IT IS ALL ABOUT CONTEXT:

HOW TEACHING MODELMAKING AND SKETCHING HAS TO BE APPROACHED IN THE RIGHT CONTEXT

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1. INTRODUCTION:

Sketching and modelmaking remain central to the industrial designer's work, particularly in the context of physical form creation and interpretation. The focus and dynamics of these activities however are changing as they work to support a more user-centered design approach that requires faster and more fluid turn-around with multiple points for validation. A hybrid workflow of digital and analog technologies has the capability to keep the designer much closer to such a user-centric design approach. As a result, both modelmaking (the making of prototypes) and sketching instruction need to undergo a transformation and alignment with the methods and processes taught and exercised in modern design practice. Whereas the traditional emphasis on technique in support of the design process is still important in terms of eventual mastery, the learning objectives have changed dramatically towards more knowledge-focused activities requiring the skills to adapt accordingly. This approach requires the designer to think much more about what we sketch, build, and model and why, rather than how we sketch, build, and model. The emphasis in teaching students to build models must be on the feedback such models provides rather than on final deliverables that merely show a final concept. New textbooks that show the modern hands-on design process that blends thinking and doing; two fundamental learning objectives for every design student are now available (Hallgrimsson, 2012) (Henry, 2012). This new integration of traditional skills aligns the designers thinking and doing to better learning outcomes. A recent article by James Self on Core 77 examined the notion of CAD versus Sketching (Self, 2012). In regards to digital and analog tools, he states "knowledge must also be developed through an education that describes and makes more explicit the relationships between tool, tool user and context of use. Merely stating the benefits of one tool over another is not enough." This paper builds on that notion of explicitness and examines several key issues that create context for teaching the skills of drawing, modelmaking and prototyping in a modern design curriculum. For the purpose of this paper, modelmaking refers to the process of making a physical model, whereas prototyping tends to be associated with how these models (prototypes) are used in the design process as means to answer design related questions.

2. MEANING OF CONTEXT

For the purpose of this paper, the notion of context is examined from various perspectives. Foremost the user centered design process is contextual: it calls for genuine needs considered in terms of the real end-users while remaining appropriate to the environmental context of use. The scientific assumption that problems can be isolated and identified through traditional research is however under increased scrutiny in the study of design thinking. In fact, problems associated with innovation tend to be ill defined, especially at the onset of a project. Scholar Nigel Cross has extensively studied how designers think and act. He identifies a different type of reasoning first noted by American pragmatist philosopher Charles Sanders Pierce in the beginning of the last century, namely abductive reasoning. This is the type of thinking associated with ideation and intuitive thought. It asks, “What could be” rather than “what is”. It differs from deductive and inductive reasoning whose objectives are to determine the truth. In his book, *Design Thinking*, Nigel Cross argues, “unlike conventional logic, a design solution cannot be derived directly from the problem, but can only be matched to it” and “in the process of designing, the problem and the solution develop together” He speaks to the “emergent properties” that lead to truly innovative insights and discoveries not initially realized that appear in “partial solutions” (Cross, 2011).

Sketching, modelmaking and prototyping are important abductive reasoning tools; they allow new ideas to emerge through partial solutions integral to the ideation stages. The tangible nature of sketches and explorative physical models encourage a highly iterative approach allowing the designer to gain new insights that they can build on, while also keeping one foot in reality, due to the sheer physicality of the process. The premise of this paper is that analog and digital ways of working can support abductive reasoning in a highly user-centered design approach. This will be examined through important contexts that exist between these types of tools, skill learning, and design theory.

3. THE CONTEXT OF COMPLEXITY

Design education has become increasingly complex requiring students to understand the broader theoretical implications and design methods required to function professionally in a competitive global product development arena. The digital tools that industrial designers rely on have also increased in complexity. Calibrating the ‘hard’ skill development to directly support the ‘soft’ conceptual skills of problem-finding and problem-solving is essential to the education of a user-centric designer. The process is not linear, sequential, or easily repeatable which requires great flexibility on the part of the designer especially at the front-end when problems are typically ill-defined and clear directions are not immediately apparent. This fuzzy front-end creates anxiety in students as they attempt to strike a balance between the inherent ambiguity of problems and a natural inclination or desire for decisive action.

For this reason, it is essential for design students to establish a degree of assurance in their broader method. Focusing on discrete skills out of the context of the larger problem sends the wrong message. In his essay, *The ideation gap: hybrid tools, design flow and practice*, Tomas Dorta invokes Donald Schön’s ‘reflective practice,’ Gabriella Goldschmidts ‘back-talks,’ and Willemine Visser’s notion of ‘cognitive artifacts, in discussing the importance of physical ‘things’ for the designer to interact with while working. “When the designer does not have the experience to mentally visualize and resolve design problems, or when the problem is too complex, these cognitive artifacts are essentials to the ideation process” (Dorta, Perez, & Lesage, 2008). The creation of such artifacts is generally provisional with less emphasis on clarity and more emphasis on feedback. Teaching students to create let alone interact with such low-fidelity artifacts is a challenge since it goes against many students’ concept of learning. Just as students are more apt to feel insecure in this early stage of concept ideation, they are just as likely to fixate on ideas that they are familiar with (Youmans, 2011). They tend to gravitate to their first ideas in part because it is the easiest method and because ‘first ideas’ tend to be valued more emotionally as internal gut reactions (Kahneman, Gladwell, et al). This is precisely the point when students need to be as open as possible and prolific. It is only through this initial phase defined by sheer quantity of output that a designer begins to see multiple options and possible themes or patterns.

4. THE CONTEXT OF TECHNIQUE AND MASTERY

The term ‘mastery’ applied to design skills is problematic. Bill Buxton’s book, *Sketching User Experiences: Getting the Design Right and the Right Design,* uses many adjectives to describe sketching including quick, timely, inexpensive, disposable, plentiful, minimal detailed, and so on. Perhaps the most curious adjective is ambiguous. Ambiguity, as Buxton uses the term, refers to what might be thought of as ‘good ambiguity’ which is distinct from ‘bad ambiguity’ or what psychologists called ‘unstable’ images such as the Necker and Kopfermann cubes, Penrose triangle, or any sketch that makes the ease of comprehension difficult especially by overlapping front and back edges or orienting the sketch in such a way that planes flatten out or critical geometry is obscured.

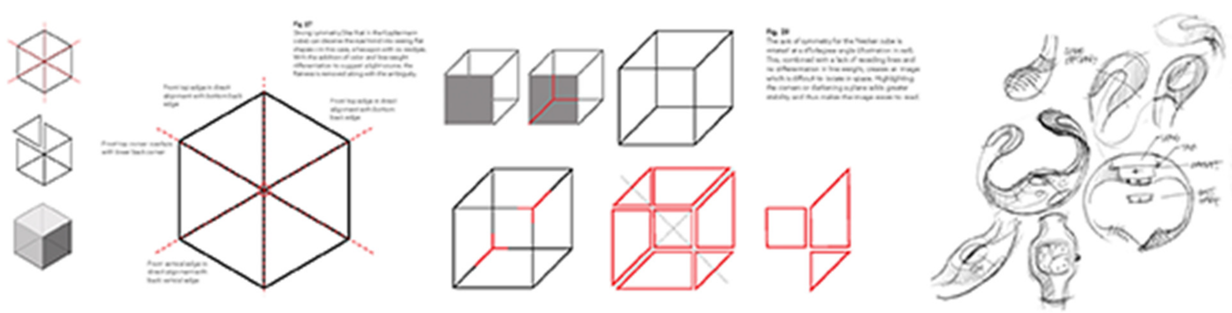

Figure 1. These illustrations from “Drawing for Product Designers” by Kevin Henry consist of the following: two examples of ‘bad ambiguity’ (the Necker and Kopfermann cubes) and one example of good ambiguity (sketches of watch concepts for Nike from Scott Wilson of MNML). Bad ambiguity results from ‘unstable’ illusions where edges overlap, line weights are undifferentiated, and illusions of depth are missing.

Buxton’s admiration for ambiguous sketches gets to the heart of the issue for several reasons. First, ambiguous sketches demonstrate the speed and lack of precision that comes with rapid ideation. Second, ambiguous sketches not only elicit conversation between the designer and the marks on the page or screen but also between the client and other designers and collaborators. Such sketches solicit genuine conversation precisely because of their lack of clarity and often invite interpretations never intended by the designer and yet viable as possible directions. Ambiguous sketches like low-fidelity prototypes built for exploration allow a designer to embody an idea quickly in order to see it, touch it, play with it, interpret it and openly discuss it with others. Without such artifacts, conversation alone or with others is not initiated. Ambiguity flies in the face of mastery as we understand it and yet it is vital to the design process at this early stage. In, *Conceptual Blockbusting*, Jim Adams writes about how most students have emotional blocks that lead to an inability to tolerate ambiguity and instead have an overriding desire for order. In effect, they fail to associate a rough looking prototype and inaccurate sketch with good problem solving. They are distracted by their belief that every step towards the final solution must be finished and refined. They do not understand the power and compelling nature of incremental development.

5. THE CONTEXT OF DESIGN PROCESS

The systematic design process taught in schools is often too prescriptive and too linear. In the broadest sense, it describes a diverging then converging process that can be drawn as an expanding and contracting funnel of ideas. Given this broad interpretation educators often devise a series of discrete steps meant to guide the student along a path to one or more solutions. In reality, the process of ideation requires extensive thinking and a prolific output of sketches and prototypes that help students isolate the issues and frame the problem from a more informed viewpoint. This may include several steps back in time if early concepts prove ineffective. Segregating processes that are defined by media (paper versus cardboard or polystyrene foam as an example) reinforce discrete mastery at the expense of the broader context. It also allows students to fixate on early ideas and focus instead on what Adams calls conceptual stereotypes thus blocking them from real creativity. In New Zealand researchers tracked 10,000 high school students to determine which methods of design development worked best and came to "….reject current models of the design process and postulate instead an increasingly refined iteration of internal (mind's eye) images and their expression in drawings and models (Kimbell et al. 1991, p. 24)." (Mawson 2003). In order for the designer to focus on the user at the center of the process rather than on proficiency of technique, the process has to be kept more open. Physical models like sketches, however, come in many varieties and are generated initially with quick sketches getting progressively more refined as the problem becomes clearer.

Digital technology coupled with analog processes in the correct context can speed up ideation while increasing the quantity of output, which ultimately makes the decision-making process richer. When sketching and modelmaking are taught as separate activities, the student risks missing this crucial connection and the process risks becoming linear and discrete once again. Although many of the associated methods are meant to be user-centered, they can instead become overly formulaic. This runs the risk that a student might focus on the many serial deliverables thus leading to a checklist mentality that lacks cohesion. A contextual design process however shifts the attention away from technologies and tools towards the end-user and context-of-use. The tools and technologies are thus applied to the problem, not the other way around. This does however raise an important challenge; how will students know what tools to use and will they develop competency that can be measured?

6. THE CONTEXT OF EXPERIENCE

Inexperienced designers have a natural tendency to fixate on a safe workable idea or unconsciously develop concepts that they have already seen (stereotypes) because they feel safe in that it will work. A student may increase their comfort with a non-innovative idea by simply switching their focus to the details in a drawing or the building of a model. For many of the same reasons that lead them to accept their first ideas (fear of failure), students often gravitate towards the tools and skills they feel most confident with regardless of overall effectiveness. This means they will avoid the tools they need to work on most to expand their skill set. As they mature through experience, most designers come to see design as the complex activity it is and expand their skill set accordingly. Experienced professionals are more apt to use tools as a means to an end rather than as a demonstration of discrete abilities. Students who only labor to improve their skill of drawing or modelmaking risk loosing sight of the larger design context.

Combine this with the ever-growing array of digital tools being added to the mix and the pressure for a student to focus more intensely (converge) on discrete skills rather than opening up (diverge) by applying a broader array of tools to the larger problem is complete.

7. THE CONTEXT OF TECHNOLOGY

Don Norman begins his new book, *Living with Complexity*, by quoting the philosopher Alfred North Whitehead: “The guiding motto in the life of every natural philosopher should be, seek simplicity and distrust it.” Norman does not believe the ultimate goal of technology is to be simple but rather to be comprehensible. He contrasts the depth, richness, and beauty that can come with complexity against the unnecessary complications that too often result from arbitrary and capricious decisions made about technology. Good design, the author says, successfully manages complexity through understandability and understanding. One of the things standing in the way of general acceptance of complexity is popular culture itself. In the 2012 June issue of Popular Science, the article*, Invent Your Own Anything*, outlines how hacker spaces and digital prototyping allow people from all walks of life to realize more ideas and use social networking and crowdsourcing to access the marketplace. Whereas “what people are doing with these new capabilities is nothing short of world-changing”, the argument must be made that design is a complex activity! Fab spaces and digital prototyping is undoubtedly the rage. They are enormously valuable for non-designers and designers alike, but they should not circumvent the rich appreciation and respect for complexity. It is somewhat remarkable that very little attention is paid to how 3D printers and other digital output tools require input first. At the beginning of this paper we made the argument that the analog skills of sketching and modelmaking need to change in a user centered design process to focus more on what we sketch and model rather than how we sketch and model. The danger in design education is that this is not being addressed; instead, we may simply be changing how we sketch and model to a digital mode, as opposed to a deep, rich and complex hybrid model. The idea of garbage in is equal to garbage out seems to have been lost in the hype.

Malcolm McCullough in his book, *Abstracting Craft: The Practiced Digital Hand,* recounts the sociologist and historian of technology Jacque Ellul’s insight that as the sophistication of technology increases, the tendency has been for humans to focus more on it (the technology) and less on what it can do. He writes, “The more time people spend learning about and tinkering with computers, the less time they spend setting goals or applying existing skills. And at a most general level, the more we learn how to do, the less we know what to do.” This is precisely what design faculty needs to do: to teach ‘through’ the technology rather than teaching ‘with’ the technology. What students often lack, especially at the start of their education, is the ability to fold hard knowledge back in to the broader sweep of their process. Technical manuals, like technical YouTube videos, continue the fragmentation of knowledge. Teaching what software can do is the equivalent of reading the owner’s manual aloud. There is simply no way for a student to retain the information or build the necessary mental model to manage the complexity. Teaching it through very specific integrated workflow suggests that the tool truly empowers the designer (extends their body/mind to use McLuhan’s prosthetic metaphor) to achieve greater and hopefully clearer results.

One way of taming the complexity of software is to focus initially on those aspects of the technology required to make design decisions. The majority of software in common use today allows many different users to do a wide range of things with the software. Rare is the situation where a designer would need to know everything a single piece of software can do. Most professional software used by industrial designers was not explicitly developed for them and they should understand that mastery of such software is less vital than mastering how the software is used in the context of designing.

8. THE CONTEXT OF INTEGRATION

In his recent article , *Teach Less, Integrate More*, Ziba's design director Paul Backet argues that sketching and prototyping are two of the essential skills that students need to learn in order to be professionals. Specifically he identifies the importance of "...teaching students to think while they sketch, or to infuse their sketching with research-driven insight." He also states that in the case of three-dimensional modelmaking "...over-reliance on increasingly accessible digital modeling means we're having students jump to 3D before they understand form and construction."

Students need to develop a sense of materials and production that is needed for an intuitive mindset and hence abductive reasoning. Students therefore need to both sketch ideas and build models to experience form and materials. These methods evolve in refinement and fidelity together as they move from the fuzzy front end of initial research and exploration towards the crisp clarity of refined and detailed products. Digital tools currently have limitations, particularly in the context of early ideation. They are too rigid, lack ambiguity while paradoxically also lacking the precise sensual context that materials afford in prototypes. They can however be folded into the process in a variety of ways that can be shown to students through example and integrated exercises.

9. NEXT STEPS

An expanded education must recognize that analog sketching, analog modelmaking, and computer aided design as well as 3D printing are linked both historically and technically. Complex surface models are created from two and three-dimensional sketches strategically placed in a virtual environment. They are sketched with the aid of the software, much as physical models are the result of three orthographic views adhered to a block of material and shaped by machine and hand. Similarly, any artifact whether flat or dimensional can be easily moved between the real and the virtual spheres. Drawings can be scanned or photographed with a mobile phone or digital camera, likewise, models can be photographed and then rendered digitally over the photo, and renderings can be placed back into the CAD environment to serve as the template for detailed and complex surface modeling. This can drive the process in any order, so that every artifact produced can now feed every other process in an endless iterative cycle. The first challenge is breaking down the boundaries and constraints established by the physical medium itself-paper, screen, material, image, etc. The second challenge is to teach a workflow that focuses on 'what' we sketch and model rather than merely on 'how' we sketch and model. In other words, technical skills support the exploration and validation in an iterative loop.

Figure 2. This tutorial in "Prototyping and Modelmaking" by Bjarki Hallgrimsson shows a simple student project that incorporates hand sketching, Illustrator work, 2D printing and modelmaking by hand. This shows a natural alignment of digital and analog means of working, where these are not disparate, but natural and complementary tools.

New digital design tools are increasingly hybrid. Two and three-dimensional scanners allow students to bring analog work into the computer environment and digital drawing tablets allow students to sketch directly on the computer. The model shown in figure 3 could for example be scanned in to 3D space. It is however important to encourage some experimentation to show that there is more than one way of doing things. This also forces the student to think about why and what they are doing rather than fixating on how. Analog hand made models at a low fidelity can for example be photographed and used as underlays for next iteration models by sketching directly on top of the pictures. They can also be used for highly persuasive design renderings where the model is used as an underlay as opposed to the other way around.

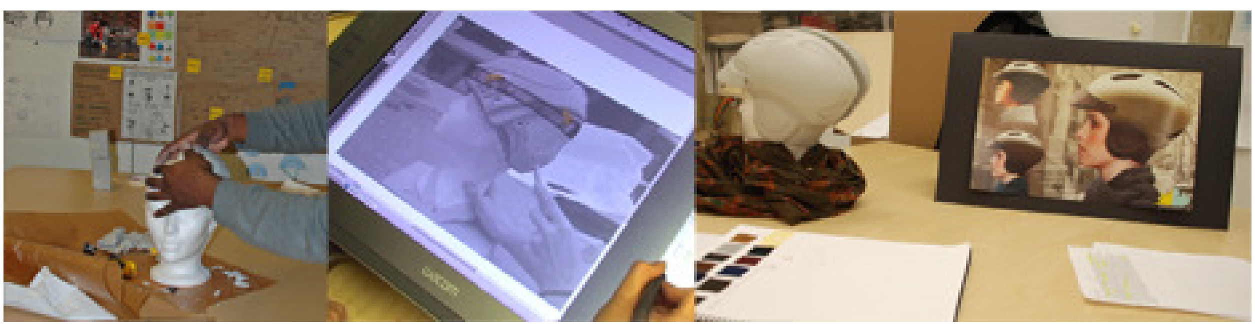

Figure 3. Second year Carleton University students used a more hybrid design approach when developing concept proposals in this helmet project. Early clay models developed in concert with sketches and contextual research allowed the students to explore finer details by importing photos into a Wacom Cintq tablet.These sketches helped to refine the models and set up a cyclical process of refinement going back and forth between physical models and sketching. Finally, the process progressed into highly detailed contextual renderings of the final helmet using Photoshop.

10. CONCLUSION

Design is a complex activity and tougher problems tend to be ill-defined as well. Designers are uniquely adept at dealing with this complexity because of their focus on abductive reasoning. This form of thinking is dependent on emergent ideas that come about because of exploration and testing of hypotheses that address "what if" and more solution-focused questions. These ideas will only prosper in the right context: one thoroughly explored, tested, communicated, and verified through tangible sketches and prototypes.

With the rapid advances in digital prototyping and other forms of digital visualization, we must not shift our emphasis merely towards a myopic focus on these technologies, but rather towards a better synthetic workflow that encourages re-framing and innovative thought less influenced by stereotyping and more motivated by new user-centered solutions. This will require a better integration of digital and analog tools so that the thinking process remains pragmatic and more open-ended with tools being applied as needed rather than simply systematically.

More research is needed to address some important questions. Primarily the difficulty will be in synthesizing traditional techniques into a more fluid hybrid workflow. Part of this involves overcoming the cultural perception of the designer as master artist, part of it will involve the recognition and acceptance of this type of workflow as a required competence of industrial designers. New books that blend these approaches are an important first step; new methods need to be studied as they emerge. Designers themselves need to take the lead through experimental processes and development of dynamic hands-on methods and tools that blur analog and digital fluently.

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