Using Interdisciplinary and Active Research to Encourage Higher Resolution Research and Prototyping in Design

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ABSTRACT

University art and design programs are branching out and creating interdisciplinary programs and research centers that connect design students and faculty across various disciplines such as business, engineering, architecture, information studies, health sciences and education.

A human-centered, problem-based approach to design research looks to position industry and academic leaders to work alongside students, community leaders, artists and non-profits to develop creative and innovative solutions to the challenges facing contemporary society. But product design benefits even more from practices that engage users throughout the entire design process, often called participatory design. Participatory design process utilizes user feedback throughout the design process to spur innovation and improve design quality.

It is possible in the classroom to engage in participatory design and participatory prototyping through the use of inexpensive 3D printers and laser cutters as well as traditional hand tools, requiring only mastery of a few simple techniques and technology readily available on laptop computers. The class research being presented was conceived as part of a new interdisciplinary classroom research space call the Digital Craft Research Lab (DCRL) housed within the department of Art and Design. Courses taught within the DCRL offer students, researchers and faculty continual access to both low resolution and high-resolution prototyping machinery and materials.

This paper looks at the role of action and participatory research in a design course that created printed hand innovations in collaboration with a nine-year-old female user. Students were asked to work on modeling new designs as well as capturing the progress in a final open source book and models.

This paper asks the question can the use of classroom collaboration, action research and work spaces encourage creativity, innovation, and critical thinking in student and professional designers?

Keywords: 3D printing, Prosthetics, Interdisciplinary Design, Active Research, Prototyping

1. INTRODUCTION

According to The Centers for Disease Control and Prevention's National Center on Birth Defects and Developmental Disabilities and the National Birth Defects Prevention Network, in a study of US live births from 2003 – 2006, there were an estimated 2,155 live births involving a reduction or difference of upper or lower limbs. There were 1,454 upper-limb and 701 lower-limb differences. In addition to children being born with limb differences – fingers, hands, and arms are also vulnerable to disease, accidents and conflict. There are approximately 50,000 new amputations a year in the United States, with the most common form being the partial amputation of a hand or fingers.

Traditional prostheses cost upwards of tens of thousands of dollars, and insurance for children who will outgrow prosthetics, sometimes in a matter of months, rarely provides sufficient coverage. According to the Amputee Coalition, even in instances of adequate insurance coverage for prosthetics, approximately half of all people will ever receive a prosthetic device.

Beginning with the Robohand project and continued through local Makerspaces, an online google group e-NABLE and general word of mouth – innovative craftsman, medical professionals, students, artists, and academics have been pairing up with those affected with upper limb differences and wanting 3D printed prosthetic hands. The process is collaborative and happens at both the local and global level. The end goal is to provide local printed prosthetic solutions that are inherently

sustainable, replacing industrial manufacturing processes with in-place fabrication by end-users with locally-reproducible and recyclable materials.

e-NABLE (http://enablingthefuture.org/)

In less than a year, the e-NABLE group has grown to 1,047 members focused on providing 3-D printed prosthetic hands free of charge to anyone who requests assistance. The collective has created multiple open source hand designs including the Odysseus hand, which is designed for use by toddlers, and the Cyborg Beast, which is the subject of a research study at Creighton University.

They self-describe themselves as originally "a couple of guys who created a 3D printed hand to help one child in need…has grown into a World wide Global Community of tinkerers, engineers, 3D print enthusiasts, occupational therapists, university professors, designers, parents, families, artists, students, teachers and people who just want to make a difference…who are creating hands for people in need and sharing their designs with the World for free." They are an online community that has come together to create, educate, innovate, re-design and give a "Helping hand" to those that need it.

In the last year print, television, Internet media, as well as trend watchers at Intel and Google all have identified the e-NABLE group and similar initiatives as leading-edge examples of scalable, crowd-sourced philanthropy and innovation.

2. THE CLASS

The undergraduate design curriculum is expected to do many things. At the end of their coursework, students are meant to be creatively flexible, experts at the affairs of business, interpersonally gregarious, adept writers and skilled at complex visual communication and leading edge technologies. There are a lot of factors complicating the efficacy of a program built to provide these skills. Important among these factors are that different people learn differently; that design coursework appears in schools and programs with vastly different philosophies of design, including being located in critically different areas (art departments, technical schools, and portfolio schools). For example, design curricula situated in an art department and/or within a school of the arts or of liberal arts may open more time for experimentation along the way to an end result, while more portfolio-based technical programs will eschew certain elements of process in order to produce more pieces of final work and sometimes using more time for elaborate software instruction. Further complicating issues, there is little room for programs to address the changing global scope and reach of design work. As design programs become overloaded with courses focused on providing new technical skills, the ability to develop cross-disciplinary and cross-cultural experiences diminishes.

Increasing Complexity of Design Problems

In his book, Design Methods, J. Christopher Jones writes about the scale of design problems within contemporary society. At the smallest scale, design solves only a small part, a component of a problem. At this level, design research is largely formal and concerned with issues of aesthetics and content hierarchy. At the product level, design looks at an entire artifact or problem. Design research may involve formal and content research. Designers are responsible for the entire making process. Within the component and product levels, design is largely concerned with the production process; in this case, it is responsible for creating a visual system and hierarchy that can be continued through a variety of media but is not as concerned with its life outside of the product. At the system level, design problems become more complex and require thorough research and thought into the context of an artifact or problem. The most expansive of Jones hierarchy levels, the community, requires an in-depth examination of the depth of a design problem. At this level, designers must address issues of sustainability and life cycle as well aesthetics and hierarchy. Jones tells us that contemporary design problems are most often at the community and systems levels, and not at the levels of products and components where our design curricula are most often centered.

Before asking design curricula to solve more complex design problems we need a better framework to conduct our research. The process of participatory action research allows students a broader frame of collaboration within the classroom and the community as well as a process of formal self-evaluation that allows students to better address the issues of a global community within their designs.

Participatory Design Research

Thinking about the people for whom we design as participants in the design process, action research is an iterative process that balances collaborative problem solving with data driven analysis or research (Reason and Bradbury, 2001). Action research has several distinctive features including the following:

- Collaborative enquiry
- Reflective practitioners
- Participatory problem solving
- Self-evaluation

Action research requires that students analyze and develop concepts and theories based on experiences. Concepts and theories are self-evaluated at multiple stages in the development process. Students involved contribute equally to the enquiry, and collaborate as

partners and as those affected by the problem and its solution. Allowing the students to experience a problem as both designer and intended audience gives a heightened sense of responsibility as well as the sense of being expert at some part of the problem solving process.

Perhaps the most important aspect of action research to the classroom process is its use of collaborative enquiry. In order for students to understand the problem outside of a largely formal framework, they need to directly observe, interact and design with other designers, developers and end users. Working in and observing multi and cross-disciplinary teams build accountability and user testing directly into the design process. Students venture into the community in order to better understand the complexity that surrounds a problem.

Participatory action research is a diverse approach to research. In recognition of diversity within this type of research, Reason and Torbert formulated a three-person framework. These three separate, yet integrated pathways are described as first-, second-, and third-person action research. First-person action research fosters self-inquiry and increasing awareness of the researcher's own everyday life as the process unfolds. Second-person action research focuses on interpersonal encounters, and the researcher's ability to collaborate with others in their community of inquiry. Third-person research activities extend the inquiry within a wider community with intent to transform the politics of the issue.

Bradbury and Reason differentiated first-person practice as 'work for oneself', second-person as 'work for partners', and third-person as 'work for people in the wider context' (Bradbury and Reason 2001). It is within the third person that students are pushed to think about design and issues of sustainability, the environment, the community and life cycle.

The work in our course represents research in design and the act of making, and seeks to answer specific questions about acts of production in design and fabrication, to determine the students' role in conceptualizing design as it applies to the creation of prosthetic hands. A central postulate of this research is that the "making" of prototypes and functional devices and getting feedback from the user, clarifies intentions and invigorates the design process for contemporary designers pursuing innovation in their craft. Emphasis was placed on the ability of rapid advances in fabrication technologies to explore the hybridization/combination of materials and processes.

We provided our students hands-on access to materials, laser cutters, and 3D printers and engaged them in a design process that is not linear but instead involves iteration and feedback loops.

Through experimentation with materials and process students were better able to understand the impact of minute design decisions upon their final prototype. Students were participants in the entire design process and personally engaged with the end user, in this case a nine year old girl, and other designers working on similar problems from other fields and from around the world, getting critical feedback via Google Hangouts, Google + web communities and our user and her immediate family. Students were asked to develop and define the design problems surrounding prosthetic device needs, use, design and production, and to identify criteria and constraints that they needed to address as part of their final project.

Our Classroom, The Digital Craft Research Lab

The Digital Craft Research Lab's goal is to foster innovative, creative research in the areas of design, craft, and art by combining advanced digital technology with traditional craft practice in an effort to educate students for the future. The DCRL fosters interdisciplinary design research, material research, and innovation through making. It is envisioned as a facilitator for partnerships between University of Wisconsin-Milwaukee researchers and regional businesses, nonprofits, arts organizations, other universities and schools.

DCRL methodology is rooted in, and dependent on, interdisciplinary collaboration. Students from vocations across the University come together to create and solve new problems in the realms of art, design, manufacturing and engineering. Each student is expected to bring to the table their own unique strengths, knowledge, and experience, with which to engage in critical creative dialogue. In addition to functioning as a valuable resource for the university, the DCRL provides for advanced students an educational atmosphere where technical proficiency, professionalism, innovation, critical inquiry and collaboration are championed. While the lab is open to all disciplines, researchers working within the DCRL research team heavily utilize its primary role as an art and design facility. The students and faculty who staff the lab are formerly trained in non-linear or lateral problem-solving processes, often employing a "gallery critique" method of collaborative problem solving.

UWM's Digital Craft Research Lab provides undergraduate, graduate students and researchers with access to the latest technology in computer-assisted design (CAD) and computer assisted manufacturing (CAM) technology called rapid prototyping. The Digital Craft Research Lab places these tools directly in students hands and places UWM along side of leading Art & Design programs in the country already incorporating this technology into their curriculum.

DCRL Physical Space

The Digital Craft Research Lab is made up of two separate spaces. A 2,500 square foot room contains 19 PC workstations, vinyl cutter, digitizing arm, a Next Engine 3D scanner, a 3D Systems Sense handheld 3D Scanner, four Rep Rap based 3D printers, 3 Makerbot 3D printers, a From Labs Form 1 printer, and a ZCorp 402C 3D printer. The second room is 625 square feet and it houses several numeric controlled machines such an 4'x8' CNC router, a 2' x 3' CNC router, an Epilog laser cutter, a metal cutting bandsaw, three metal grinders, two drill presses, a manual lathe, two vacuum formers, a Tormach PCNC 110 milling machine (capable of machining aluminum, steel, and titanium), along with basic fabrication equipment.

3. CONCLUSION

Our world is currently experiencing a three-dimensional digital revolution that has been spawned by the information age. This 3D revolution is bringing about changes to our world by spawning start-ups, innovative products, and jobs in new markets that did not exist even a few years ago. It is connecting students, researchers, professionals and hobbyists from different disciplines, locations and backgrounds in ways that we could have never imagined. It is an exciting time to be designers, makers and craftspeople.

We believe it is time to look at new ways of sharing our abilities and to engage with a larger community of makers in order to broaden the scope of the field of design. It is time to be open to new opportunities to advance education, scholarship, and entrepreneurship within an university setting.

As noted in Mathew Crawford's book, *Shop Class As Soulcraft,* people in today's society realize it's no longer as fulfilling to move information around from one place to another and that their connection to the material world has been lost. The students in our universities realize that to learn theory without in-depth experiential knowledge is useless to them in the current job market. The popularity of classes at MIT such as Neil Gershenfeld's course, "How to Make (almost) Anything" and "How to make Something That Makes (almost) Anything"—in addition to the many Makerspaces that are popping up all over the world—are proof that people are interested in learning how to "make" and are interested in hands-on creative experiences.

In recent years, the University of Wisconsin-Milwaukee has seen a revival of students interested in creating and crafting objects from outside the arts. In the last six years, students from Engineering, Architecture, Information Sciences, and Health Sciences have had access to upper level courses in Art and Design that teach them how to "make," or more specifically courses that teach material, process, the histories associated with both and how material and process can be applied to current practices in their respective fields of study. In many cases, Art and Design courses have been integrated into curricula in other colleges. Additionally, Art and Design faculty have begun to teach courses to students in the Colleges of Heath Sciences, Architecture and Engineering and Applied Sciences. It is through these new interdisciplinary opportunities that students are being introduced to both new and old technology and working collaboratively with students and faculty in design, digital studio practice, physical computing, art, health sciences, engineering and architecture.

As technology develops and the lines between disciplines continue to blur we will see the need for specialists who understand how to solve difficult problems through the creation of three-dimensional objects. This requires us to continue learning new skills and to develop and share how to integrate them into our current practice.

We hope to offer a path to prostheses for families otherwise without access or funds, and to positively influence our students social engagement and community impact. Since the start of our project to create a hand for one student six months ago, faculty and students have created hands for eight children globally as well as created freely shared research and models for others to download. A single course has inspired a new model of educational collaboration between the sciences, technology, design, manufacturing, and community service that is being integrated into additional courses as well as a new BA program in digital fabrication and design.

Through social technologies, we are able to reach out to people and markets that we might not have had access to before. We are at a pivotal period in design and the timing is right to contribute to a broader segment of society if we can find a way to accept, integrate, innovate, and collaborate within the university setting.

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