Scaling the DIY Approach: Do-It-Together with Student Staff Service Learning

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INTRODUCTION

This paper endeavors to reflectively analyze the process of building a fleet of large, durable tables with student workers' labor, primarily using the tools in our FabLab. Exploring causalities between experiences gained as part of the table project and increased fluency with general FabLab tasks such as explaining nuanced processes to and/or problem solving with learners, this analysis seeks to contextualize the library culture that made a project like this possible, in the hopes that an honest sharing of our experiences and lessons learned might assist other academic makerspaces in employing student service learning projects to improve their own makerspace infrastructure. Far beyond the simple benefits of useful objects, student staff who were regularly involved in working cooperatively to construct the tables also built self-confidence and seemed more likely to engage with day-to-day learners in the lab to ensure they were achieving the desired quality of output on whatever machine they were using. These students gained a sense of responsibility for a job well done, honed their ability to check the quality of their work/work of others, an increased understanding of various materials and tooling procedures, and a resiliency that is less likely to be intimidated by protracted, involved tasks.

Together, we built 18 large tables (eight 3'x4', five 5'x5', two 7'x7', two 9'x5', and a 20'x3' cabinet) with 1" threaded steel pipe frames on double-locking casters and 2" maple butcher block work surfaces. In contrast to the IKEA-style readymade assembly some students had prior experience with, this nuanced process involved cutting steel pipe to length and die-cutting threads; assembling those pipes into table frames; cleaning the protective grease off the steel; transporting the frames across campus to apply clear coat; preparing large slabs of wood for joining; gluing very large pieces of wood together; clearing the glue residue and sanding smooth; drilling properly sized and aligned holes; applying Danish oil and buffing dry; and finally mounting the wood to the steel frames. These robust tables are now a defining feature of our large FabLab, constantly in use as a substrate for all manner of making activities, group projects, and class meetings, while also attracting students looking for a comfortable place to study.

CONTEXT

Energized by the vitality of the Fayetteville Free Library [1], UTA Libraries began offering access to 3D printing as part of the Digital Media Studio in 2013, where students and faculty were able to print posters and edit videos. This public access production facility was tucked away in the basement and run by the same staff members who were also responsible for digitization services and the Libraries' website. Services were popular, though underutilized; the capacity to expand required reorganization. The UTA FabLab opened in October 2014 in a small corner of the first floor of the Central Library that had previously served as a service desk for the Office of Information Technology, with two full-time technicians and over a dozen student employees helping people learn how to use 3D printers, a laser cutter, vinyl cutter, mini-mill, electronics station, and virtual reality station. Moving digital fabrication access to the first floor greatly magnified student enthusiasm for this type of space in a way that both vindicated the strategic risk of Libraries' administration and highlighted the limitations of what would be possible in that space. The rest of the first floor surrounding the OIT-turned-FabLab corner was an average late-20th century library space with clusters of computers, some couches and chairs, dingy carpet, and relatively dim lighting; it was rapidly apparent that an ambitious expansion of UTA Libraries' FabLab services would be embraced by the campus community.

Led by the shared vision of Dean Rebecca Bichel [2] and Associate University Librarian Suzanne Byke [3], significant renovations to the first floor opened up an 8000-sq.ft. space for the FabLab, and sought to implement emerging understandings of how space design impacts the potential for learning, including ample LED lighting and modular study/maker space throughout [4,5,6,7]. Situating the FabLab prominently on the first floor was an intentional decision that sought not only to increase the potential for use by students who might not otherwise seek out digital fabrication tools, but as a testament to the understanding that "[s]pace has importance in discussing the newer role of the library (embodied by its librarians and other staff intentions and activities) as a collaborative partner or a facilitator in learning and in the creation of new knowledge."[8] The other core-level perspective determining the nature of the FabLab, and the Libraries system we exist within, is our dependence on student employees as the front-line for customer service. Student employees are far more than merely logistically necessary to provide the breadth of services and hours of access due to obvious structural wage differentials and increasingly limited institutional budgets; employing students critically reinforces a conceptual commitment to student-first services by offering more relatable assistance to the average college student than more mature library staff, while the additional training and support student employees receive in order to be effective library ambassadors is contextualized as an investment in the impact on retention, professional development, and workforce preparedness academic libraries can have on students prior to their graduation[9,10,11,12]. In this context, the FabLab leadership (Dean, AUL, Director of the FabLab, and Technicians) reached entirely different decisions than we would have if space planning was isolated as an economic issue considered at face value, without the overarching priorities central to the mission of UTA Libraries. This paper highlights one such instance.

CONSIDERATIONS

When organizing for the order-of-magnitude expansion (from 800 sq. ft. to 8000 sq. ft.), we were collectively underwhelmed with the institutional furniture options within our budget. There were several options that satisfied the interests of the administrative leaders, namely that the tables must be easily movable by being on casters, and that they should look invitingly contemporary. The technicians had concerns regarding the resilience of the tables initially selected for the space, which were still very much in the same vein as the majority of contemporary educational institution furniture. Laminated particle board is easily damaged by a variety of common tools & processes at the heart of a makerspace, including X-ACTO knives, files, drills and other handheld rotary tools, soldering irons, acetone, etc. Additionally, the initially selected tables achieved their aesthetic by minimizing the visual impact of the legs, though this also significantly weakened the table; a table top attached independently to four relatively small legs is not nearly as robust as a table top attached to a frame of legs connected to each other. While there certainly are strategies for mitigating the potential for damaged tables by posting signage and having staff monitor people's behavior in the space, we wanted a space that felt earnestly welcoming in a way that would be rather impeded by a large list of forbidden actions[13]. In circumstances of human safety, and subsequently machine safety, telling people "no" is critically important, but with all the benefits of planning how to fill a renovated space, we sought structural methods to avoid issues of policing behavior when possible.

The butcher-block workbenches suggested by the technicians in lieu of the glorified laminated particle board would have been far cheaper and certainly more durable, though they were not particularly attractive and thus failed to gain approval. Working with the Director of the FabLab, Katie Musick Peery, to identify the concerns most meaningful to the upper administration, we came to a realization that helped build a bridge across some miscommunication within the team surrounding this issue: the administration's stated desire for an "industrial" style was not necessarily interchangeable with strictly functionalist priorities, as the technicians had largely interpreted it. Following this definitional breakthrough, we found images online of a type of table construction using steel plumbing pipes to form a frame for a wood-topped table that exuded industrial-chic. I prepared sketches within this aesthetic as part of a proposal, and was granted approval for building a prototype which would determine whether or not we would build our own or order those initially selected.

The prototype was built with off-the-shelf components from a big-box hardware store, with their employee cutting the pipes down to size and threading the ends of each length. Assembly was simple and the administration liked what they saw, though they stated a strong preference for a bare metal look rather than the asphalt-covered pipes available in store or the paint job originally proposed. I found a source for A53 1" steel pipe that wasn't coated with the asphalt slurry normally used to protect the surface of "black pipe"; premature oxidization was prevented instead with a grease that could be cleaned away to prepare the surface for application of a clear coat. I prepared a cost estimation sheet reflecting the best values I was able to find for the quantity of pipe, fittings, casters, and maple butcher block we would be purchasing, and was even able to include obtaining our own pipe threading machine, all for less than the cost of the commercially-sourced solution. Concerns for costs of staff time spent building the tables overriding the cost savings were weighed against the technicians' concern that laminated particle board tables would have been ruined by normal maker activities relatively quickly, thus requiring allocation of future funds to purchase another set of tables. In addition to appeals to long-term budgetary concerns, the context of student service learning and the thought that we would eventually be able to offer learners access to the pipe threader and/or lead workshops on the construction of similar projects were essential to gaining administrative approval for the project. We had recently hired new students from a wide variety of majors, though none of our 33 employees had appreciable metal or woodworking skills, so the workflows of this large table project were incorporated into their training regimen.

TRAINING

Following the paid training provided by lab technicians and experienced student leads for these new hires on file preparation basics and routine operations of a 3D printer, laser cutter, vinyl cutter, mini-mill, sewing machine, 3D scanner, and customer service protocols in anticipation of their regular job duties staffing the lab, I worked with students individually and in small groups to train them on whatever aspect of the tables needed doing at that time. It is vitally important to differentiate between the intentions driving these two types of training.

General FabLab Student Employee Training

Lab equipment instruction followed the ethos of collaborative training in order to "reduce required instructor time and resources […] and to provide observational learning opportunities [for trainees] that compensate for hands-on practice efficiently and effectively, as predicted by social learning theory."[14] In our experience, we did not observe collaborative training to be a true replacement for actual hands-on experience outside the context of a training session, though the process of observing co-trainees complete the steps one after the other did appear to decrease the number of actual hands-on repetitions it took to gain mastery over tasks such as switching out filament in a 3D printer, threading a bobbin, or maintaining accurate registration when using a handheld 3D scanner. Additionally, we took time to craft the curriculum of the lab equipment trainings in an effort to go beyond preparing student workers for rote interactions by explaining the methods through which the technologies actually function, and by going over examples of how changing various settings alters the qualities of the output. We put significant emphasis on internalization of the logic presented, preparing student workers to problem solve many issues autonomously and provide advice to learners regarding which processes and which settings might be most appropriate for the project they came in to work on.

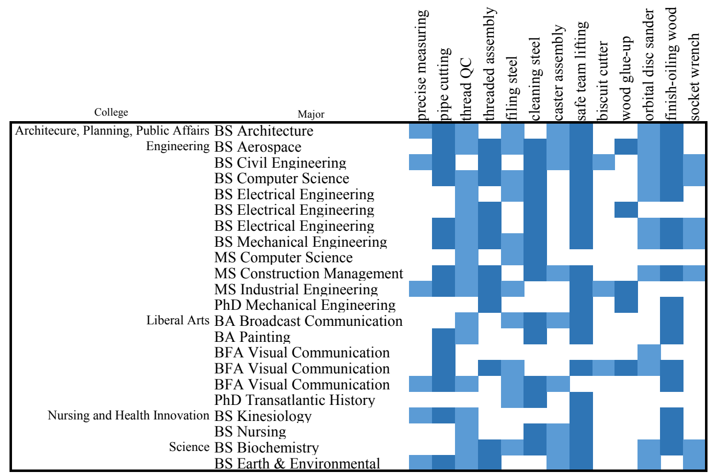
After completing the set of trainings, each student employee was assigned to ideate and iterate an independent project using at least three separate technologies they had been trained on, accelerating their familiarity with both the design process and the applied use of FabLab equipment. Student employees submitted sketches and proposals of what they wanted to make, and were given guidance to ensure everyone was attempting a project scope within their individual "zone of proximal development"[15] - challengingly achievable for a first project using these technologies but taking into account each individual's incoming skillsets. In short, we were laying the foundation for our staff to help facilitate -and function in- a welcoming DIY-oriented culture in the FabLab.

Student Employee Training for the Table Project

In stark contrast to the general FabLab equipment training, the training student workers received to assist with the tables was decidedly not comprehensive in nature. There were several reasons for this, not least of which was the fact that not all FabLab employees participated in building the tables, whether due to prioritization of other projects FabLab leadership had assigned them to work on[16], an availability schedule that was either opposite my own or that dictated their hours with us were primarily when lab activity left little time for additional tasks other than helping learners, or because they simply hadn't yet attained sufficient competence with the general lab equipment. The decision to not involve all student employees was rooted in a desire to cut down on repetitive introductory training sessions and curriculum preparation time, reinforced by an awareness that we were not necessarily preparing them to assist autonomously with learners coming in to use the pipe cutter; we needed their help to complete the project. In the spirit of "legitimate peripheral participation"[17], students were active participants in a variety of processes as outlined in Table 1, though their work was generally closely supervised and they were given constant constructive criticism to improve their craft. Nobody involved in building these tables could claim this as a DIY accomplishment; we approached everything as an opportunity to "Do-It-Together." Throughout each workday, I mentored student staff on the proper techniques of using the tool-at-hand, ensuring that they understood not only how to use the equipment safely but also how the tool was acting on the work-piece, along with other theoretical and practical knowledge-building conversations, thus contributing to their capability to discern quality workmanship, enhanced problem-solving abilities, and growth as increasingly self-actualizing humans.

With service-learning projects, the specific technical details required to complete an assignment are important, though the true value of experience transcends the particulars[18]. Student employees who worked on the DITtables gained skills that were "not so much interdisciplinary but a-disciplinary"[19], as discreet skills are distinctly secondary to the soft skills in terms of building a repertoire of transferrable competencies[20]. Student staff involved in building the DITtables did not just witness the renovation of a large, empty room into a vibrant space with modular tables, they were an intimate part of the transformation.

Table 1 - Table Training Distribution by Major



PROBLEMS & SOLUTIONS

Every project ever attempted encounters unforeseen problems along the way; the following section outlines some of the struggles we faced and the solutions we found to mitigate them, in the hopes that these insights might be of use to readers as they take on projects at their own institutions.

From the outset of this project, we underestimated how long it would take to complete. Specifically, we were overly optimistic about how effectively unskilled student employees would internalize the nuances required to work autonomously while achieving a high-quality output. Some students did learn particular processes sufficiently that they were able to work without supervision, but these were the exception and even then, often achieved this degree of competence as we were nearing the end of that stage in the workflow. It is important to respect the very real differences between vocational schools and industrial arts classes[21], and the many ways both of those experiences are vastly different from the curriculum that academically high-achieving students are accustomed to mastering. In hindsight, it might have been more expedient to identify a cohort of capable students at the beginning of a given stage to receive in depth training on that process, then have them serve as leaders overseeing quality control when working with other student workers as assistants. On the other hand, even our quickest-learning and most detail-oriented students still had quality control issues, which may have made a train-the-trainer model problematic.

SCALING THE PROTOTYPE:

As mentioned, the design, component sourcing, and assembly of the prototype was simple and straightforward. When scaling the process of building a mid-sized one-off to a large set of 18 tables, it seemed the responsible thing to do would be to take advantage of routine cost-saving measures such as purchasing with quantity discounts from industrial suppliers. For some materials, such as the pipe, this allowed us to find stock that was not available in store and for a much better value. Other materials, such as the pipe fittings, were readily available in store, though we were able to find a moderately better price by purchasing from the same supplier as the pipe. This proved a fateful decision, as those fittings were not machined as accurately as the ones obtained from the big-box hardware store, though this was not immediately clear. After the first four frames, we attributed assembly difficulties to our own accuracy on the thread cutter. We became fastidious with the tolerances of the lengths of each segment and the threads cut on each end. Quality control procedures were put in place, including checking each end of every pipe by screwing on a fitting to test for the amount of free travel before the taper tightened up, and lining up all the pipes that had been cut to a specified length and pushing one end against a flat board to quickly identify any discrepancies. After the next set of frames were even more difficult to assemble, despite being absolutely certain that all the pipes had been cut and threaded precisely, we knew there must be a problem with the fittings. After checking that all the next table's fittings threaded on the same amount to a common test thread, and that table was still difficult to assemble, we realized that the error was in the relationship of one threaded port to another within each fitting; supposedly 90-degree and/or 180 degree threaded ports on the fittings were several degrees out of tolerance, requiring brute strength and coordinated teamwork to force components into alignment. This hypothesis was proven when we began assembling larger table frames, where the greater linear distance made the angular discrepancies unmistakable. By this time, however, we had completed all the 3'x4' tables, and the added leverage of the longer pipe lengths for all the other frames we had left to build mitigated this issue well enough that we decided to go ahead with the fittings we had so they would all match.

It should also be noted that threaded assembly of a closed frame is inherently difficult and not really what these components were designed to do. We had originally proposed to build our own welded frames, which would have been incomparably simpler than the threaded solution, though we were also trying to build the tables using technologies we offer access to in the FabLab, and we are quite understandably unable to weld indoors in the library.

MYSTERY BUSHINGS:

A bizarre series of events -still unexplained- unfolded around the bushing which connects the table frame to the caster at each leg. When preparing the prototype, I took one of the pipe fittings and a bolt with the same thread spacing as the caster stem to a hardware store specializing in threaded fasteners to figure out some options for connecting the two. The initial thought was to purchase solid plugs to fit the tapered pipe thread and drill /tap our own straight-threaded hole through the center of each, however, with a little searching through the bins of components, I was able to find a bushing that accomplished just that straight off the shelf, all for marginally more than a simple plug. They had 4 in stock, too, so it seemed a very fortuitous find at the time.

After approval of the prototype, it was time to scale up to purchasing the quantities required for the entire fleet of tables; I returned to the same hardware store to work out a bulk order. They were out of stock, and the area had been rearranged. Working with the store manager, we looked up the UPC by purchase history associated with my credit card, only to find that the code corresponded to a different product altogether. The manager did some more research in the company system, both in store and thereafter in a more thorough search of their inventory and ordering systems. Evidently, there was no record of that company ever having stocked the product I had definitely purchased from them. After spending a couple days looking up and calling all the North American manufacturers/distributers of pipe fittings I could find, it became clear that nobody regularly manufactures such a part or can remember anybody else ever having done so. Plenty of firms offered to custom make the part as a special order, though the estimates for that started at nineteen times the cost of the original part! We eventually bought tapered plugs, as originally planned, and tapped them using the mechanical engineering machine shop on campus. The question of how I was able to purchase the initial four in the first place still haunts me; the transferrable knowledge here is apparently to always inquire as to the availability of a component in bulk when purchasing parts for a prototype, even if one is unsure if the prototype will work and even if the part seems commonly available. Alternatively, we could have redesigned the table frames (and re-cut a number of pipes that had already been prepared and assembled) to adapt to more readily available hardware.

INSTITUTIONAL RELATIONSHIPS:

The process of building these tables was a wonderful catalyst for strengthening relationships between the FabLab and other departments on campus. As mentioned earlier, the mechanical engineering machine shop had tools and expertise which were invaluable to us. Many academic makerspaces exist in parallel with traditional machine shops on their campus, and there are many good reasons to cultivate a good working relationship between the two departments.

We do not have a spray booth inside the library, yet we had to clear coat the steel to protect against rust. I got in contact with the manager of the campus paint shop, and after meeting to discuss the project, he agreed to allow us the use of their spray booth, provided we work around their schedule. In order to get the table frames from the library to the paint shop, I worked with the property management team to get certified to drive their large trucks. This access was also provided with the caveat that we work around their schedule. There were a few occasions where one of those two schedules changed last minute, requiring a flurry of rescheduling on our end, though the facilities were vital to the success of the project and the relationships forged through working together have proven recurrently useful.

Additionally, several members of UTA Libraries administration (including the Dean) participated in a day of assembling the larger table frames, which not only allowed them an opportunity for greater understanding of the struggles involved with the project, but also allowed the student employees a greater sense of relatability with Libraries' upper administration.

LEARNING TO BETTER USE OUR OWN EQUIPMENT: Given the large size of the 7x7' and 9x5' tables we were building, we had to purchase butcher-block table tops that were the correct length and half the width, then glue the two halves together ourselves. We got our pipe clamps at the same time as we were attempting to roll out flexible filament usage on the 3D printers, so this provided an opportunity for a few students to 3D model clamp guards and go through the iterative design process until we found a functional solution to protect the tabletops from being marred/indented by the clamps. When we got the boards lined up in preparation for gluing, it became clear we were going to need to dress the edges, as the boards were not perfectly straight. We had long since decided a circular saw would not be an appropriate tool for the space though it would have been the go-to tool to quickly achieve the straight edge we needed. We requested a track saw, though this was not approved due to remaining safety concerns as well as a worry that the tool would find little usage outside of this project because of the other saws we already had in the shop, so we decided to create a true, glue-ready edge using the ShopBot. Rather than only trimming the straight edge we needed to glue, I programmed the ShopBot to clean up three edges, as not all the tables had arrived exactly the same length and the end-grain had been laborious to sand smooth on all the smaller tables. This provided me with hours of familiarization on the ShopBot, and allowed several occasions for student employees to observe the set-up procedures and safe operation of a machine they had not yet been formally trained to use. The 9' tables we made exceeded the bed capacity of our ShopBot, which prompted us to devise and test jigging methods for moving the board between passes while still achieving a perfectly flush edge.

CONCLUSION

Did this process ultimately cost more than it would have to simply purchase the available tables on the market? Absolutely. Any holistic cost/benefit analysis, however, would have to grapple with the more intangible benefits of student service learning, a sense of legitimate ownership of the space by both full-time and student staff, and the allures of having a custom solution with a unique aesthetic. Given this context, even though all the wood joinery was glued and the metal components threaded, we totally nailed it!

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