Designbuilding Empathy through Design Workflow Software and Designbuild Pedagogy

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INTRODUCTION

Designbuilding Empathy combines the teaching of introductory design workflow software with designbuild pedagogy to provide opportunities for students to develop empathy for the construction process through physically making their designs. This paper argues that by integrating the design and analytical power of workflow software with the experiential, social and practical experiences of designbuild pedagogy, students will understand construction as a part of design, preparing them to be better collaborators and leaders upon entering the architecture profession.

Design workflow software and designbuild pedagogy have each, in unique ways, expanded the architect's leading role in the design and construction of buildings. A 2017 article about design workflow software by Richard Garber argues, "Process is no longer an explicitly design-side operation; architects are increasingly involved in component manufacturing and construction, allowing them to expand the territory and traditional role in building design they have held since the time of Leon Battista Alberti in the 15th century."[1] Additionally, designbuild pedagogy satisfies a strong desire in architectural education for hands-on thinking, social engagement and interdisciplinary collaborations that enable students to experience designs progressing from concept to constructed reality.

Many of today's beginning design students in the millennial generation come from primary and secondary educations lacking "integrated tectonic experiences."[2] Yet, as future architects, these students will guide the design and delivery of physical institutions, public spaces and cities. In a 1995 essay Jorge Silvetti states that "[i]n architecture, something always has to be designed, detailed, spec'ed, bid, built and paid for, something that is concrete and finite...a product is necessary."[3] How can educators teach a generation with limited integrated tectonic experiences to lead the design and production of our physical spaces?

RECLAIMING THE PROFESSION

William Carpenter, in *Learning by Building* (1997), argues, "The architect's role in today's practice has eroded as other professions absorb parts of our once comprehensive profession. Interior designers overtake the building from within, engineers have begun to offer complete building design services, and builders now provide services as design/builders, allowing clients to have a project designed and constructed by the same entity. Architects should have a knowledge of building and the respect once given to them by clients and other professionals."[4] Carpenter makes clear that learning by building pedagogy does not intend to turn professional architects into builders. He writes, "This is not to say that the architect must build everything, but the architect should not simply observe; the architect should be immersed in the potential of construction and its conception."[5] This paper speculates that architects can reclaim a leading role in the design and delivery of buildings in part by teaching students design workflow software coupled with designbuild pedagogy - building upon movements already underway worldwide. Chad Kraus argues in *DesignBuild Education* (2017), "Resisting the contemporary tendency to reduce architecture to superficial aesthetics or form making, designbuilders seek to reunite increasingly disparate realms of the disciplines of architecture."[6] Designbuild pedagogy prepares future architects with agency, authority and accountability to engage in the construction of their designs; as opposed to merely witnessing its occurrence.

DEVELOPING EMPATHY

How might educators develop empathy for the construction process on the part of students? Students develop empathy for the construction process by participating in the production of designs. In the book *Five Houses, Ten Details* (2009) Edward Ford articulates, "The way to architectural empathy is through an understanding of weight, material and assembly."[7] Kraus argues that this empathy extends to builders and craftspeople via participation in the construction process. "Through immersion in the construction process, the future architect develops an empathy with builders and craftspeople. Designbuild education begins to act as the bridge between academia and practice, between the designer and the maker, often adopting similar concerns to the profession at large."[8] Empathy for the construction process encourages more holistic designs which value construction considerations in the design process such as tolerance, scale, labor, tactility, cost, schedule, efficiency, detailing and assembly.

CONNECTING DESIGN AND CONSTRUCTION

Robin Evans eloquently describes the disconnection between architectural design and construction in the text *Translations from Drawing to Building* (1997). "My own suspicion of the enormous generative part played by architectural drawing stems from a brief period of teaching in an art college. Bringing with me the conviction that architecture and the visual arts were closely allied, I was soon struck by what seemed at the time the peculiar disadvantage under which architects labor, never working directly with the object of their thought, always working at it through some intervening medium, almost always the drawing, while painters and sculptors, who might spend some time on preliminary sketches and maquettes, all ended up working on the thing itself."[9]

How might architectural educators teach students the digital, physical and social workflows, which connect an architectural design to its construction? This paper briefly considers four pedagogies commonly used to connect architecture students with full-scale constructed designs: the full-scale drawn detail, the construction site visit, design workflow software and designbuild pedagogy:

Full Scale Drawing

The full-scale drawn detail enables the architecture student to visualize a design's scale in relation to the human body. While drawing, a design student can physically mimic assembly with the necessary construction tools to ensure the hand and tool choreography within the given space. This technique was far more common in scaled hand drawing, than it is in scaleless digital drawing space. While full-scale drawing brings the architecture student closer to scale and assembly, it ignores other construction issues such as material performance, tolerance, and tactility.

Construction Site Visit

In the construction site visit students tour buildings in various stages of construction, often guided by a site supervisor or project architect and observe people and machines assembling a building. These tours reveal full-scale assemblies, detailed connections, machine and builder choreography and the conditions under which builders work. While experientially beneficial and helpful for understanding large projects, these exposures are brief, insulated from real construction dangers and only show construction at one moment in time.

Design Workflow Software

Design workflow software such as graphic scripting, Computer Aided Design and Manufacturing (CAD/CAM) and Building Information Modeling (BIM) enable the designer to three dimensionally visualize and analyze a building prior to construction. Design workflow software also enables designers to efficiently view and assess thousands of design alternatives using a limited number of variables in design space optimization. Today's architectural design and production mentality, termed "mass customization"[10], involves small teams of designers utilizing primarily digital platforms to create specialized building parts developed through digital analysis and physical prototypes.[11]

Designbuild Pedagogy

Designbuild pedagogy accentuates the physical and interpersonal experiences of architectural design and construction. Kraus argues that designbuild pedagogical theory emerges from elements of critical regionalism, phenomenology, and pragmatism; which share values of, "direct engagement with people, places and processes and a valorization of everyday experiences."[12] Hallmarks of designbuild pedagogy include learning by making, material engagement, place specific design, and local community outreach.

LEARNING BY MAKING

What role should the act of making take in a student's design process? Does making occur after a design is complete, as a way to test an idea in full-scale? Alternatively, can the act of making be the design process itself - with ideas emerging from physical contact with materials and tools? In the 2017 essay *Embodied Making,* Terry Boling argues that making at full scale can be the design process itself, not a result of it. He claims that due to the prevalence of digital drawing and fabrication students and faculty are hungry for physicality in design. Boling comments, "The pedagogical position outlined here, however, is that making at full scale is not simply a means to an end, but is actually a powerful design tool that can provide specific feedback distinct from other modes of design inquiry."[13] This paper presents a project, which includes making as part of the design process. Students work with commonly available materials to initially hand-build constructs, thus gaining a sense of material tendencies and opportunities prior to then integrating digital design and fabrication processes.

THE PROJECT | DEPLOY: TRANSFORMABLE PRIVACY SCREENS

This project's objective is to leverage and integrate both emerging design workflow software and designbuild pedagogy to develop empathy for the construction process on the part of architecture students, thereby positioning them to be better collaborators and leaders in the design and delivery of buildings upon entering professional practice.

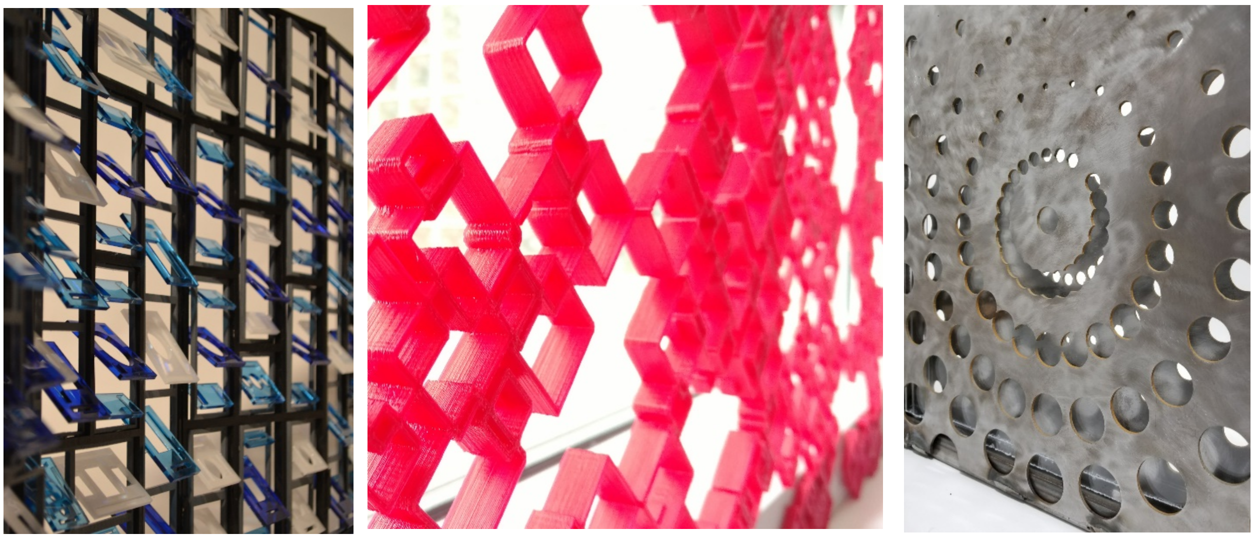

Fig 1. Students design and construct privacy screens utilizing a variety of fabrication methods and materials ranging from waterjet cut steel to laser cut acrylic and additively manufactured frames. Students both collaborate with professional fabricators and construct themselves, simulating a collaborative professional practice model. Projects by Meagan Zablocki, Taylor Sokacz and Ryan Geisler, and Thivakar Bala and Stephan Karetnik.

Curriculum

This project occurs in the final course of a four-part Visual Communications sequence for undergraduate architecture students at Lawrence Technological University College of Architecture and Design. Program Chair James Stevens, Professor Ralph Nelson and alumna Natalie Haddad write about the college curriculum saying, "Our pedagogical strategy is to lead students through experiences that simultaneously engage the real and the representational in a productive tug of war."[14] Indeed, this course has both representation and production ambitions, which are integrated into the act of designing, making and presenting.

The course introduces students to digital drawing and rendering in Rhinoceros, parametric graphic scripting in Grasshopper, and CAD/CAM in RhinoCAM. Students also build upon previous training with fabrication facilities such as the woodshop, metal shop and additive manufacturing laboratories. Stevens, Nelson and Haddad articulate the importance of an iterative digital and physical workflow in the college curriculum writing, "The computer has leveled a new complexity on the student and architect. It can too easily remove from us an awareness of scale, tolerance and tactility by providing a universally scaled world that is always level, square, and untouchable. The computer, in effect, dictates that the world should match the abstract coordinates of our software, which we all know is never true."[15]

Scale

Now in its second year, the project began as a six-week, end of semester final project in which students worked in pairs to design an approximately 7' x 15' x 6" deployable privacy screen. Students physically modeled the screen's entirety at 2" = 1'-0" and constructed a connection detail at full-scale. In its second year, the project has expanded to the full semester to enable more in-depth development in three phases - design workflow software, material engagement, and construction. The screens, which were initially without specific sites, now are sited in the college library to encourage students to respond to site-specific conditions such as function, sound, light, viewer and user. The librarians provide valuable insight into how people use the library while also expanding the project's social network beyond the typical student, teacher, and critic.

The project explores the threshold for effectiveness in terms of how comprehensive a student construction experience needs to be in order to gain the aforementioned benefits. Much has been written about designbuild scale, particularly related to practical struggles institutions face with larger scale projects, such as houses or public structures.[16] Given this project's semester curricular requirements and limited funding this project limits scale. However, practicality is not the only reason for limiting scale. Operating at the detail scale enables students to engage construction processes without scale overburdening them. Boling argues that, "Limiting the scale and scope of projects is one way to achieve the pedagogical goals of designbuild without sacrificing quality."[17] Complimented through in-class discussions, readings and professional guest speakers, students are guided to translate the scale shift from detail to building.

Beginning Design with a Precedent

Students begin the project by reverse engineering architectural screen precedents that are complex enough that parametric modeling in Grasshopper is necessary for accurate representation. Teaching students new design software by modeling existing geometries enables students to focus on learning the software by modeling tangible entities. Grasshopper developer David Rutten argues, "If you want to learn Grasshopper the best thing that you can do is take a real problem that you have to solve and that you understand well, so that when you learn about Grasshopper you are not both baffled by the problem and Grasshopper, but only by Grasshopper."[18] Students develop scripts in Grasshopper to model the precedent, which are then further developed to explore their own design concepts. The students select from a diverse shortlist of precedents that vary in scale, material, construction system, location and performative function to expose the class to a broad range of possible inspirations. Precedent examples include the Institut Du Monde Arabe in Paris, France by Jean Nouvel, Louis Vuitton Roppongi Hills store in Tokyo, Japan by Eric Carlson and Aurelio Clementi and the Eskenazi Hospital Parking Garage Facade in Indianapolis, United States by Rob Ley among many others.

Material Engagement

Following the introductory software tutorials and precedent analysis students extract one design concept that they wish to develop via physical material engagement. These concepts range from operable screens, to surface conditions, to moirè patterns and other effects. Students explore the concepts through physical tests in the college's buildLab using woodworking and metalworking tools. During this hands-on phase, the design concepts evolve as they intermix with ideas from physical material engagement. This process of students synthesizing multiple design inputs simulates the complex design considerations in professional practice.

Students interact with skilled craftspeople on and off-campus. Carlo Scarpa believed that, "the process of making was [not] limited to drawing only. Stonemasons, woodworkers, glassblowers, and other artisans were an integral part of his design/build process. He was often involved in endless and exhaustive discussions with the constructors of his projects, valuing their opinions."[19] Interacting with the social networks that support construction including craftspeople, vendors and consultants is an important aspect of designbuild pedagogy. Alberto Perez-Gomez argues that students develop important sensitivities to the physical and cultural world outside of campus when they engage these social networks.[20] For example, when students interact with material vendors they are enhancing their designs with developed cultural knowledge about material sourcing, performance, alternatives and costs. Students source and order their own materials, oversee their design and fabrication schedules, develop budgets and perform and hire specialized labor when needed. After this material engagement phase students further develop their Grasshopper scripts and setup CAD/CAM toolpaths to operate on the now familiar materials with digital fabrication tools such as CNC routing, waterjet cutting and additive manufacturing.

Evaluation

In evaluating successes of this small-scale digital designbuild project both conceptual and practical considerations are at play. Bolin, whose studios at the University of Cincinnati regularly engage detail-scale designbuild comments, "It is made clear [to students] that innovation, curiosity and sensuality are as valid criteria as budget, schedule and program."[21] This balance between practical and conceptual evaluation parallels a distinction between the discipline and the profession that this project seeks to simulate. In a 2016 essay Todd Gannon argues, "The profession of architecture, undertakes building and city making as a service to society, and therefore at times primarily attends to issues of accommodation, efficiency, sustainability and cost-effectiveness. The discipline, on the other hand, pursues building and city making as an art form, and thus works primarily to advance the public imagination - a term we use as the process of forming images in the mind."[22] Students are encouraged to simultaneously consider questions of "why" with questions of "how".

Students appreciate the simultaneous exploration of concept and practice, as well as combining digital workflow software with learning by making, as evidenced by the end-of-semester course evaluations. "I learned from being able to explore design and fabrication simultaneously," said one student and, "The project pushed the boundaries between visualization and fabrication", said another.[23] In the final review students are asked how the making process altered their initial design concepts. In the case of the two students who studied the 2002 Serpentine Pavilion, they identified design concepts of continuity and flatness that were motivations for their screen design of intersecting rectilinear glass and wood geometries. However, they needed to produce multiple physical iterations before achieving the same smoothness that they could easily represent in their drawings. Another pair that studied the Eskanazi Hospital Parking Garage Facade identified design concepts of parallax and synthetic facades, which inspired their design for a non-functional screen to shield an unappealing view that visually changes as one moves around it. Their initial screen design developed in the Grasshopper script proved too intricate and varied to fabricate tectonically, and the students ended up additively extruding the screen using polylactic acid. The failure of the initial fabrication strategy led to important learning outcomes about how one considers making in the design process.

CONCLUSION

This project seeks to empower architecture students with tools and experiences to help them collaborate and lead the design and delivery of buildings in professional practice. It engages certain risks of expanded student responsibilities that do not occur otherwise in architectural education projects. Full-scale fabrication entails risks such as construction safety, student-borne material and machining costs, and interpersonal conflicts when students engage with professional fabricators, vendors and clients. Engaging these risks in the academic context prepares future architects to empathize with the complex production of buildings. Understanding these risks enables architects to better control the "increasingly complex outcomes of the design and construction process."[24] Architects are privileged to be leaders in the design and delivery of buildings and should seize opportunities to claim this domain. The continual emergence of design workflow software and designbuild pedagogy at scales both large and small promises to enable architecture students to connect design and construction as part of the same feedback loop, thus preparing them to be leaders in the design and delivery of buildings upon entering professional practice.

References

1. Garber, Richard. "Digital Workflows and the Expanded Territory of the Architect." AD Workflows guest-edited by Richard Garber, vol 87, no 3, 2017, p. 10

2. Kraus, Chad. "Architecture into Presence." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 93

3. Silvetti, Jorge. "After Words." Assemblage, vol 27, August, 1995, p. 78

4. Carpenter, William. Learning by Building: Design and Construction in Architectural Education. New York: Van Nostrand Reinhold, 1997. Introduction p. 2

5. Ibid. p. 2

6. Kraus, Chad. "Introduction." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 12

7. Ford, Edward. Five Houses, Ten Details. New York: Princeton Architectural Press, 2009. p. 26

8. Kraus, Chad. "Introduction." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 12

9. Evans, Robin. Translations from Drawing to Building and Other Essays. Cambridge, Mass: MIT Press, 1997.

10. Carpo, Mario. The Second Digital Turn: Design Beyond Intelligence. MIT Press, 2017.

11. See webinar presentation by Zaha Hadid Architects and FRONT, Inc. of their collaboration on the Morpheus Hotel. https://wiki.mcneel.com/webinars/morpheus. Accessed Feb 22, 2018.

12. Kraus, Chad. "Introduction." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 6

13. Boling, Terry. "Embodied Making." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 140

14. Haddad, Natalie; Nelson, Ralph; Stevens, James; . "Practicing the Digital Vernacular: Raising a Barn and Raising Questions." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 155

15. Ibid. p. 156

16. Maines, Katherine and Middlebrook, James. "The Introductory Architecture Studio Revisited: Exploring the Educational Potential of Design-Build Within a Liberal Arts Context." Journal of Architectural Education, vol 70, no. 1, March, 2016. Pp. 154-164

17. Boling, Terry. "Embodied Making." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 153

18. Rutten, David. Grasshopper Getting Started 09. Introduction to Grasshopper Videos. https://vimeopro.com/rhino/grasshopper-getting-started-by-david-rutten. Accessed Feb 22, 2018

19. Carpenter, William. Learning by Building: Design and Construction in Architectural Education. New York: Van Nostrand Reinhold, 1997. Introduction p. 21

20. Gomez, Alberto Perez. "Foreword." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 3

21. Boling, Terry. "Embodied Making." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 144

22. Gannon, Todd. "Figments of the Architectural Imagination". cataLOG: The Architectural Imagination edited by Cynthia Davidson and Monica Ponce de Leon, Anyone Corporation, 2017, p. 66

23. Anonymous students. Visual Communications 4 Course Evaluation. May 2017.

24. Boling, Terry. "Embodied Making." Designbuild Education edited by Chad Kraus, Routledge, 2017, p. 142