role of construction in the practice of architecture, they needed to understand, like Zumthor, the nature of the building as an assembly, a collection of joints that brings a diverse selection of parts

together in a meaningful way. The task given to explore these ideas was simple: connect together two 2'-0" long lengths of 2x4. There were two different constructions requested of the students for this problem. The first had to be constructed entirely of wood (Figures 6|7) and the second had to use one or more different materials to create the assembly (Figures 8|9). First, the students were asked to select an item of inspiration. This item became the genesis of their design strategy for the attachment of the members and ranged wildly from a skateboard truck to a bra strap to a pair of scissors. Starting with a series of sketches and quick models, the students outlined their strategies for imparting the lessons of the item of inspiration into a construction detail and several weeks into the semester, they created the first pair of connections and presented the work. After studying the initial results, the students rethought their work based on the learned knowledge of the abilities of the wood and the critique of their design and again were asked to sketch their thoughts. The final pair of constructions was presented at the end of the semester which afforded the students the ability to draw on the entire body of coursework for inspiration for their concluding works.

Figure 6: R. Finn – Construction (Container Latch)
Photograph by Author

Figure 7: K. Coughlin – Construction (Train Wheel)
Photograph by Author

Figure 8: M. Ollmann - Construction (Drawer Slide)
Photograph by Author

Figure 9: K. Schwebel – Construction (Hinge)
Photograph by Author

Although the student interest level in learning through building at full scale remained the same as listed with project 2, the exit survey indicated less student satisfaction with problem 3. The average student score for the effectiveness of this project was a 3.6, a considerably lower mark than those awarded to the two other projects. I believe part of the reason for this low score was the absence of a direct link from this problem to the other two. The goal was to have the students use these details early on as inspirations in their own right with respect to the design of the house from the first problem as well as in a more creative based construction analysis in the second problem. Unfortunately, this goal was not able to be realized in this course. While a simple connection at the surface, these constructions can provide the fundamental basis of design and construction at multiple scales throughout a work of architecture. It is the hope that in future iterations of the course, this project can evolve into an important tool in helping the students to understand in a direct way, the abilities and limits of one of the core materials of our built world.

Conclusion

In his paper "The Essence of Building Technology," Edward Allen stated that "it's nice to know what Heidegger said about laying bricks, but not as nice as really understanding bricklaying and how to use it in one's building." (Allen 2007, 9) Perhaps Allen is correct in his statement; thinking about the brick is nice, but knowing how to properly use a brick is better. In this introductory building construction course the students were given the opportunity to explore wood and light wood frame construction from both perspectives. The problems the students navigated through provided them with critical learning opportunities centered on the goal of opening the student's eyes to perceiving construction in different ways. Using experiential-based learning objectives, the students were thrust into what was initially an uncomfortable situation due to their relative inexperience and the lack of answers provided to them upfront. As their confidence grew, the students gained more ability to traverse the three problems and build upon the many mistakes made along the way. The dialogue achieved within the exploration of the layers of representation peaked with the building of the sectional assemblies.

In addition to the introductory and exit surveys, the students were required to fill out course and instructor evaluations at the end of the semester. Three questions from these evaluations are of particular importance in the context of this discussion. Question 1 on the course evaluation states, "Was the course a good learning experience?" The 59 student respondents rated the learning experience at an average of 4.85 out of 5.0, or a 97%. The second question asks, "Was the course content good?" The average rating from the students on this question was 4.61 out of 5.0, or a 92%. And the last question asks, "Generally, was the course good?" The students gave the overall course an average rating of 4.69 out of 5.0, or a 94%. The students were also given the opportunity to provide any additional thoughts on the class in these evaluations. Out of the 48 students who participated, 28 specifically indicated that the course increased their knowledge base and that they enjoyed and appreciated the learning experience provided though the course construct. 27 of the respondents stated their appreciation for one or more of the projects. In contrast, the most significant criticisms of the course were that the pace was too fast (7 respondents) and that the overlap of the projects was too demanding (5 respondents).

Although this semester proved to be a success for the students, there are still great strides to be made in refining this educational experience. Clearer links between the projects, more refined choices for topical readings and case study examples, the generation of a more interactive learning environment, and an appropriate pace for the class are amongst the many challenges facing this course in its future iterations which will occur each spring for the foreseeable future. Fundamentally, however, this course has come to rest on the simple principles of experiential learning, first hand manipulation of building materials, and a rigorous, process-driven exploration of a small part of the built environment.

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