A Model for Every Purpose:
A Study on Traditional versus Digital Model-Making Methods for Industrial Designers

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Introduction

This paper examines to what extent design students need to learn traditional model-making skills in a digital world. Computer aided design (CAD) has somehow eclipsed traditional skills such as hand sketching and making models by hand. Design research is also increasingly a main focus for the design professional (Arnold, 2001). Educators are faced with the difficulty of balancing new digital skills and theory against hand skills such as drawing and model making, which typically have taken a considerable portion of studio time in the past.

Literature reviews highlight the importance of early, rapid and focused qualitative prototypes; extremely simple mockups are often enough to test and explore new ideas. Learning how to make quick prototypes by hand, therefore, underlines the importance of the "fail often to succeed early" mantra (Kelley, 2001).

Book on Sketching Sets Precedent

Design Sketching by Olofsson and Sjolen (2005), has become a heralded industrial design resource book for universities as well as practice. The authors started the project, because they "could not find a good modern book on industrial design sketching techniques." A lot of books were out of print and had lost some of their relevance. The book is also unique because it looks at design sketching in a holistic way, through relevant and modern examples, showing the fusion of both hand and digital methods. The authors have divided sketching into three major areas of application for the industrial design process; these include exploration, explanation and persuasion. As a result an intellectual process giving a clear purpose for sketching complements the sketching techniques.

The Lack of 3D Model-Making Books for Students

The similarities to model making are very clear, since books on the subject seem to be out of print and do not address the process of design research. In practice, model making has evolved from being mostly a product for presentation, to being more of a tool for making focused prototypes for learning and answering product development questions. This affects the model making objective and hence method. Physical model making techniques has largely been left up to students to learn on their own, by experimentation or from others. Even something as simple as knowing where to go to buy materials can be a real chore. Many instructors offer demonstrations of specific model-making aspects and materials; others simply defer to shop technicians. Online resources such as the Core77 network are a good way for students to share ideas and get information, but still have precious little information on the topic of model making. In the past model making was typically seen as a formal activity mostly for purposes of presentation to a client. Quick and rapid techniques and materials were therefore given less attention than those related to working with a specific material with the emphasis of getting a high-quality visual result.

The following project shows how simple models can complement the sketching process. In this second-year project, students are asked to design a metaphorically inspired electronic accessory. Several iterations are required, in order to balance utility and emotional aspects. Model making in clay, combined with sketching is both a way for the students to develop the design, while learning more subtle aspects of form, such as dominant and subordinate forms, controlling surface and edge transitions as well as lighting and color. Students comment that the process of making the models allows them to become better at sketching. Instructional resources for sculpting with automotive clay are not applicable to this particular hands-on and quick process. A handout sheet was therefore developed that gave students a step-by-step process, focusing on simple aspects of handling the clay and tools, while explaining the context of form exploration.

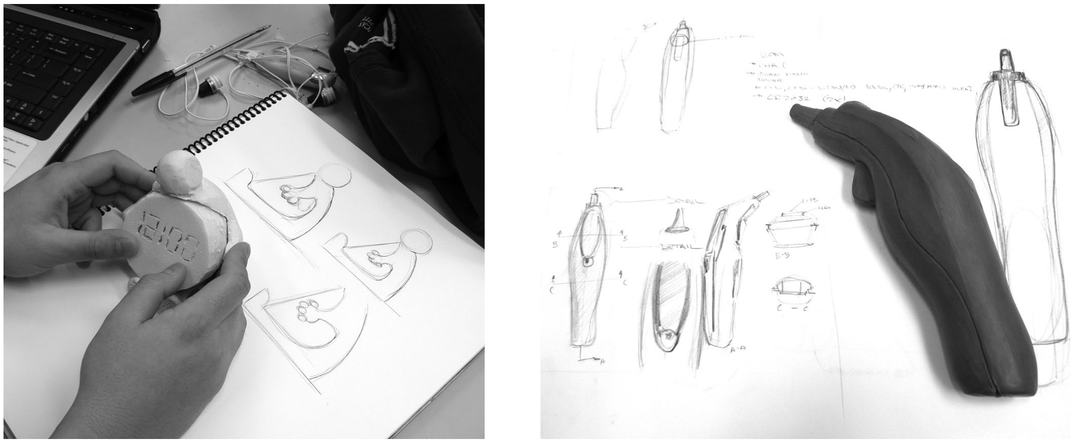

Figure 1. Simple clay models complement sketching ideation.

Investigating Model-Making Needs at the School of Industrial Design

This author has been documenting and researching model-making needs at the School of Industrial Design at Carleton University for the past couple of years. In discussions with students, workshop technicians, and faculty, a range of issues has been identified. Model making and visualization is at the core of industrial design but needs to be modernized in terms of a holistic approach. This means an examination of different techniques and objectives, as well as looking at health and safety aspects, including new greener materials and technologies. The following are some notes from these discussions.

Students are taught about a range of design issues through model making. Rowena Reed Kostellow's exercises on form manipulation are an example of learning about formal organization by making models (Hannah, 2002). Models also help the student gain an appreciation of structure and strength as well as material and manufacturing. Prototyping exercises are crucial to design research and iterative product development. Instructors are quite concerned about environmental issues as well as health and safety aspects of materials.

Students generally understand what is being expected from them in terms of hands-on model making, but can become overwhelmed by deliverables. They are sometimes confused about the difference between different types of models in terms of their purpose. They typically rely on faculty, technicians and peers for support and may go online to find additional resources. The diagram below illustrates how students currently have to approach a comprehensive model-making learning process. This is likely a similar situation at many other schools.

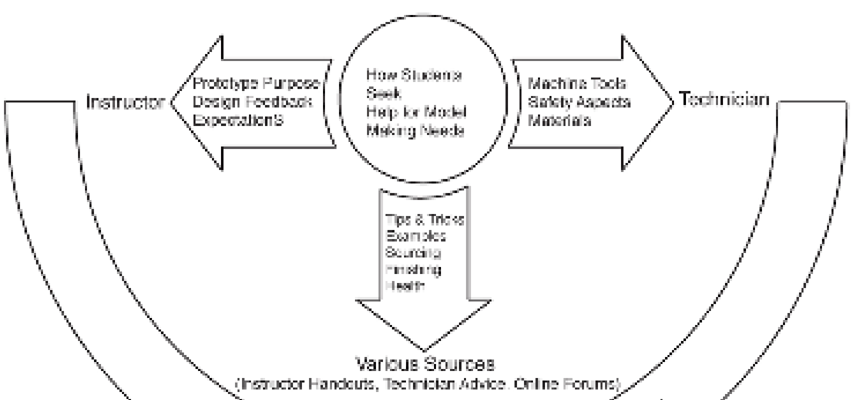

Figure 2. Building a comprehensive student model-making skill and thinking set.

Technicians mainly focus on assisting the students with machine tools, rapid prototyping services, and materials. They are concerned about safety in their labs, which covers the machine tools as well as material health and safety. Our technicians are not typically designers, but tend to have a machinist background. This can sometimes make it challenging for them to fully relate to the prototyping objectives in terms of the design process. Meetings between instructors and technicians are therefore important, in order to plan the projects.

Prototyping in the Context of Design Research

Physical prototypes are a critical component in terms of conducting user-oriented testing. Insights from successful case studies in design clearly show the relevance of hands-on approaches. A classic example of this was the first model of a surgical sinus-operating tool, designed by IDEO for Gyrus ENT. The model was made by taping together a clothespin, film canister, and marker. The resulting prototype proved the concept of a forward swept handle and "jump started the design process" (Katz, 2006).

For the purpose of this paper, traditional model making is seen as the process of making physical models by hand for the purpose of learning about formal relationships as well as prototyping. Stephanie Houde et al., introduced the notion that to prototype is to "explore or demonstrate some aspect of the future artifact" (Houde & Hill, 2006). This is an important definition when looked at in terms of design research. Educators need to think broadly about this when advising students about digital versus hands-on prototyping approaches. Take as an example, the student project below illustrating the formal development of a folding bathroom scale. Through user research, the student gained the insight that bathroom scales were difficult to accommodate in tight bathroom spaces. As a starting point the student sketched some ideas for a folding scale. The product would take up a smaller footprint when not in use by being designed to stand on its side. A series of simple models were important in terms of establishing the design criteria. This included how the folding mechanism should be constructed, how big the display should be, what footprint is stable, etc.

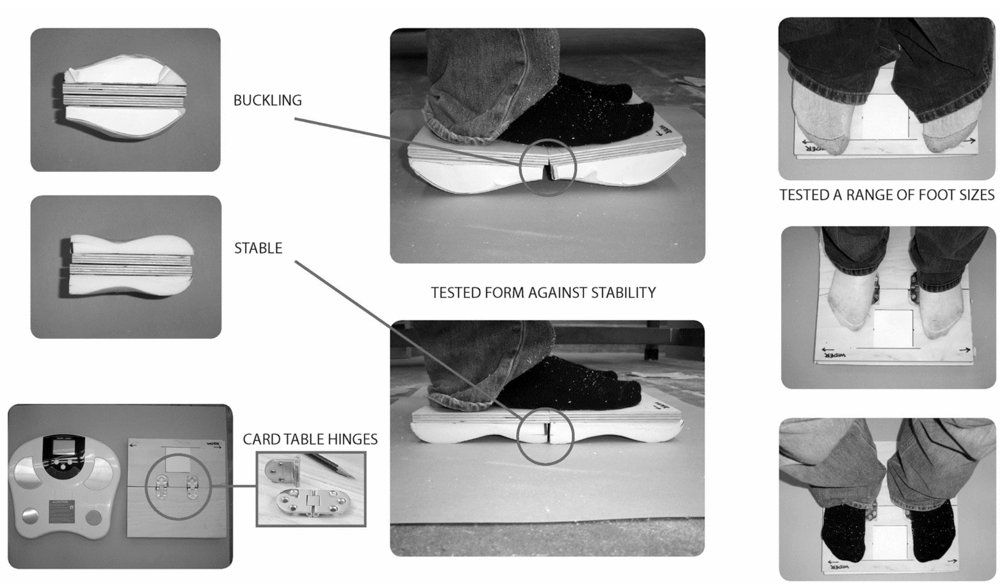

Figure 3. Simple user-oriented models give students appreciation of design issues.

This type of hands-on approach is not always obvious to students unless it is understood properly in the context of research. A student might instead be tempted to design the product in CAD and then test the final design in terms of a CNC model. This however would really limit the knowledge gathering and useful data, which then could be applied to the design options. In other words, the student learned about structure and gained an appreciation for the issues by looking at a range of physical options.

CAD is, however, a good and appropriate starting point for some projects. As an example a group of senior students were given the task of designing eyeglasses. In this case, it made a lot of sense to use CAD as a starting point for the research, since scanned data of the human head was a crucial aspect of understanding the required geometry. Getting the final design right would still require multiple iterations of printed parts.

Context is a crucial part of user-oriented research. Many contextual questions can still not be effectively addressed on the computer. Software continues to evolve and will invariably be able to address more design aspects in the future. In order to conduct research, the designer often has to obtain insights through the interaction with real people through a physical prototype. Whether this prototype is built by hand or designed in 3D and then printed is not as important as making sure that the student has the skills to make the prototype in an efficient manner, while absorbing formal theory as well as research driven design learning.

Digital Prototyping

Design students are increasingly creating virtual 3D CAD models as part of their final project deliverables. These digital models also routinely allow students to use affordable 3D printers (which have become standard equipment at many industrial design schools) to create physical prototypes. The CAD models can also be rendered for highly persuasive presentations in a range of product colors and options.

The promises of 3D digital printing make this whole process sound very easy. “Need a replacement part for a product? Just print it.” These kinds of statements undermine the deep learning and appreciation of geometry, which design students need to develop in school. Computer skills require a substantial amount of iteration, reflection, and discussion with instructors, in order to be useful design exercises.

CAD exercises can be used to both teach program skills, while still impacting a heightened knowledge of both form and color. This is perhaps more obvious in 2D graphic exercises where the computer is more similar to any other 2D medium. It does apply equally well to 3D CAD teaching, where a focus on just skill is not going to allow the students to learn about theory of form or other design aspects beyond the persuasive.

In an advanced computer applications elective at Carleton University, students were challenged to reverse design a plastic housing component from a handheld electronic product; for example, a computer mouse or remote control. The students had to study the fine nuances of form through digital means such as digital photos and measurements. When the students had to recreate the products, they often realized that the products were more complex in terms of geometry than they had initially anticipated. They also had to print the part on the departments *Dimension* 3D printer and try to reassemble the printed prototype back into the original product. The students spent four to five weeks on this process and most were unable to replicate the original parts perfectly. That being said, all the students gained a better appreciation for formal complexity.

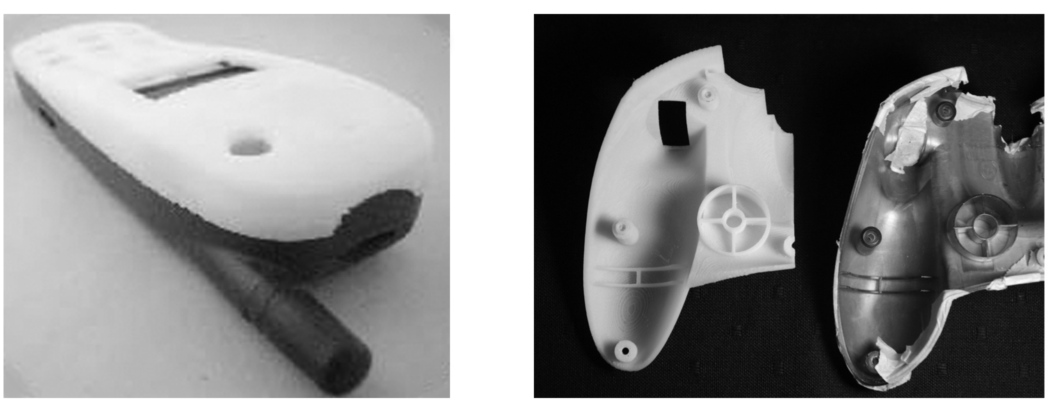

Figure 4. Reverse design exercise teaches students about formal complexity.

Industrial designers have been able to influence CAD vendors to include features with specific application for design visualization. One of these tools is the *curvature combs* found in Solidworks sketches. The combs show a graphical presentation of the change in curvature of the surface, they can be used to explain the various types of tangency conditions affecting surface transition quality. In Figure 5, a radius is compared to a very similar looking spline edge transition. Both situations are tangent, but have a different rate of change of curvature. This is a great example of CAD being used in the context of not just building geometry, but as a way to visualize geometry and form.

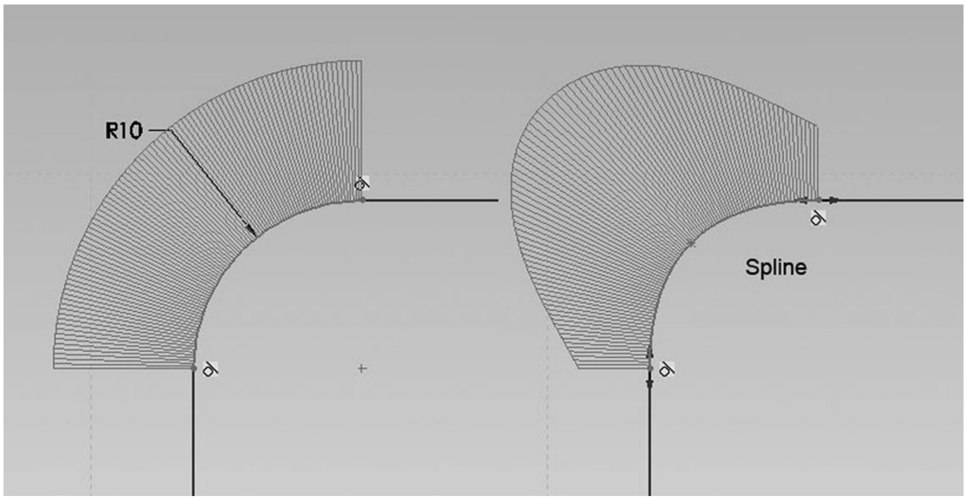

Figure 5. Digital tools such as *curvature combs* give students understanding of complex geometry issues.

Alias Studiotools has a sketch environment within the 3D modeling environment and designers are able to go seamlessly from 2D sketches via Wacom™ tablets. This convergence of hand skill with digital technology, allows the student to both learn free hand sketching and new digital technology at the same time. The digital benefits in this case are obvious and allow students to create 3D geometry right on top of their sketches.

New and smart digital tools should however not completely replace “tinkering.” Clive Thompson, a columnist for *Wired* magazine, recently wrote how he does not think that digital technologies should not completely replace working with your hands, especially when it comes to creativity, “when we stop working with our hands, we cease to understand how the world really works” (Thompson, 2008). Would the IDEO designers have envisioned their solution for the ENT surgical tool as readily or at all if they had not been trained to mock things up quickly using readily available materials?

Conclusion

In practice, the professional industrial designer has to produce highly persuasive design solutions in a cost effective manner. Depending on the project, digital prototyping can often fulfill a substantial amount of the product development process. Professionals are already highly trained and experienced in understanding form and can probably use experience to guide many design decisions. In education, students do not have this experience with materials, structure, and fine nuances of form. The students are therefore not just communicating their design ideas when developing a model, they are actually learning about form in a kinesthetic fashion. Through the above examples, the author has tried to highlight that both digital and hands-on tools are important both in terms of skill and theory. The convergence of digital tools and hands-on methods has to continue in conjunction with design theory. This requires the development of exercises, which allow the students to learn these new skills and theory in a manner that is interconnected. For example, rather than have a group of students learn CAD by doing yet another design project, there are many instances and opportunities for exercises that through CAD allow the student to learn about the theory behind geometry as well as formal organization.

An emphasis on purpose, rather than level of refinement, allows the student to understand how important 3D visualization is for the product development process. If students are trained to be problem solvers, then model making should also follow the same principles. Currently model-making techniques are often shown in the context of materials being used; for example, *foam models.* A comprehensive approach will instead look at model making from a holistic point of view: materials, skills, options, design process, greener methods, and health and safety.

Students need a more comprehensive model making resource on traditional as well as digital prototyping for various phases of the design process. This kind of resource should contain information on the prototyping process and would be greatly assisted by examples of projects showing different approaches, as well as convergence of hand with digital skills. At Carleton, documenting and analyzing different hand and digital skills has lead to a series of handouts focusing on stages of development and suitable materials for prototyping. A book is also under development.

References

Arnold, J. (2006). The reconciliation of research and creativity in industrial design, *Eastman IDSA National Education Symposium Proceedings*, Austin, Texas.

Hannah, G. (2002). *Elements of design: Rowena Reed Kostellow and the structure of visual relationships.* New York: Princeton Architectural Press.

Houde S., & Hill, C. (1997). What do prototypes prototype? In *Handbook of human-computer interactions*. M. Helander, T. Landauer, & P. Prahbu (Eds.). Amsterdam: Elsevier Science.

Katz, B. (2006). Prototyping the Future from http://www.ideo.com/pdf/barry_katz_essay.pdf (accessed April 2008)

Kelley, T. (2001). *The art of innovation*. New York, NY: Doubleday Books.

Olofsson, E., & Sjolen, K. (2005). *Design sketching*. Klippan, Sweden: Ljungbergs Tryckkeri AB.

Thompson, C. (2008). How DIYers just might revive American innovation. Retrieved from www.wired.com/techbiz/people/magazine/16-03/st_thompson#.