HYBRID IDEATION AND FABRICATION

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1. INTRODUCTION

Visualization and fabrication tools in product design are evolving at a dramatic pace and are producing more intuitive and affordable technologies. These technologies open many opportunities for designers to tinker, explore and develop both artifacts and solutions for the challenges faced in today's society. Debates continue on how the use of digital visualization processes such as computer aided design and digital illustration compromises the exploration of three-dimensional forms and empathic user understanding (Lee and Park, 2003). The tools available today successfully integrate digital and physical methods for the generation of 2D, 3D and even 4D concepts, all in a continuous and effective way. This paper describes a case study titled "Hybrid Ideation and Fabrication", which focuses on a recent yearlong collaboration between a top Industrial Design program, a leading software company and the methodologies employed.

The main objective of this collaboration was to explore the integration of analog and digital tools in new product development, and to maximize the designers' ability to understand, test and refine their ideas. Departing from the traditional model of discreet courses taught in single term, a unique collaboration across the entire graduate level curriculum provided the students the means and the breadth to apply these tools across multiple courses simultaneously, and spanning the full academic year.

By creating a format to explore analog and digital visualization and modeling methods in courses dealing with applied projects, research and skill development the students were able to dramatically reduce their learning curve and successfully integrate methodologies across their curriculum. A key component of this process was the use of state of the art Computer Aided Design (CAD) software that provided an intuitive yet powerful workspace and a seamless connection with 3D printing and other types of rapid prototyping outputs.

2. OVERCOMING THE ANALOG/DIGITAL DIVIDE IN VISUALIZATION METHODS

CAD has become a key tool for designers. Its ability to develop concepts that are easily communicated across the business and that maintain intent throughout product development phases make it a key component for understanding and visualization of tangible solutions (Chandrasegaran, et al., 2013). Despite all the benefits that CAD offers, a major concern is the risk of bypassing physical exploration of design concepts, which in many cases jumps directly from sketches into digital models and prototypes. This process leads to assumptions and oversights that can only be discovered with physical testing and exploration. CAD also challenges users with a steep learning curve, which makes for frustrating sessions and limited results before a person can model the geometries that he or she has in mind. There is a common pattern where novice CAD users have no choice but to let the software to drive many of the decisions and make various compromises along the way, accepting whatever shapes the software generates (Peng, et al., 2012). It is only after a lot of practice and knowledge that a CAD user can obtain the exact design intent to a level of quality that will produce good parts in manufacturing.

3D printing and rapid prototyping have closed this gap significantly while also enabling makers to fabricate designs in creative and feasible ways for small markets or personal needs. This trend is making a profound impact in design education and is only expected to grow. However, designers should not underestimate the issues with 3Dprinting around cost and turnaround time of our current technologies. Most people are surprised at how long it takes to 3D print an object, which for a model such as a coffee mug can take about 12 hours using a

Makerbot Replicator and 18 hours with a 3DSystems Cube (Willit, 2015), some of the most popular printers out in the market.

Another issue with integrating CAD and traditional analog modeling processes is that while it is technically easy to move downstream, meaning from digital models into physical output, it is much harder to more upstream. 3D scanners offer adequate ways of importing physical models into CAD environments, but this takes time and practice. Additionally, most imported models are almost impossible to edit directly in the computer, and designers generally use them only as reference objects, having to create new models around them.

3D printing is revolutionizing the industry and is opening doors for new types of businesses and practices. Along with this evolution, CAD programs are becoming more mainstream and intuitive to use. The idea of spending months learning a CAD program is becoming obsolete. On one hand there is a plethora of software options and many designers prefer to be familiar with multiple packages rather than specialize in only one. On the other hand, the new generation of CAD programs are becoming very intuitive to use and allow for easy creation of models while maintaining critical aspects such as surface continuity, mechanical details, etc. As part of this new generation of products, much of the focus around additive manufacturing is in optimizing workflows for fabrication, which doesn't necessarily follows large-scale manufacturing principles, but rather is intended for personal printing and fabrication of products of virtually any category (Lipson and Kurman, 2013). This shift is opening up opportunities to new types of development and is increasing the need for more fluid ways of connecting the benefits of creating computer models with the validation and refinement that only happens from interacting with models and prototypes in real life and with real people.

3. HYBRID IDEATION AND FABRICATION METHODOLOGY

In order to address the issues mentioned earlier and to maximize the potential of CAD and 3Dprinting in the design process, a model collaboration was established between the Industrial Design program at Rochester Institute of Technology and software company Autodesk. The collaboration aimed at identifying opportunities for blending traditional (analog) and new (digital) tools for form visualization and development, leading to better understanding of product needs and feasibility.

This collaboration included a number of key strategies for educational delivery across multiple courses. It is common for sponsored projects to be framed within a design studio course. The difference with this collaboration was it's implementation across five courses in the graduate level program. The courses included studios, computer modeling, form development and mechanical applications. This combination allowed for students to explore different alternatives for exploring their ideas without feeling the constraints of a singular instructor, topic or tool set.

Taking advantage of the semester-system used in the program, the yearlong collaboration was grouped in two phases: the Fall focused on Ideation and Spring on Fabrication. This organization allowed students to combine different tools that ranged from broader, abstract thinking assignments to projects that were more pragmatic and applied. Nevertheless, overlap of the two approaches occurred often and in fact it was always encouraged.

3.1. IDEATION PHASE

During Fall semester, students explored abstraction, form, CAD and studio courses with a emphasis on sustainable design. A key goal of this semester was to create design "inputs" via analog tools (sketches, mock-ups) and digital tools (digital sketches, digital models) into iterative processes and comprehensive workflows (See Figure 1). Other important areas included definition of design intent, translation between inputs such as sketches, mockups, 2D/3D scans and the outputs, including preliminary and final 3D models (See Figure 2).

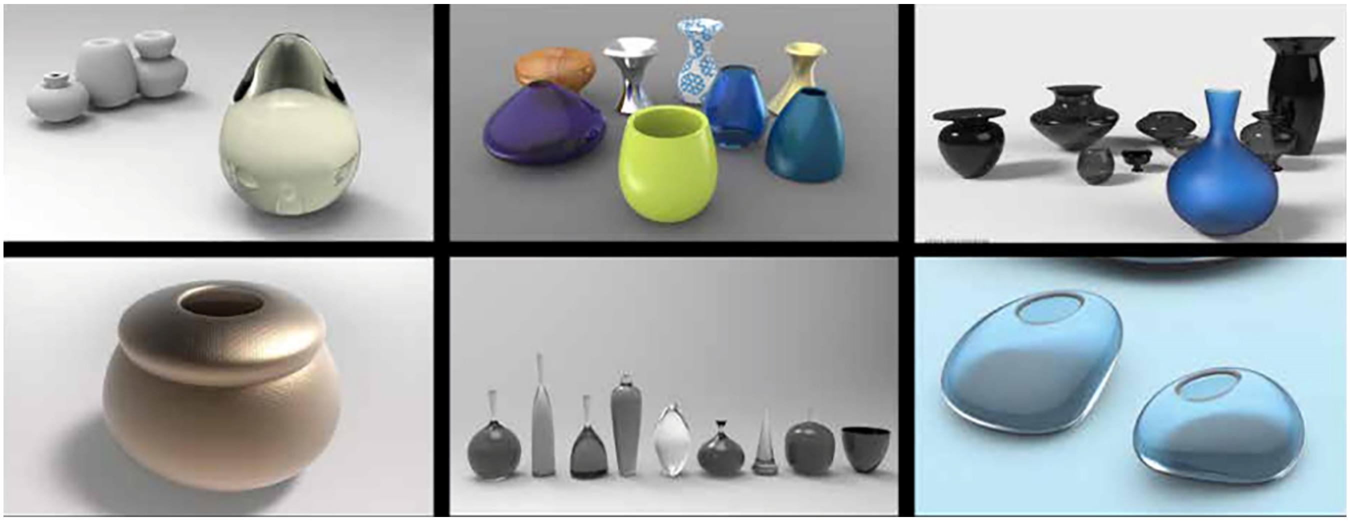

Figure 1: Vessel exploration allows learning CAD software while maintaining a dialogue around form development. Images by: Yolegmma Marquez and Patricio Corvalan.

Figure 2: Examples of 3D prints and molded pieces made out of plaster. Images by: Yolegmma Marquez and Patricio Corvalan.

3.2. FABRICATION PHASE

During Spring semester, students continued developing their processes through iterative sequencing that went from physical to virtual and virtual to physical in both studio and exploratory courses (See Figure 3). As students set their design direction, the fabrication of physical models with both digital and analog techniques became paramount in successfully addressing user needs, manufacturing considerations and the environmental impact of their final designs. Computer Numerically Controlled (CNC) output processes for this phase included Laser cutting, 3D printing, routing and machining along with various analog processes. (See Figure 4).

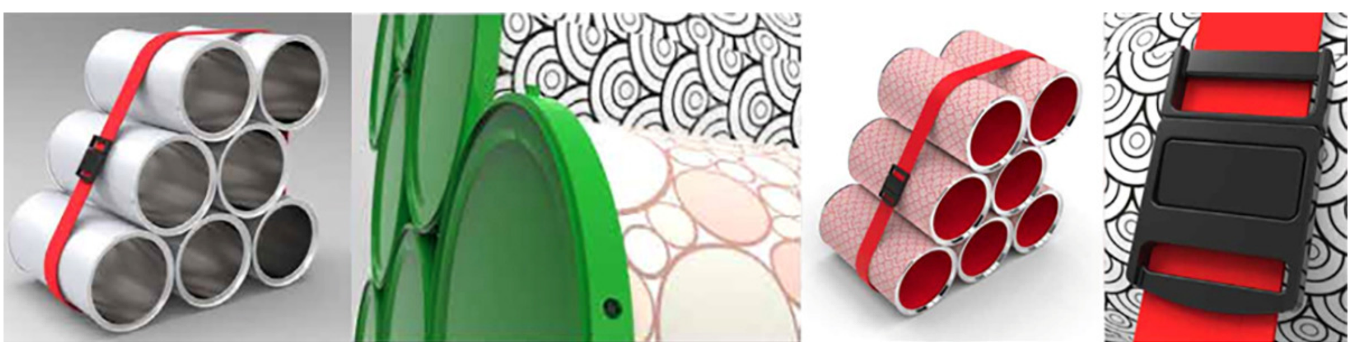

Figure 3: Concept for repurposing of waste packaging containers by Patricio Corvalan. Images by: Patricio Corvalan.

Figure 4: Drinking glass by Timothy Copeland. Development included computer and foam model. Images by: Timothy Copeland.

3.3. NEEDS FOR THIS APPROACH AND ITS BENEFITS

Common structure for design programs focuses on specific courses and topics. This arrangement provides a clear way of making sure that the necessary skills are covered and it also aligns with the certification requirements from educational organizations such as National Association of Schools of Art and Design (NASAD). A limitation in traditional curriculum structures is that skills are mostly learned in silos and it is difficult for students to integrate them effectively. The design community has seen a sharp increase in discussions about the state of design education and its current limitations, which often include the lack of skill integration , limited collaboration, and obsolete methods that don't reflect the processes used in professional practice.

These issues were address in the Hybrid Ideation and Fabrication collaboration which focused on integrating the technical skills offered in all courses of the first year curriculum of RIT's industrial design graduate program. This allowed for a more comprehensive instruction of design tools as well as more opportunities for applying them in different scenarios. A main component of this project was the use of Autodesk's Fusion 360 CAD program, which allowed students to get familiar with CAD in a fast and non-intimidating way. Along with computer modeling techniques, students were also exposed to traditional model making skills as well as to methods for transitioning between physical and digital models via 3D printing and 3D scanning. The use of these methods provided a common and fluid language for everything from product ideation to concept development. Students were able to apply this process in various courses projects ranging from the more technical (Advanced CAD, Form of Function, and Visualization and Communication) to the studio sequence "ID Laboratory."

As students refined their projects they were able to go back and forth between physical and digital models and from rough mockups to detailed models. This fast iterative process allowed them to quack, validate and refine their ideas, as well as knowing that they could combine the best tools for specific components of a product. This process was applied to diverse projects areas such as consumer products (See Figure 5) and low cost solutions for social innovation (See Figure 6). This integrated workflow produced results that allowed students to take full advantage of current and emerging technologies, while developing meaningful design solutions in a seamless, accelerated pattern aligning with the impending need for designs that solve today's most challenging problems.

Figure 5: Shower head by Arm Ratchanon. Development included sketches, foam models, mechanical model and 3D printed parts. Images by: Arm Ratchanon.

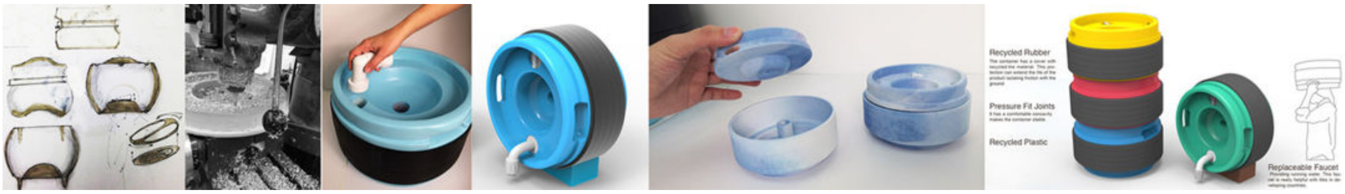

Figure 6: Portable shower for developing countries by Yolegma Marquez and Qunxi Huang. Development included sketches, foam models, mechanical model and 3D printed parts. Images by: Yolegma Marquez.

3.4. CHALLENGES AND AREAS OF IMPROVEMENT

The largest challenge faced during this project was the time needed for printing, scanning and processing models. Depending on the technology used, 3D scanning and processing of models can be time consuming and labor intensive. Printing time limits scalability of methods in larger groups. Students learned quickly that printing models of handheld devices took around 8 hours, while larger product such as footwear took well over 24 hours to complete. Unless there is access to several printers to work simultaneously, the amount of students who can print their work at any given time is significantly limited.

Fortunately, the actual modeling of forms (whether digital or analog) is one of the most effective and fluid components of this process. This allows for students to create their designs (which can be considered the most important part of the process) in an effective, engaging and dynamic way. Once the technological learning curve and implications of time management are understood, students are quickly able to develop a plan that minimizes frustration and unproductive time segments.

4. CONCLUSIONS

The integration of visualization technologies in design process offer a wide array of opportunities that make processes more effective, efficient and engaging. New developments such as 3D printing and intuitive CAD software allow designers to create solutions in a seamlessly fashion without the need of complex manufacturing setups. Everyday users also benefit from these tools and are empowered to tinker and make products without significant struggle or training.

In parallel to the development of maker movements and intuitive CAD tools lies the integration of analog and digital tools in a flow that can go downstream and up. This versatile process is still developing but already offers benefits that can be integrated effectively into design process. Examples of this integration are innovative educational experiences, which allow students to explore possibilities for developing form and function in a streamlined way. Not only do they learn from this diversity of tools and frameworks but they also discover common languages that allow them to navigate through different tools for form development, design definition and final deliverables.

As design education keeps evolving there is great potential for developing opportunities that transcend traditional curricula with separate courses, which I believe severely limits the opportunities for the fluid integration of skill sets. Students often struggle with integrating these skills in college and it is not until they start working professionally that they are able to bring everything together. Processes such as the one described in this paper provide opportunities for students to jumpstart this process, consciously integrating skills in a way that improves their efficiency and elevates the quality of their final result. Integration of tools and knowledge throughout the entire curriculum allow students to make key connections, provides a flexible structure for faculty and collaborators and affords opportunities for topics and projects that result in important contributions to the meaningful practice of design.

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