The SLO_Gen Table: Cultivating Industry/ Academic Partnerships

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IN COLLABORATION WITH

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The SLO_Gen Table is the physical outcome of a multi-threaded industry/academic partnership including Cal Poly Architecture, Gensler Los Angeles, Buro Happold Los Angeles, fabricator R.D. Wing Co., and material supplier LG Hausys. The table offers a dramatic and sensual introduction to the offices of Gensler LA amidst the visually and spatially stunning central atrium at the core of their new office (fig. 1). In addition to the physical outcome of the table itself, there are several less tangible outcomes in this one-year collaboration that cut across issues of curriculum, the role of digital fabrication and the academic design-build studio, and importantly, the collaborative enterprise at the core of this industry/academic partnership. This paper unpacks the experience and design process developed from this ambitious project, while further articulating the opportunities and implications of these less tangible outcomes in the context of academic curricula.

The opportunity for this project developed after several years of successful academic co-ops with Cal Poly architecture students in Gensler's Los Angeles office. In these co-ops, students gain professional experience while also taking an academic studio led by practitioners, receiving academic credits in parallel with their professional internships. Shawn Gehle, Design Director for Gensler LA, had run several successful studios with Cal Poly students leveraging their energy and abilities toward urban research underway at Gensler[1]. During this time, Gensler LA was making plans for their new office in the core of downtown Los Angeles[2].

Figure 1: The SLO_Gen Table.

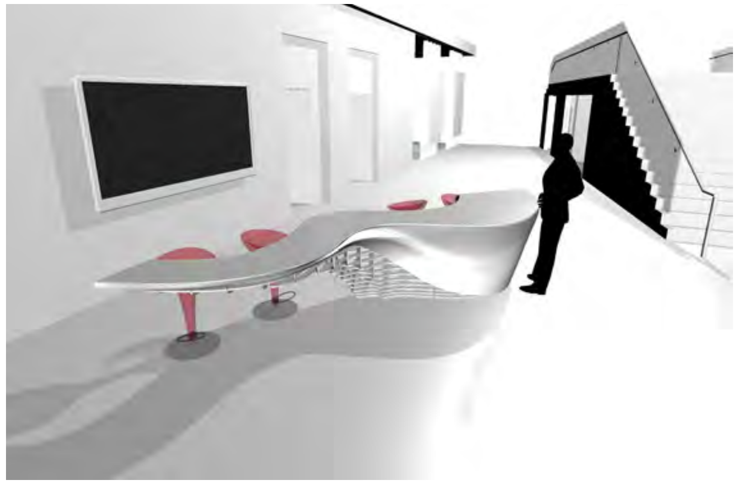


Figure 2: Student rendering at the end of June 2011. While key features of the final project are apparent, the geometry has yet to be tamed.

From Gehle's experience leading a professional co-op studio on urban issues, he saw the opportunity for a more hands-on material driven studio working with industry partners to fabricate a focal piece for the lobby of their new office.

With the office beginning construction, time was of the essence. However, professional project schedules rarely mesh with academic schedules. Fortunately, we[3] were able to assemble an ad-hoc crew of three students who had both the interest and the need for a Spring 2011 studio in their fourth year in our five-year Bachelor of Architecture program.[4] The intended schedule was for a Spring 2011 for-credit studio to develop schematic designs, with design development developing over the summer, and final fabrication in Fall 2011, in time for the projected office opening. In actuality, the SLO_Gen table took a full-year of dedicated effort from March 2011 to the installation in March 2012. As Gehle reflects in hindsight, this project was "something nobody knew what they were getting themselves into."

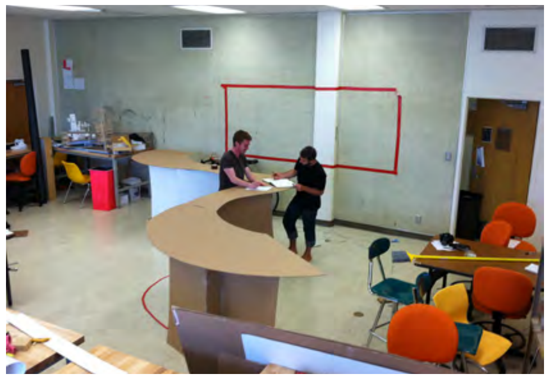
Figure 3: Students complete a full-scale rough mock-up of the design in Figure 2. From this mock-up, they realized the size and curvature needed to be refined.

DESIGN PROCESS

Along with the considerable opportunity of this project came a very real aspect of risk for both Cal Poly faculty and Gensler alike. The opportunity for Cal Poly Architecture, and its Digital Fabrication Laboratory, or d[Fab]Lab, was significant, but with that came a unique pressure as a student-designed project. For Gensler the risk was particularly apparent, not simply in the monetary risk in funding the table, but in the potential of an empty lobby if the project were not to succeed. Gensler's optimism and positive student feedback in face-to-face as well as on-line reviews contributed a great deal to the success of this partnership[5]. With Gensler LA four hours apart from San Luis Obispo, we held frequent discussions and design reviews through GoToMeeting video conference calls. Although a technological detail, and now routine in global practice, this proved to be essential to this collaboration and paved the way for future industry academic partnerships.

Figure 4: The refined final design after mock-up.

The primary challenge at the beginning of the studio was the particular design brief was left flexible to test the students' potential. This included designing not only what became the table, but the reception desk as well as a casual sitting area. Each student's initial design proposals reflected his or her interests and abilities: one student was primarily interest in form-making; another student, who had the least digital skills, focused his energies on materiality; and the student with the most digital sophistication focused on techniques for variable components. Taken individually, each idea was out of control in its own way. However, as their different ideas were brought together, two different things happened. First, the brief began to take shape based on a common direction of what worked in the space, including its location and as a place to gather—anywhere from small one-on-one discussions to as many as 12 people. Second, the schematic design began to develop combinations of each of their interests combining form, material, and increasing precision and sophistication. Sparing much detail in the process, a rough, if crude, approximation of the final design did not surface until the end of June 2011 (fig. 2). While identifying some key features in the final table, the form was still out of control. After the students built a full-scale rough cardboard mock-up, they realized both how large and how much curvature they were introducing (fig. 3). This rough mock-up proved to be a significant project, if not pedagogical milestone, from which we had a quick but intense one-week design development phase to return with a refined design proposal (fig. 4).



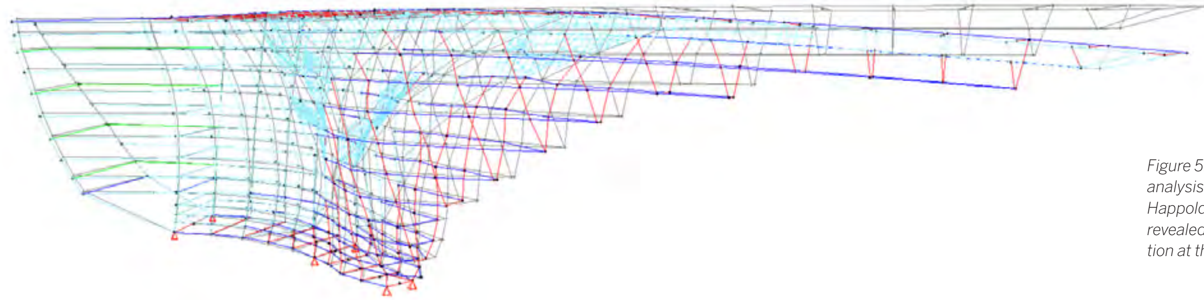


Figure 5: Egg-crate analysis by Buro Happold Los Angeles revealed 3" of deflection at the cantilever.

ENGINEERING

With this final design's considerable size at over 16' long with a 7' foot cantilever, Buro Happold Los Angeles was added to the mix of collaborative partners to provide engineering. The plywood egg-crate system was first analyzed independently from the HI-MACS shell, taking into account a range of joint fixity from fully fixed to introducing fabrication tolerances to set the rotation at each joint. This analysis resulted in 3" of deflection at the tip of the cantilever (fig. 5). While this was clearly not acceptable under any circumstance, it was compounded by the fact that any deflection from the egg-crate would transfer to the HI-MACS shell in which even minor deflection would result in cracking. To stiffen the cantilever, S-curved back-to-back angles running the length of the table with perimeter strapping beneath the surface were used to stiffen the egg-crate. The entire table, egg-crate system, support structure, and HI-MACS surface, was then analyzed as a composite system. As a composite system deflection was resolved, and stress analysis of the HI-MACS skin confirmed that any stress transferred to the skin was within panel specifications.

FABRICATION

Initial discussion began with a large architectural woodworking shop in Los Angeles, as we began to source local area thermo-forming fabricators for the HI-MACS surface. Ultimately, due to the demanding thermoforming required in this design, the HI-MACS material representative recommended R.D. Wing Co. in Seattle. With a background in fabrication for Aerospace in Fiber Reinforced Polymers (FRP), as well as being fully equipped with 3- and 5-axis CNC routers, it had both the experience and the tooling to execute the complex double curvature of the thermoformed shell. As a specialty fabricator with experience in architectural components as well, the company also had incentive in the project as a showpiece of its abilities. Due to the tight tolerances required between the egg-crate and the surface, R.D. Wing chose to fabricate both in-house (fig. 6).

The students' 3d Rhino model was the *only* design document transferred to R.D. Wing. We were able to provide an accurate estimate of the 12 sheets of plywood required for the egg-crate structure, but were not able to estimate the number of sheets required of composite panels as this was based on how the surface would be parted and molded. It is also here where the expertise of R.D. Wing was considerable. The s-shaped top panel was formed as a seamless flat top from four 30"x144" stock pieces—the only flat piece in the shell. The surface sides were panelized into five sections, with each section further subdivided into areas that would require a single slump mold, and areas of more intense curvature, such as the creases, that required a male and female mold to apply pressure from both sides to get the shape and detail desired (fig. 7). Molds were glued together in 4-6" stacks from large scraps of 15-20 lb polyurethane foam left over from other projects. A trim line was scribed into the molds at their parting lines. From 12 sheets of solid surface panels, individual pieces were formed and seamed to form the five sections (fig. 8). These sections were then bonded to the egg-crate with silicone to form one composite structure.

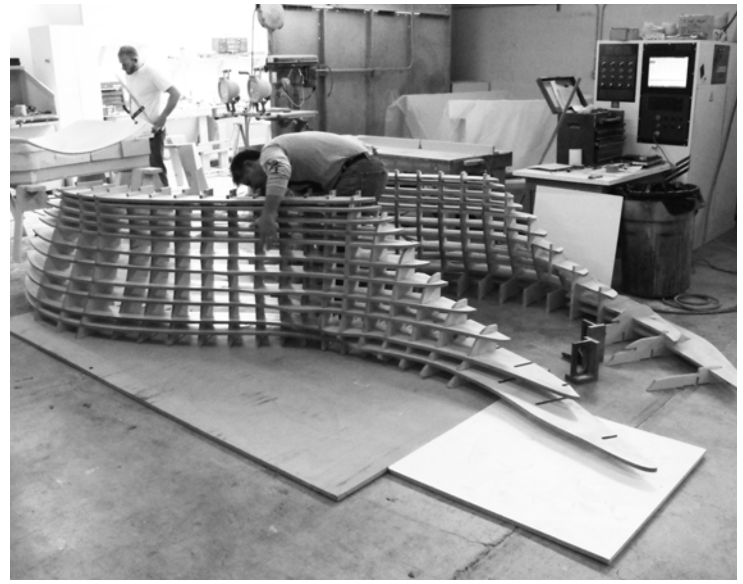


Figure 6: Two-part egg-crate under construction in the shop at R.D. Wing, Co. in Seattle.

While the above describes the process of fabrica-

Figure 7: Male and female mold required at areas of intense curvature, such as the creases.

Figure 8: Seaming of smaller sections to form a larger panel.

tion, the reality is this process required a great amount of precise hand trimming, providing support backing at corners with seam straps which required notching of the egg-crate structure to match, to say nothing of the hand polishing to provide a continuously smooth and seamless surface (fig. 9). As evidenced not only by the final product, but throughout the process of fabrication, R.D. Wing proved to be master craftsmen in working with FRP composite solid surfaces, which was as much digitally fabricated as it was hand-crafted (fig. 10).

FILE TO FABRICATION REFLECTIONS

Working closely with industry as a collaborative partner challenged some of the accepted academic approaches to digital fabrication and the academic design-build studio. This raises some questions about the role of the designer and the place of digital fabrication in this process. The term "file to factory" is more properly represented in this project as "model to factory". File to factory as a methodology incorporates cut files directly from the designer ready to be fabricated. This is what I had expected to deliver, at least in the case of the egg-crate, but in reality we exchanged no 2d files, no printed matter, just a single 3d Rhino file.

In multiple conversations with R.D. Wing, we agreed to simplify our model of the egg-crate with centerlines only to allow the fabricators to account for plywood thickness tolerances. This also meant that they were then responsible to model the egg-crate bridal joints, which proved to be a challenge for them working in MasterCAM. In consideration of the time constraints, I only learned after the fact that they hired an external consultant to develop the cut files. While this is something we could have developed through our parametric model, this is really a question of efficiency and cost, not a question of design. However, in making preliminary prototypes, the students understood that the egg-crate required a parting line to be able to assemble the pieces. While this was presented in the students' final design presentation, this information was not passed onto the fabricator nor was this parting line represented in the centerline digital model. As we were no longer involved during the fabrication process, nor did the consultant make this realization, the fabricators found out the hard way after cutting out each rib, requiring each individual piece to be cut by hand. While not onerous, but certainly tedious, this did affect craft albeit on largely hidden joints, but moreover points to a gap in the transfer of information.

While the egg-crate is the most conventional aspect of this project, and one that could be conveyed in the most conventional of information in the form of 2d cut files, the external surface had no underlying logic to be parted, apart from the flat top and two compound curved sides. Even the basic issue of how the seam would transition from flat at the top to the sides given the ¾" thickness was a complex issue due to the compound curvature, which was simplified on their end with a profile cut on their 5-axis router. Furthermore, although we worked closely with LG Hausys to find the maximum curvature radii for the HI-MACS surface, this information was for conventional single curved bends.

Consequently, we had no criteria to evaluate if the extreme curvature in the creases was possible beyond our initial design consultation with R.D. Wing and their confidence that they could indeed do it. While the egg-crate could have been conveyed in a file-to-factory approach, the experience with thermoforming solid surface material and the associated expertise in mold making was best left to the experts which includes how the complex curved surface would be parted, and thus the transfer of a 3d single surface model was most appropriate.

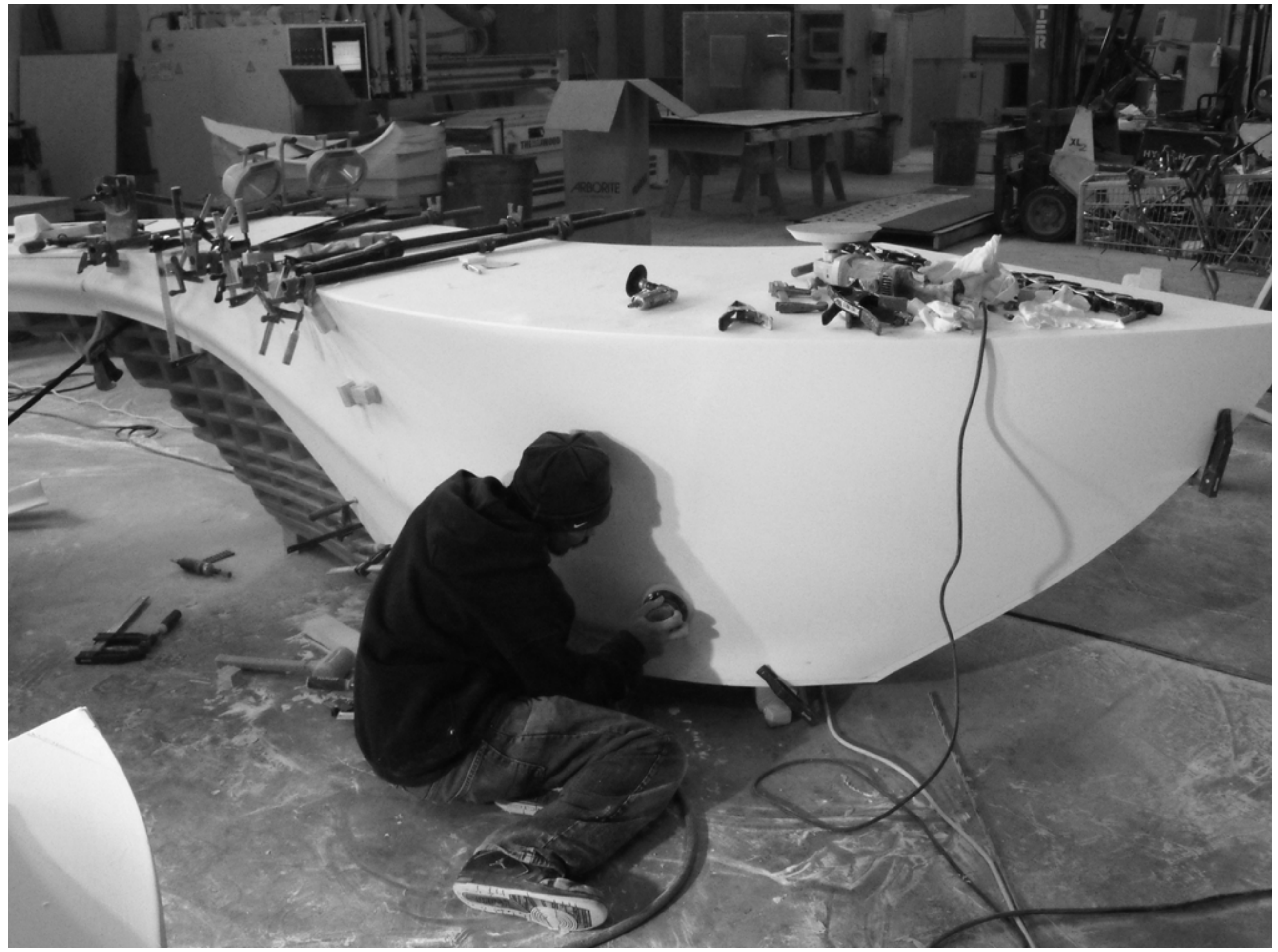
DESIGN-BUILD IN THE CONTEXT OF EXPERT FABRICATORS

Working with expert fabricators also challenged the expected level of fabrication in the academic design-build studio. While initially I expected this to be a much more hands-on project, in the end the absence of full-scale production helped to identify the critical moments that prototyping is significant. Rather than refined digitally fabricated prototypes, the rough cardboard full-scale prototype had the most significant impact on the students design development. In other words, rather than being a refined prototype, it helped them to refine the design. Similarly, the students constructed just enough of the egg-crate model to realize it could not be assembled, and through this, formed an alternate approach with a center parting line. Finally, a vacu-formed small-scale model of a section of the table was created for the final presentation, but like all presentation models, was used to sell the design more so than to refine the design. While in no way do I wish to down play the important pedagogical role of hands-on full-scale construction, it is revealing that the most significant prototype in the design development was not the refined one, but the quick and dirty full-scale cardboard prototype. Working with expert fabricators, rather than trying to be one, focused the expertise of the designer on understanding scale and proportion that requires a different degree of prototype with different purposes.

INDUSTRY/ACADEMIC PARTNERSHIPS AS R&D

The success of the SLO_Gen table goes beyond the table itself, opening up new applications and opportunities for Gensler LA and Cal Poly alike. As a focal point in Gensler's Los Angeles office, it sparks conversation and interest and has also become a site of further design innovation becoming the surface for a multi surface experience using the HI-MACS white surface as a touch interface for the display screen in the background[6]. From this demonstrated innovation of FRP thermo-forming, Gensler has further explored the application of thermo-formed FRP cladding systems. For Cal Poly, the publicity through numerous design blogs and industry case studies offers exposure to the program in non-academic venues.

Figure 9: Hand polishing of HI-MACS to buff out all seams into a single surface.



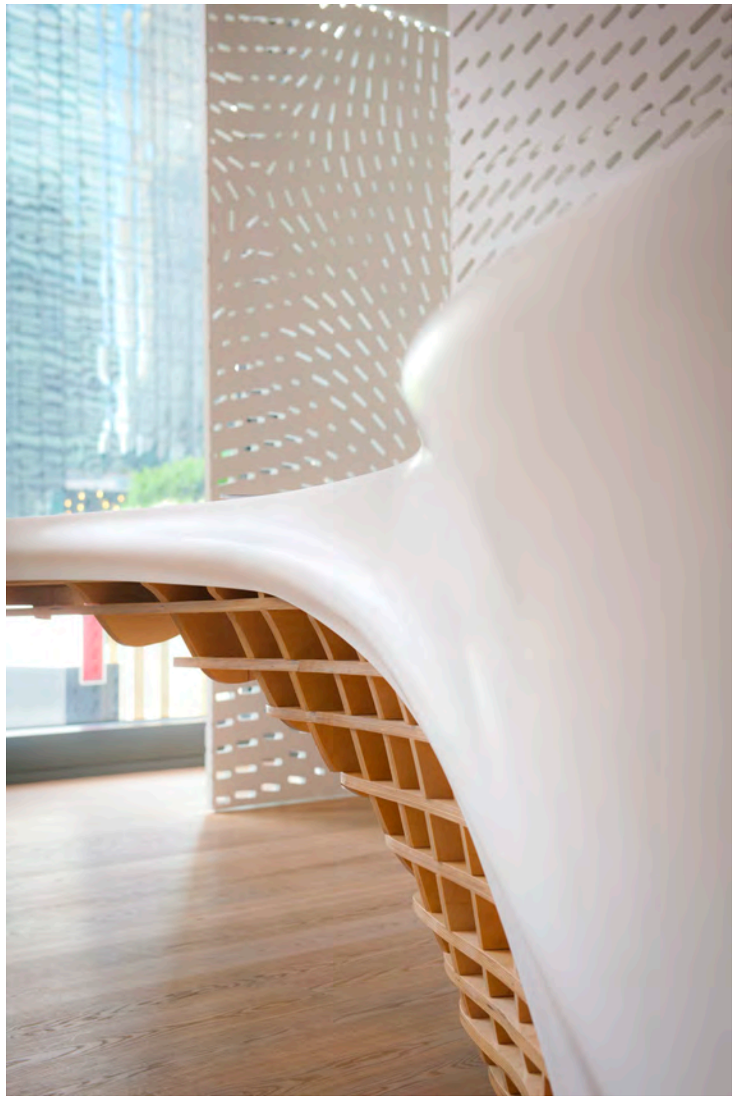


Figure 10: Final detail with egg-crate and compound curvature of the shell.

However, the primary intent is not that this is a one-off project, but points to a much more ambitious curricular development to continue to sustain and cultivate the relationships formed in this academic/industry partnership, which requires the continued cultivation of talent and opportunity. As academic teaching schedules are often planned a year in advance, and as industry opportunities rarely come with such advance notice, the ad-hoc collection of students and overload teaching that the SLO_Gen table required is not a sustainable long-term solution for such academic industry partnerships. The SLO_Gen table provides a visible example of the phenomenal outcomes of such partnerships, but a larger curricular structure to cultivate these relationships as well as student talent is needed.

CULTIVATING TALENT: THE MATERIAL INNOVATION LAB (MIL)

Parallel to the design development of the SLO_Gen table, I was in the process of developing a new multi-course curriculum in digital fabrication at Cal Poly, San Luis Obispo. All too often in any tool-based course, such as a seminar in digital fabrication, once the students develop their skills sufficiently enough to pursue more innovative applied research, the course is over. As Cal Poly is on a 10-week quarter schedule this is even more pronounced. And yet, this shorter course duration became an asset in developing two new courses, Arch 461_Computer Aided Fabrication which is the pre-requisite for Arch 471_the Material Innovation Lab (MiL). This two-course sequence follows established theories of cognitive behavior, particularly in regards to learning new tools and technologies. Learning a new tool or technology creates a focal awareness in which intentionality becomes about that tool[7]. Furthermore, when something goes wrong, or something "breaksdown," this only returns attention to the tool-at-hand. In other words, a transparency of use has not yet been achieved, placing emphasis on the technology. This can readily be seen in any technology seminar or studio in which the discussion is more about software than it is architecture. A broader, more sustained cognitive model would include this functional use of learning tools, but then connects this to a wider disciplinary network, to then allow focused investigation into architectural applications. While the first course introduces tools and techniques, the second course engages a wider network of industry partners enabling the Material Innovation Lab to operate as an innovative applied research lab.

Intermediate to advanced students interested in digital fabrication at Cal Poly are able to take Arch 461 exposing them to parametric design and digital fabrication through the lens of material constraints and opportunities[8]. As a prerequisite, this provides fertile ground for the Material Innovation Lab. It is important to note that these courses are intentionally not offered sequentially, but at minimum a quarter if not an entire year apart such that students initially exposed to new tools and techniques have time to develop their abilities through their design studios. Consequently, students come back to the Material Innovation Lab often with more experience than from the course alone. Furthermore, the Material Innovation Lab, in both name and course description, dispenses with any mention of the word "digital". As a self-selected cohort of students, we know that digital fabrication is part of the background of their experience, and consequently the course fully employs parametric design and digital fabrication but as tools at the periphery of the discussion enabling rapid fabrication of prototypes, molds etc, as a fully integrated digital / physical learning environment. This enables the Material Innovation Lab to operate as an applied and innovative research lab developing full-scale prototypes with industry partners. As a recurring course in our curriculum, it allows us to continue to cultivate talent, maintain professional contacts and form new ones, such that we can connect talent with opportunity as it arises.

This has enabled us to pursue new collaborations testing the limits of FRP Unitized façade systems with Gensler LA, Kreysler and Associates, and ENCLOS as well as receive significant funding from the Concrete Masonry Association of California and Nevada (CMACN) to design and develop new innovative CMU approaches through advances in mold-making afforded through digital fabrication.

Like the SLO_Gen process, if not inspired by it, the Material Innovation Lab offers a horizontal model of student and faculty engagement. The course is conceived as a "think-tank" in which all members of the class—faculty, students, and collaborators alike—are equally engaged in the development of a common problem, typically driven around a particular material. Ideas are neither individual nor proprietary (at least not so far), faculty are not necessarily the experts, and students are further "taught" through live feeds with industry collaborators sharing their experiences and ambitions.

ENDNOTES

1. Each studio culminated in a video that can be found here: http://vimeo.com/65184582 and here http://vimeo.com/52642730.

2. While contemporary practice has largely proven more agile to integrate digital tools out of necessity, in academia on five-year curricular cycles, integration has been much slower and a long time coming, and yet this new generation is in turn influencing practice. For example, the role of digital fabrication for the waterjet cut screens behind the table is a case in point. Developed in part with the help of Tam Tran, now a Gensler employee, but at the time, one of the fourth-year co-op students. As a second year architecture student, Tham crashed a one-day parametric seminar I taught on "Explicit History" (before it was named Grasshopper) and ran with it, creating digitaltoolbox.info with his second-year colleague Scott Leinweber. While I was only reminded of this when writing this essay, I have included this as an endnote to exemplify the shift from an ad-hoc to a more fixed and stable curricular approach that concludes this essay.

3. Former colleague Jim Doerfler, who coordinated the Cal Poly co-op students, as well as former co-director with me in our Digital Fabrication Laboratory (d[Fab] Lab), invited me to join the project.

4. With the majority of our students in our fourth-year curriculum off-campus, it was a stroke of luck that these three students were available and a great fit for the studio. Similarly to Endnote 1 above, this points to the need for a larger curricular framework to support such industry/academic partnerships.

5. In addition to Shawn Gehle's constant support throughout the project, the support of Gensler architects Sabu Song and Richard Hammond in supporting the students is greatly appreciated.

6. See http://vimeo.com/72684794

7. Terry Winograd and Fernando Flores, *Understanding Computers and Cognition: A New Foundation for Design* (Reading, MA: Addison-Wesley Professional, 1987).

8. Jeff Ponitz, Mark Cabrinha, Clare Olsen, and Carmen Trudell. "Project-Based and Procedural Pedagogy in Digital Fabrication," in NCBDS 29: *Actions: Making of Place – Proceedings of the 29th National Conference on the Beginning Design Student* (Philadelphia, PA: Temple University 2013).

IMAGE CREDITS

Figure 1: © Gensler Los Angeles

Figure 2: Student rendering by Cory Walker.

Figure 3: Photograph by Cory Walker.

Figure 4: Student rendering by Cory Walker.

Figure 5: Image courtesy of Buro Happold, Los Angeles.

Figures 6-9: Images courtesy of R.D. Wing Co., Inc.

Figure 10: © Gensler Los Angeles