

(Digital) Design-Build Education

Andrew Colopy
Rice University

THE INSTRUMENT OF PRACTICE

Architectural education is often held up as an exemplar of project-based learning. Perhaps no discipline devotes as much curricular time to the development of a hypothetical project as is found in the design studio model prevalent in US architecture schools. Whether the emphasis is placed on more 'classical' design skills—be they typological, tectonic, or aesthetic—or on more 'socio-political or eco-cultural aims,' studios generally include the skills and values we deem instrumental to practice.¹ The vast majority of such studios, therefore, emphasize the production of drawings, images and models of buildings, i.e., representation.² This is not altogether surprising, as these are, by definition, the instruments of practice.³ But the emphasis on drawings and models also reflects the comfortable and now long-held disciplinary position that demarcates representation as the distinct privilege and fundamental role of the architect in the built environment.

That position, however, continues to pose three fundamental and pedagogical challenges for the discipline. First, architectural education—to the degree that it attempts both to simulate and define practice—struggles to model the kind of feedback that occurs only during construction which can serve as an important check on the fidelity and efficacy of representation in its instrumental mode. Consequently, design research undertaken in this context may also tend to privilege instrumentation (representation) over effect (building), reliant on the conventions of construction or outside expertise for technical knowledge. This cycle further distances the process of building from our disciplinary domain, limiting our capacity to effect innovation in the built world.⁴ Second, and in quite similar fashion, the design studio struggles to provide the kind of social perspective and public reception, i.e., subjective political constraints, that are integral to the act of building. Instead, we approximate such constraints with a raft of disciplinary experts—faculty and visiting critics—whose priorities and interests seldom reflect the broad constituency of the built environment. The third challenge, and a quite different one, is that the distinction between representation and construction is collapsing as a result of technological change. In general terms, drawing is giving way to modeling, representation giving way to simulation. Drawings are increasingly vestigial outputs from higher-order organizations of information. Representation, yes, but a subordinate mode that remains open to modification, increasingly intelligent in order to account for direct translation into material conditions, be they buildings or budgets.

DESIGN-BUILD

While having grown more acute, these concerns are not altogether new. One strategy to address them within a project-based curriculum has been to incorporate the realities of construction and political constituency simply by having students design and construct an actual building. Contemporaneous with the educational theories of the Pragmatist John Dewey, American precedents for such an approach date back to at least to the late 19th century. Booker T. Washington's work with students at Tuskegee University (then Tuskegee Normal and Industrial Institute), for

example, and later, the merging of Dewey's teachings with those of the Bauhaus by Josef and Anni Albers, among others, at Black Mountain College.⁵ Such endeavors became increasingly formalized as distinct programs within school curricula during the second half of the 20th century, including the First-Year Building Project at Yale University, established in 1967 and the oldest continuously running program in North America.⁶ Now commonly referred to as *design-build*—though distinct from the project delivery method—perhaps the best known of such programs is Auburn University's Rural Studio founded by Samuel Mockebbee and Dennis K. Ruth in 1992. Rural Studio, along with the Building Project, served as a model for a growing number of similar programs that emerged in the late 90's, including the Rice Building Workshop, established in 1996 by Danny Samuels and Nonya Grenader at Rice University.⁷



Figure 1. Introduction of the prefabricated core during construction of +House. The project was developed as Rice Building Workshop transitioned to become Rice Architecture Construct and is the program's first completed Accessory Dwelling Unit.

Given the aforementioned challenges, academic design-build programs are receiving renewed attention.⁸ As many recent publications point out, these programs have been increasing in numbers such that a majority of US schools now offer some form of design-build education.⁹ Speculation as to why includes a millennial generation of especially socially-engaged students, and, of course, the competing desires both to more fully engage, or, as it were, substantially disengage with technology.

While the extensive benefits of design-build education have been well articulated elsewhere,¹⁰ it is worth calling attention here to two that are difficult to achieve in typical, studio-based instruction alone as they also directly address the first two concerns outlined above. First, any actual building necessitates some form of social engagement and political consensus. This is the foundational aim for many design-build programs: the opportunity for students to engage the political process that is architecture, but also to provide a direct social good and the experience of doing so as an

integral aspect of education, thus providing context, relevance and instrumentality to the socio-political or eco-cultural aims of today's curricula. It's worth noting that within the political landscape of a university, this approach also typically means partnering with outside non-profit organizations to avoid any commercial interest—in effect, providing a form of community service, but also establishing a potential context for research without said interest. Second, design-build education is nearly always distinguished by the *kind* of experiential learning it affords: teaching students how the act of building and the actual material product impacts the design process and representation directly—vividly illustrating issues like constructability or feasibility—but also by making apparent more diffuse concerns like labor and sustainable practices, and the less direct but no less consequential role that representation plays in creating the built environment.

Despite the growing number of design-build programs, parallel increase in student interest and an ability to address such challenges, many programs face serious hurdles regarding their future viability. They often lack broad support among faculty and are seldom included as required curricula, all while demanding extensive investment in time and money.¹¹

To address these concerns, there are two critical issues for design-build education today: research and relevance. First, such programs are seldom fully recognized for the disciplinary knowledge they create. This condition is partly a structural problem given that such research is often viewed as peripheral to the discipline. But it is also the case that the research component of such demanding and ill-supported work tends, understandably, to receive less attention. This reality pits the high costs of design-build—whether measured in dollars, curricular priorities, or faculty commitments—against an inverse set of university priorities that overwhelmingly values research over teaching and service. Second, the longstanding emphasis on small, one-off projects built for local communities using traditional techniques—while important and worthwhile endeavors—nonetheless struggles to find relevance in an increasingly global practice of large, technically advanced projects. In response to these two issues, many design-build programs will need to better advocate their value as research and develop strategies to address an increasingly complex and global industry.

In considering the role of research within design-build programs, it is worth reflecting on the subtle difference between process and method. A process produces an effect—an end. While nearly synonymous, a method *applies* knowledge of a process to achieve a desired effect—a means to an end. Oxidation, for instance, is a process; galvanization a method to curb its effects. The distinction might be said to parallel that between basic and applied research. In many respects, of course, all design research tends toward the applied end of such a spectrum. Nonetheless, design-build work constitutes perhaps the most idiographic form of such research, a characterization that clearly and specifically positions its value and argues for its necessary inclusion within a research-oriented curriculum.

DIGITAL FABRICATION

As of yet absent from this discussion is the extensive research into digital fabrication processes that has taken place in recent years, research germane to the issues design-build program's face in finding relevance amid rapid technological change and increasingly complex, global projects.

In architectural discourse, the term *digital fabrication* has come to refer generally to the automated or semi-automated translation of virtual models into material artifacts by various computer-controlled technologies. The impact of such processes began to be felt within the discipline in the late 1990's during what historian Mario Carpo has termed the *first digital turn in architecture*.¹² Branko Kolarevic may have coined the now ubiquitous term and was perhaps the first to articulate the full array of now familiar processes in a 2001 paper for ACADIA.¹³ However, it is likely SHoP's guest-edited issue of *Architectural Design* from the following year, *Versioning: Evolutionary Techniques in Architecture*, that served to introduce the concept to a wider disciplinary audience and helped to precipitate the decades of research that would follow.¹⁴

Today, the exploration of digital fabrication processes is so commonplace that one questions why the past twenty years of research has so seldom taken place within an established design-build program? Furthermore, though a few have articulated it as such, why is said research not more widely characterized as design-build?¹⁵ After all, the results are often full-scale, inhabitable structures built by students.

One possible explanation may pertain to the scale and scope of the investigation. Limited mostly to small pavilions or installations, such work has seldom produced the synthetic experience of a full building with all its various integrated systems and complex external contingencies (of course, the same could be said of some design-build programs). In effect, one might say that the focus has been on basic research—more process than method. A second possibility may be due to the emphasis on technical development absent any wider social perspective. Where such a perspective is on offer—most often, under a rubric of sustainability—a technological determinism all too often stands in for a deeper sense of technics.¹⁶ And of course, some programs take up an ideological position against the use of such technology altogether. Then again, the rift may be a mere artifact, a legacy of the reality that most programs and their foundational aims predate today's technological capacity.

Whatever the reason, design-build programs are well-positioned to advance a conversation on digital fabrication today, and doing so is apropos given increasingly widespread adoption. Where once digital fabrication was the purview of complex forms or mass customization alone, ready availability and reduced costs—especially with regard to the changing economies of labor—render even the most banal of some building components embedded with greater potential. To better understand these conditions, continued investigation into digital fabrication would benefit from the fully idiographic context design-build programs already provide. Antoine Picon recently offered a tacit call to such an endeavor by

identifying digital fabrication not simply as a technical problem, but a "cultural and political one."¹⁷

RICE ARCHITECTURE CONSTRUCT

After joining Rice Building Workshop as Co-Director in 2017, we identified these disciplinary challenges, issues and opportunities for design-build education, and began to evolve our own program to address them.¹⁸ First, we established a new name to call attention to the changes underway. RBW, as it was more often called, became Rice Architecture Construct, or simply Construct (kən'strækt), for short, or Construct ('kän'strækt), in equal measure—a homograph meaning both *to build* and *an idea*. Fitting, given the synthetic nature of design-build, but also an attempt to underscore our commitment to design research as fundamental to the endeavor. Then, we subscribed to a straightforward principal: include digital fabrication as a limited yet integral part of each project, examining the impact on both building and design. Finally, we made four structural and thematic changes to the program: to its curriculum, to the scale of projects undertaken, to the way it takes aim at a particular social issue and to the target of technical investigation.¹⁹

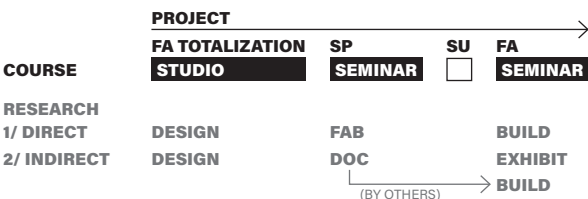


Figure 2. Basic curricular structure of Construct allowing for two projects running in parallel on 18 month cycles within one of two research tracks.

First, curriculum: projects now originate each fall in a design studio rather than an elective seminar. The studio is one of four options in a required curricular component known as Totalization, a comprehensive studio program with dedicated funding and the support of technical consultants.²⁰ Projects are then furthered in a seminar following one of two tracks: the direct production of a building by students, or, one constructed professionally with student involvement that includes a parallel technical investigation and public exhibition. The change facilitates more in-depth research, reaches more students and allows us to share the work with a wider public audience. Second, scale: the program's longstanding attention to the single-family house has been reoriented around creating non-standard, adaptive prototypes—similar in size but designed for multiple locations to scale impact. Third, the social aspiration: in light of the current national dialogue on housing affordability, we

elected to keep to that enduring social aim while shifting focus to a particularly relevant aspect of the conversation, infill accessory dwelling units. And fourth, the technical investigation: an emphasis on modular, prefabricated construction has been redirected toward non-standard envelope systems, leveraging combined mass-customization and performance optimization processes. As technological innovation shifts to issues of search and data,²¹ it is apparent that digital fabrication will be instrumental in further synthesizing and automating design and construction. To that end, much of the research is centered around furthering a specific methodology, one provisionally termed the *Solid Surface*, with the intent to better instrumentalize the building envelope as a means of integrating design process, representation, simulation, fabrication and construction.



Figure 3. Entry view of completed +House. (photography by Paul Hester)

Construct completed the initial phase of this transition last year with the opening of +House, a 360 square foot accessory dwelling unit. The project was built for a non-profit in Houston’s Third Ward, Agape Development, and now houses two cohabitating counselors as part of their program for at-risk youth.²² In coordination with the completion of +House, we organized a public exhibition, *Six Projects on Accessory Dwelling*, to share the design and fabrication research from the inaugural research studio, Accessory, and a subsequent seminar, Paratype.²³ The Accessory project worked with the Menil Foundation on a speculative set of proposals to replace their lost and aging garage apartments, and Paratype examined alternative modes of automated fabrication and assembly for two of the proposals.²⁴ A subsequent research studio, Secondary, examined the viability of a larger development: two single-family and two accessory dwellings on a single Houston lot.²⁵ The studio collaborated with Buffalo Bayou Partnership and Covenant Community Capital, which develops low-income housing in Houston’s Fifth Ward. One proposal is currently advancing toward construction in partnership with Covenant.



Figure 4. View from above of *Six Projects for Accessory Dwelling* at the Moody Center for the Arts. (exhibition design by Andrew Colopy and Eric Cheung, photography by Paul Hester)



Figure 5. Detail view of one Accessory studio project, *Fremd Zone*, by students Hillary Davlin, Seth Defore, Jordan Gracia, and Haotia Ma. (photography by Paul Hester)

These changes to the program at Rice, while developed within a particular context, are mindful of the challenges, issues and opportunities faced by design-build education more generally. The intent is to improve upon the role design-build has long played in addressing the gaps in typical studio education while elevating the relevance and impact of such research on the discipline. Though specific to circumstance, it is hoped that the approach may serve as a useful precedent as design-build pedagogy continues to evolve.



Figure 6. Final model from Accessory studio of *envelop/unfold* by students Claire Chalifour and George Hewitt

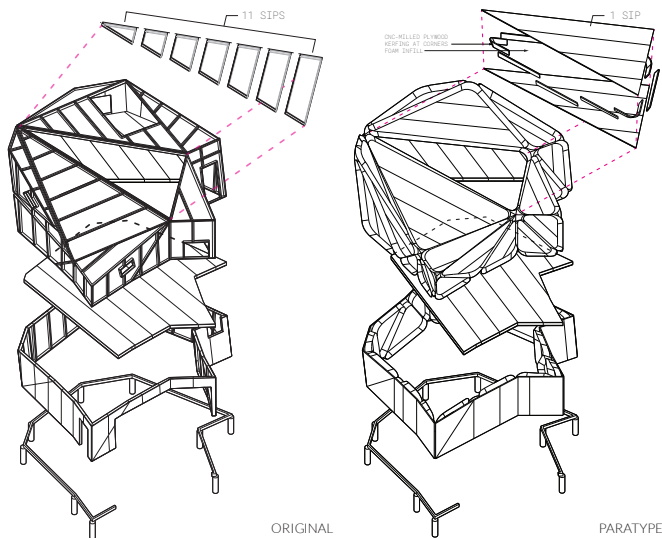


Figure 7. Original Accessory studio SIP envelop strategy for *envelop/unfold* and proposed Paratype with inverted SIP logic by students Claire Chalifour, George Hewitt and Ilya Rakhlin.

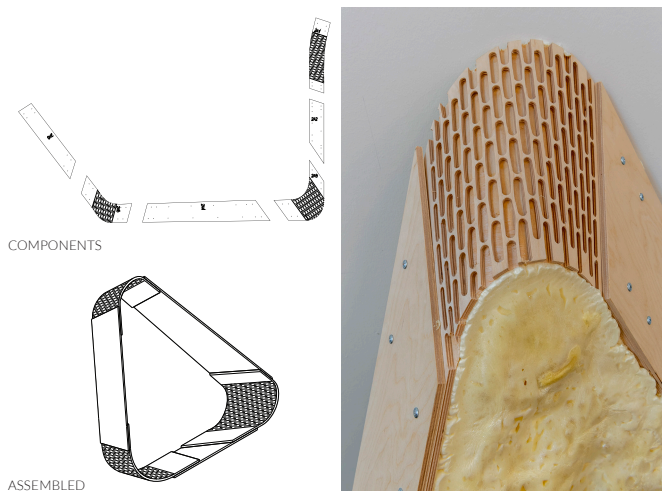


Figure 8. Inverted SIP logic and prototype with kerfed plywood frame and foam infill developed in Paratype seminar by students Claire Chalifour, George Hewitt and Ilya Rakhlin.

Notes

1. The dialectic described herein between 'classical' themes and other 'pressing issues' is not my own but is taken directly from the Call for Submissions to the 2019 ACSA/EAAE Teachers Conference.
2. Here, and throughout, I mean representation in its instrumental mode, distinct from the semantic capacity of architectural works generally.
3. More accurately, such representations constitute "instruments of service" as defined by the American Institute of Architects. For example, see AIA Document A201™-2017: *General Conditions of the Contract for Construction*, Article 1.1.7.
4. The condition leaves practice—largely beholden to commercial interests—the principal site for such innovation.
5. Harnack, Curtis. "John Dewey in the Bauhaus," review of *The Arts at Black Mountain College*, by Mary Emma Harris, *New York Times Book Review*, August 9, 1987.
6. Now known as the "Jim Vlock First Year Building Project."
7. The examples here are mostly drawn from, and for a more extensive overview of academic design-build programs see: Hayes, Richard W. "Design/Build: Learning by Constructing," in *Architecture School: Three Centuries of Educating Architects in North America*, ed. Joan Ockman (MIT Press, 2012) 286-90.
8. Throughout, I am referring only to educational design-build programs, distinct from design-build as a mode of professional practice or project delivery method.
9. For additional background on the increasing number of design-build programs and the challenges they face, see: Gjertson, Geoff W. "House Divided: Challenges to Design/Build from Within," in *2011 ACSA Fall Conference: Identities Global Challenges* (ACSA Press, 2012) 23-35.
10. For instance, see: Chad Kraus, ed. *Designbuild Education* (Routledge, 2017). See also: Tolya Stonorov, ed. *The Design-Build Studio: Crafting Meaningful Work in Architecture Education* (Routledge, 2017).
11. Gjertson. 27-28.
12. The designation of 'first' coming after a subsequent book, *The Second Digital Turn* in 2017. See: Mario Carpo, ed. *The Digital Turn in Architecture*

1992-2012 (Wiley, 2013).

13. While the concept most certainly pre-dates the essay, the first direct usage in an architectural publication of the term 'digital fabrication' in the author's investigation occurs by Branko Kolarevic in two publications from the same year: "Digital Fabrication: Manufacturing Architecture in the Information Age" published in the proceedings of ACADIA 21, held in Buffalo, New York in 2001; and "Designing and Manufacturing Architecture in the Digital Age" published in the proceedings of the 19th eCAADe Conference in Helsinki, Finland, 2001. No earlier usage could be found in any ACSA proceeding or keyword search of the Avery, CUMINCAD, RIBA API, JSTOR, Google Scholar or WorldCat indexed volume (and where keywords reference earlier texts, the term does not occur within the actual text). A WorldCat search revealed instances of the term in usage by other disciplines, especially related to printing technologies beginning in 1998, with scant usage prior to that year. In an email exchange with the author on July 8, 2019, Kolarevic explained his usage of the term originated with an elective course titled "Digital Fabrication" in the spring semester while teaching at the University of Pennsylvania. He was unsure if he was the first to introduce the term but could not recall observing a prior usage. He noted that the term emerged as he, "...was looking for a different way of referring to CAD/CAM and came up with 'digital design and fabrication' and digital design and production' to suggest a more 'synergistic relationship' between the two; 'manufacturing' just didn't sound right in the context of [the] architecture or building industry."
14. Though, it should be noted, the term 'digital fabrication' never occurs in SHoP's introductory essay.
15. Some have reasonably framed this larger investigation as design-build. For example, see: Carpenter, William Joseph. "Digital Fabrication and the Design Build Studio," in 102nd ACSA Annual Meeting: *Globalizing Architecture /Flows and Disruptions* (ACSA Press, 2015) 513-21.
16. Technics in the sense described by Mumford. See: Mumford, Lewis. *Technics and Civilization* (Harcourt, 1934). Or, for a relevant summary, see: Moe, Kiel. "The Social Construction of Sustainable Technics" in 96th ACSA Annual Meeting: *Seeing the City* (ACSA Press, 2015) 672-76.
17. Picon, Antoine. "Foreword" in *Digital Fabrication in Architecture, Engineering and Construction* by Luca Caneparo (Springer, 2014).
18. Those principally involved include myself, Co-Director Danny Samuels, Dean Sarah Whiting and Technology Fellow David Costanza.
19. We also began planning for a more sustainable funding model, though not of sufficient relevance here to warrant a full discussion.
20. For additional information about the program, see: Troy Schaum, ed. *Totalization: Speculative Practice in Architectural Education* (Park Books, 2019).
21. For further discussion, see: Marble, Scott. "Everything That Can Be Measured Will Be Measured," in *Technology|Architecture + Design*, 2:2 (Taylor & Francis, 2018) 127-29. See also: Carpo, Mario. *The Second Digital Turn* (MIT Press, 2017).
22. The full project team for +House included Construct Co-Directors Danny Samuels and Andrew Colopy; Construct Fellows Jason Fleming, Eric Hester, Roque Sanchez and Rose Wilkowski; Construct Students James Carr, Ningxin Cheng, Hillary Davlin, Nell El Souri, Leyla Hepsaydir (2 semesters), Michael Hernandez, JP Jackson, Daniel Kleeschulte (2), Julie Klosterman (4), Yu Kono (2), Keija Lu (2), Xi Luo, Eleanor Ma, Haotian Ma, Edna Otuomagie, Alex Palmer, Jonathan Pan, Rui Qi, John Rudd (3), Shiori Sageshima, Sebastian Torres (2), Claire Wagner, Rose Wilkowski (4), Xiangcheng Xing and Jiaxing Yan; Kirk Craig and Carl Winn from Agape Development; and consultants Bradley Doherty and Vladimir Berka from Insight Structures.
23. *Six Projects on Accessory Dwelling*. 30 August-22 September, 2018. Moody Center for the Arts, Houston, Texas.
24. Accessory studio students: Francis Aguiard, Claire Chalifour, Hillary Davlin, Seth Defore, Jordan Gracia, Rachel Grady, George Hewitt, Younha Kim, Haotian Ma, Micah Piven, Lau-ren Turnage and Jiaxing Yan. Paratype seminar students: Claire Chalifour, Eric Cheung, Ekin Erar, George Hewitt, Jack Hilchey, Illy Rakhlin and Yixin Zhou.
25. Secondary studio students: Caroline Brigham, Stephanie Chou, Margaret Hall, Jack Hilchey, Haimei Li, Qi Luo, Kajal Patel, Hannah Perrino, Katherine Tees and Densie Yee.