

# **LEARNING BY MAKING EMBEDDING HANDS-ON EXPERIENCE FOR INDUSTRIAL DESIGN EDUCATION**

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## **INTRODUCTION**

Industrial Design (ID) has always strived to master the latest tools available in order to deliver designs to the clients with more efficiency, accuracy and coherency. This places the Industrial Designer into a system that is affected by technology. Consider the arc of evolution of the car phone as it became the cell phone, and most recently, the smart phone. Users of these devices interacted with the technology in different ways throughout the evolution timeline. In a way, people can track the change of technology by marking the changes in user behavior. As technology evolves, so does the practice and behavior of designers. What designers know and understand changes as well. It is important to realize that this change occurs with losses and gains to the practice. Example: Designers lose the knowledge to operate a blueprint machine as they gain the ability to operate large format plotters. In each instance where a technological advancement affects the behavior and knowledge of the Industrial Designer, it is crucial to make certain that the profession is not losing a core value along the way. Replacing an old practice for a new one is inevitable. However, old practices that are core practices remain constant and therefore inelastic to the forces of technological evolution. As is the case with sketching, this is an old practice, but remains the primary tool for designers because its use is at the very core of Industrial Design practice. Other practices inform knowledge to the profession. What is defined as either a core value or an old value can determine what designers know versus what they used to know.

## **THE PROBLEM OF REMOVING HANDS-ON MAKING FROM ID CURRICULUM**

Hands-on making is one of the oldest techniques used by designers to create prototypes and models of their designs. Technology offers designers new valuable ways to reach the result of a finished model or prototype without hands-on manual skills. While this may be the go-to method for practicing professionals, is it satisfactory to remove hands-on making from Industrial Design curriculum? If so, does the ID student lose something that is just an old way, or do they lose a path to knowledge that is tethered to core values of the profession? This paper will argue that hands-on manual skills are crucial to the Industrial Design student because the experience offers students exclusive access to design tools and design knowledge. Making the case requires a woodshop turned research laboratory, where two pieces of furniture will be fabricated as experiments.

## **RESEARCH HYPOTHESIS**

What do Industrial Design students gain by making their designs using hands-on techniques? Are these techniques valuable paths to knowledge and information that enhances the student's understanding of constraints and materials? How does hands-on making compare to hands-off making? Does automation fail to teach real-world problem solving? The author built two furniture prototypes over the course of nine months in a shop space utilizing manual skills as the primary method of fabrication. These experiences were documented with in-depth journal entries, photographs and video.

**Project 1. Treble Clef Wall Desk:** The desk is designed to have a fold-down work surface which provides space for a laptop. The desk will be built primarily out of donated hardwood veneer laminations. The process is one of only a few additive processes in woodworking. Most woodwork is subtractive. Along the way, many processes will be implemented and reworks to the original design will take place. What will this say about the competency of the original concept? Does this reworking take place when a designer hands a drawing to a craftsman?



Fig. 1) Treble Clef Wall Desk initial design imagery and process photos.

**Project 2. 3-Legged Tractor:** The 3-Legged Tractor will be made of laminated solid hardwood and will involve a large turning operation on the lathe followed by a great deal of hand carving. The form of a tractor seat is the perfect candidate for a 3-axis CNC operation. The computer can easily handle the various contours, valleys and peaks. Hand carving is the pinnacle of intimate slow woodworking. If the objective is to work really fast, then the CNC router can make quick work on the complex form. But the objective is to see how much one can learn from the material, and about the material. Pallasmaa (2009) explains, “You cannot make what you want to make, but what the material permits you to make” (p.55). This will require developing muscle memory, understanding grain direction and tear-out, and learning how to make symmetrical forms.



Fig. 2) 3-Legged Tractor initial design imagery and process photos.

## FINDINGS

- Making requires understanding the tools; sometimes adapting them by making jigs and carriages to allow enhanced bespoke uses of the tools to meet the needs of the geometry.
- Working in the shop environment means relying upon others to assist and critique. The *drive-by-feedback* is valuable and flows naturally in a shop space.
- Things break. The shop space does not care how perfect a CAD drawing is. The materials fight back and require a great deal of dialogue between maker and material.
- It is always good to continue drawing throughout the building process. Sketches are not just for showing other people ideas. Students need to see their own ideas and figure things out. Pirsig (1975) discusses the difficulty with this ability to see, “We are trained *not* to see it. . . The truth knocks on the door and you say, ‘Go away, I’m looking for the truth,’ and so it goes away” (p. 5).
- Shifting reference – The object takes form in a shop which in turn makes parts or all of the drawing obsolete as far as a point of reference at full scale. Better to rely upon the built object than the symbol of the built object. See Fig. 3
- In the shop space, risk-taking is an inverse operation from the virtual digital making process. As more work is fabricated, future steps are counted as opportunities to destroy previous accomplishments. In CAD, future steps build on the established context, and assist in the possible solutions (see Fig. 4).
- Incremental steps verses overall process. Making teaches the value of knowing more than just the next step. With several identical pieces, the designer learns to use the tools as an assembly line, and make extra parts in case something breaks. Designers are used to creating process books for their projects, but knowing that a stool leg will require 34 separate operations before completion is a more intimate understanding of materials, tools, and the ramifications of a given design.
- Knowing that *tear-out* is a primary concern when working with solid woods, the *field of perception* needs to increase around such activities. Understanding any material’s weakness should prompt the designer in the shop space to the same state of mind. Ken Robinson (2001) states, “We do not see the world as it is but as our particular human senses present it to us” (p. 115).
- Losing Touch; The Five senses - Students’ time outside the shop environment is time spent primarily engaged with their design projects using the sense of sight. When the student begins to use the computer as a tool, the screen work is a single sense interaction. Design students fair quite well with the sense of sight. Educators agree with experts that the designer’s eye is a crucial sense to develop in Industrial Design curriculum. When a hands-on approach is integrated, the other four senses awaken and contribute to knowledge and learning. The design student’s sense of smell can detect and report to the brain information that helps a designer understand what material is being used, and how that material is reacting to machining, cutting, forming and finishing. Many design making processes involve heat. In some cases, the olfactory perception may be the only sense that is capable of reporting the amount of friction being applied to a part while machining takes place. For example, when a piece of hardwood is being fed into a table saw, the smell of the dust can dictate feed rate into the blade. Combine this with the sense of hearing and the smell of burning maple will coincide with a change in rpm as the saw motor bogs down under the load. Chances are that the next sense to inform the brain will be tactition. The sense of touch will feel the resistance of the maple board. All of these senses can tell the brain something specific and intimate about the process in hand faster and more directly than sight. Looking at the board does very little to inform the operator what is happening where the blade meets the wood. Engaging the senses, however, does not just aid in the *use* of the shop space, but helps produce the results from making altogether. A form may look a certain way on paper, but once a physical model has been made, the human hand can inform the designer with information that may not be visually apparent. This is to say that simply holding a form study or white model in hand while being blindfolded will reveal subtleties and nuances with form and surfaces. Research has shown that student’s ability to recall and remember certain things grows stronger when this memory is imprinted to the brain by more than one sense; the olfactory sense being the strongest.

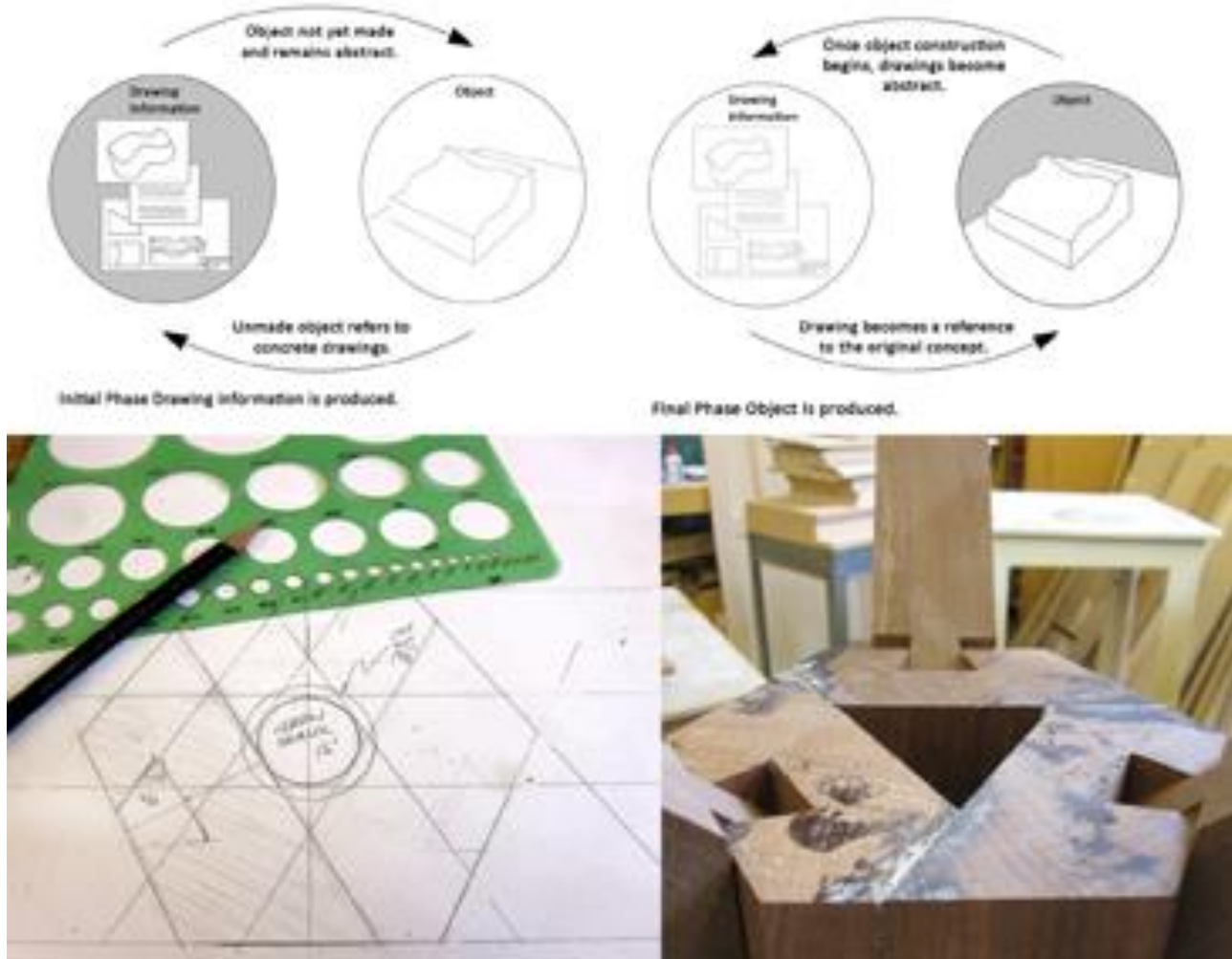


Fig 3.) Shift of Reference: In the shop space physical objects are concrete which refer to drawings that become abstract after fabrication begins.

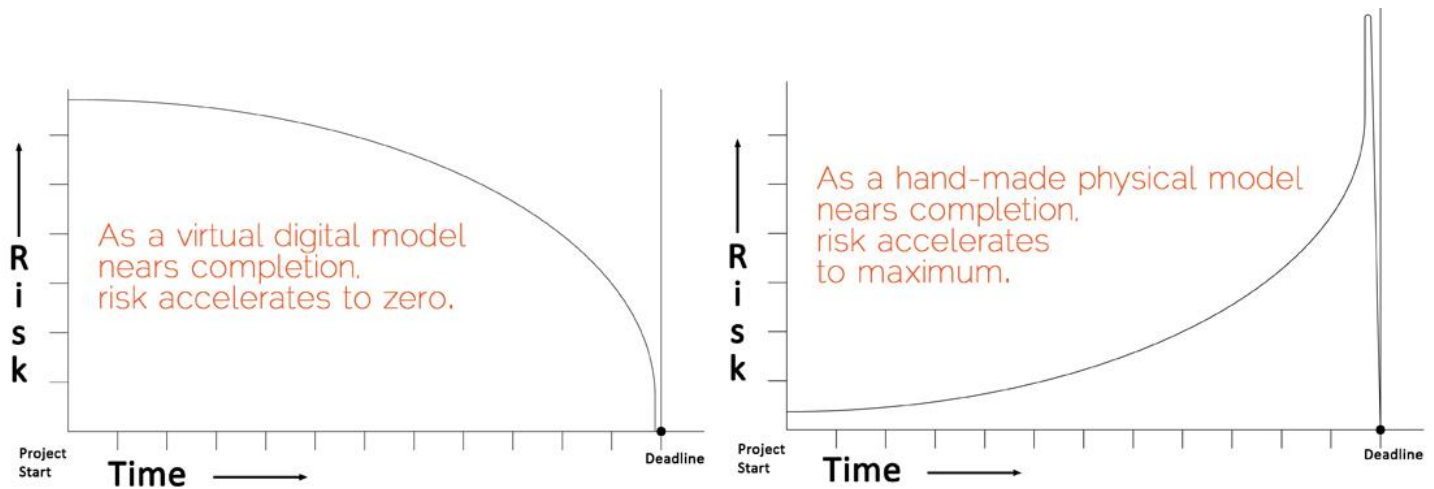


Fig 4.) Graphic depicts the comparison of drawing a design verses building a model or prototype. The graph on the left shows how context alleviates risk as the CAD effort nears completion by eliminating possible solutions that do not connect to the previous efforts. The graph on the right shows how incremental successful steps can be destroyed by the next ensuing step.

## APPLICATION

Students who use a shop space as part of the overall studio space will benefit from working through Industrial Design problems. This is primarily because the making environment, which utilizes hands-on manual skills, offers knowledge and a form of learning that no technology can mimic or substitute. The exclusive knowledge and learning experiences found within are well aligned with the values of the Industrial Design profession. The hands-on making culture of Industrial Design education is not important because it is an old culture, but because it is a *core* culture. Students have the advantage of being part of an opportunity in school which affords them the right to immerse themselves in all aspects of, and all ramifications of hands-on making. This is a small window of time along the course of their careers. The hands-on making culture rarely finds its way into professional practice. This is to say that students will most likely work for a studio or corporation that contains little to no shop space. However, the experiences in ID students' education help them cross a major threshold in *thinking* and give them possession of ideas and paths to knowledge that they can apply to every project in their professional career. With this in mind, the next question is: What is the best way to integrate hands-on making into existing curriculum especially where hands-on making of physical models is phasing out?

**Space:** ID students need two distinct spaces. First, a classroom/lecture environment that is clean and orderly which caters to visiting professionals and can be refined enough to double as an exhibit space displaying the students' projects. Second, a shop space, naturally more chaotic and loud, and serves a number of different roles throughout the day. Inside the shop each area belongs to every student, and work flows around the tools and benches. This is in contrast to the classroom where spaces belong to a grid pattern with individual desks for students. A classroom has a natural justification. The front of the room is established. Most of the time, the students' work station face a single direction. The shop has no front, back, or sides; just locations of operations.

After examining research, the case for a making-emphasized program benefits from considering both the classroom and the shop as learning environments. Without any infrastructure, a professor can stop the isolation of these two environments and combine them into one. Lectures, critiques and mentoring can and should take place inside the shop space. This may seem radical to professors who rarely visit students in the shop environment. This interaction can sometimes take place during the studio section's timeslot. Bring the students into the shop and demonstrate technique, skill, and intent. Using the shop space during normal classroom time will help set the students' minds toward the notion that the shop is a great learning environment. Furthermore, this helps some students out of their shells.

The classroom can become a comfortable place. This is because the ramifications of failures within a specific design are not exposed in the same manner as within the shop. In the classroom, the drawings, sketches, and computer models all appear as solutions to problems; whereas in the shop, those same drawings pose as a series of problems to be solved during construction. Subconsciously students see the classroom as a refuge from this exposure and delay discovery in the shop. There are two primary reasons for this: 1.) the students have not been trained to accept the value of failure in the experimentation phase of their design project, and 2.) the students are not familiar with the shop environment, and are simply unprepared to work in a shop with confidence. It is the professor's job to instill confidence in the shop space in order to avoid the 'foxhole' approach to the classroom. This confronts the stagnation issues with shop confidence and helps properly align the definitions of both spaces.

The shop mentality can be part of the classroom as well. Students are much more likely to comment on construction methods and progress in the shop. The common use of tools and shared burden of completing a physical model happens in overlapping spheres in the shop space. This is less likely in today's Industrial Design studio. Students can hunker down behind their computers, or focus on their sketching in a quiet static way. Simply isolating these activities to the desk and chair in the classroom lowers the observational conversations that naturally take place in the shop. Flow of students is all but nonexistent. Rearranging the furniture can help with this to a degree. But the real mindset desired can be practiced during class time where the professor can set the tone for circulation and open discussion. Furthermore, students' work should be displayed vertically for all to see. The classroom can function like a nerve center for the project, and encourages the thinking that supports further steps in manufacturing by realizing that the real world work happens just down the hall in the shop.



Another way to bring the shop mentality into the classroom studio is the notion of clean artifacts. If a student has planned to design something which will be made of alloy, the student should bring a sample in and set it next to their drawings. Or if a certain hinge or hardware is to be used, have this at the ready. What takes place is remarkably useful. Nicolas Grimshaw (1993) commenting on Grimshaw and Partners' office:

"I have always seen the office as part workshop and part studio. My ideal is for each team to have a working model beside them so that they can be continuously aware of the scale and size of the spaces in which they are working. Pieces are added and removed so that in the end the model has the feeling of a battered tapestry. One can also see pieces of buildings, castings and fixings lying around people's desks. This illustrates our constant dialogue with all the various manufacturers and suppliers" (p. 146).

In the case where the school's department has in place a shop technician, he or she can be invited to the classroom during the initial kick-off of a new design project. The technician will benefit from knowing explicitly what the project entails, and the students will be able to raise concerns regarding the project to both the professor and technician. The technician can better serve the ID department by planning for upcoming use of the shop, and knowing what tools will be needed to complete the project. The professor now has a partner in both technique and design theory who is willing to stand beside the students from start to finish. This further enforces the notion of the shop as a learning space by inviting the shop technician into the classroom.

## Typical Design Process

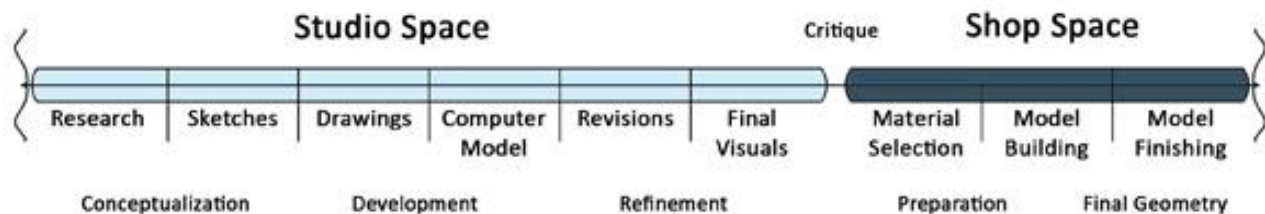


Fig 5.) Graphic of a typical project timeline. The process is illustrated in relation to studio space and shop space.

## Combining Shop with Studio

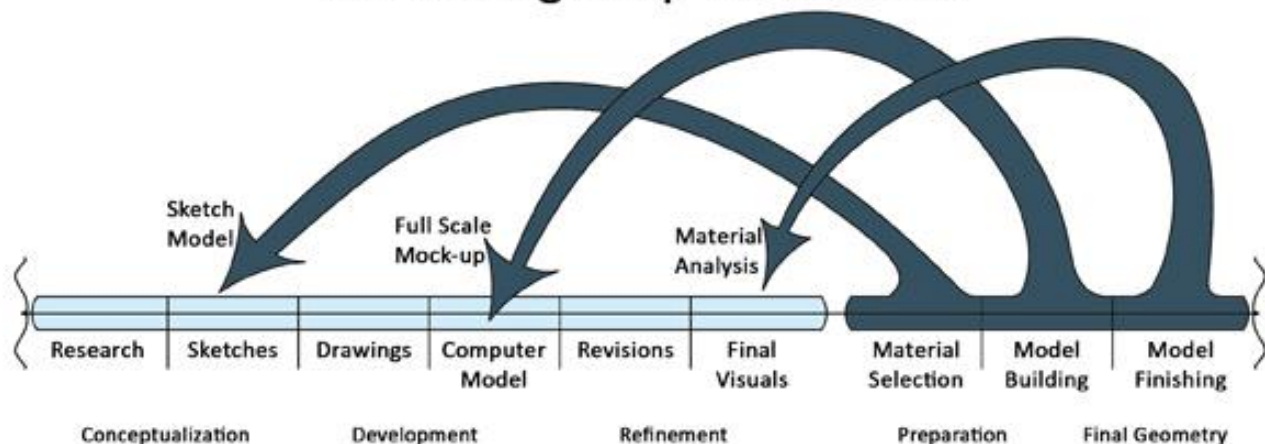


Fig 6.) Transition of shop integrating to every stage of design process.

# Hands-on Embedded Design Process

## Studio - Shop Space

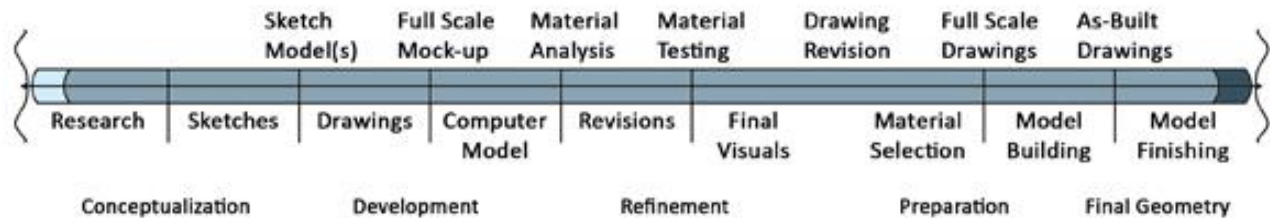


Fig 7.) Making embedded into process.

**Materials:** At some point during foundational ID training, the connection between the characteristics of materials and desired forms and uses for design must begin. As students are learning the basics for form-giving, they need to learn the basics for the materials of choice in tandem. What a particular design is meant to be made out of, greatly impacts the range of forms possible. Even if the ID student is charged with making a white model, or mock-up version of the real thing, where silver paint may represent stainless steel on the prototype, the student is best served if they are challenged to design their forms to fit within the constraints of the material choice. This notion of constraints is what sets us apart as Industrial Designers. Understanding this takes time. Therefore the training of material knowledge should not be considered an upper-level idea, but treated like a foreign language that begins with the basic structure, and advances with vocabulary and nuance over time. Waiting until *after* form-giving foundational work has been established does little more than delay the inevitable collision with the real world. Even in the virtual sense, creating geometry in CAD programs may need to be completely revised when real world hardware or materials are specified in CAD drawing form. Some software choices attempt to simulate this. One example of this from outside of the ID studio is the Autodesk® program *Inventor* which has the ability to call out when a piece of stainless steel sheet metal is shown drawn at a radius that is not possible for the material to be formed to. Accepting that materials have their own language is a big step early stage of an ID student's curriculum.

Pallasmaa on materiality, (2009) "The work of the craftsman implies collaboration with his material. Instead of imposing a preconceived idea or shape, he needs to listen to his material . . . Each material has its own life, and one cannot without punishment destroy a living material to make a dumb senseless thing. That is, we must not try to make materials speak our language, we must go with them to the point where others will understand their language" (p.55).

Designing projects that reflect a growing fluency in materiality brings the ID student closer to basic requirements of professional practice. How can activities within the ID project scope help designers understand materials and their properties using a hands-on approach? Professors can create ID projects that feature particular materials and process to familiarize their students with the behavior and properties of materials. When a final model must be constructed with *real* materials, the student is even more compelled to try things in preparation for the end result. Such as attempting to bend or cut sheet metal to a specific size and shape *before* having to fit to a nearly complete model. These experiments link back to trying things in the shop space at the conceptual phase. They also help designers find where constraints really come from. Patrick Dunn (2005) refers to this as a component of the designer's *problem space* and mentions a number of contributors. Dunn's term *problem space* reminds designers that their projects are never just about the designer and their ideas:

"All design activities occur with boundaries set by constraints. Time, budget, user preferences, organizational culture, available technology and the personal whims of clients are all design constraints that define the "problem space" in which the designer works. Constraints are the things that need to be taken into account when solving a design problem. A good understanding of a project's constraints – and the ability to make informed trade-offs between them – increases the probability that the designed solution will meet the needs of users and clients" (p. 2).

When design students consider this problem space, the materiality boundaries are best defined in the shop space. Ultimately the best knowledge about a certain material comes from having to form it, or machine it. Growing fluent in a given material's language, a design student will avoid the pitfall of discovering that the design they have conceived cannot be formed using the materials they have specified.

## CONCLUSION

Campaigning for more making in any institution can be approached from myriad ways. Hundreds, if not thousands of different arguments are in place to make such a stand. Each argument contains a different objective connected to the same means. This hands-on making is essentially human. By engaging in hands-on making, a person connects their entire battery of senses to the task. No wonder so many people are part of the bigger discussion. Sennett (2008) claims that, "all skills begin as bodily practices" (p. 65). If the power went out tomorrow, and no more devices or equipment could be switched on, the human race would rely primarily upon what they could do with their hands. Pallasmaa (2009) writes, "Practices of the human hand around the world form the true survival skills of humankind" (p. 52).

From there we zoom into work, vocation, and what we find value and worth in a day's labor. Mathew Crawford (2009) discusses the dichotomy of mental versus manual work, and argues that the degradation of blue collar work has not just hurt our economy, but has affected our self worth, and understanding of all things surrounding us. He sees today's contented as the cabinet maker, the mechanic, and the plumber.

Within vocation there is a special breed of professional who benefits from the latest technology and the oldest hands-on technique at once: the Industrial Designer. Most of the professional work produced by an industrial designer will take place on a desk and inside the screen of a computer. Their clients live far away, and the things they design are most likely built in countries outside their own. This work is studio work. This work is office work. Those who hold these positions were once Industrial Design students housed within a major that is now in danger of losing some of its core values. Technology has provided a way for Industrial Design students to complete school with very little to no hands-on making experience. The shop space has adapted to house rapid prototyping and CNC devices that disconnect students from a form of learning that is unique to the hands-on making shop space. Just like embracing sketching and hand drawing as a core value, we need to consider this shop-space experience a core value, which should be fostered and nurtured alongside all of the advancements of automated making.

Industrial Designers are used to the studio environment in which they act as Don Schön (1985) described as "reflective practitioners" (p.98). Similar to engineering test labs, the design studio relies on a common space where making takes place, and is accessible for informal discussion and criticism. A shared shop space for making is a core ingredient in a creative community. Without reorganizing priorities in Industrial Design curriculum, the space where this takes place, along with its tools and knowledge, may become virtually unknown.

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