Designing an Immersive Design Challenge: Digitally Fabricated, Solar Charging Station for Public Spaces

Rickey Crum¹, Katie Krummeck², and Sunjoli Aggarwal³
¹Rickey Crum; Lyle School of Engineering, Southern Methodist University; e-mail: rcrum@smu.edu
²Katie Krummeck; Lyle School of Engineering, Southern Methodist University; e-mail: kkrummeck@smu.edu
³Sunjoli Aggarwal; Lyle School of Engineering, Southern Methodist University; e-mail: sunjolia@mail.smu.edu

INTRODUCTION
At the Deason Innovation Gym, a makerspace in the Lyle School of Engineering at Southern Methodist University, we engage students in developing their maker abilities and mind-sets through real-world projects. In order to engage, motivate and sustain the interest of many types of students with varying levels and sources of motivation, we have developed multiple types of maker-based learning experiences. These experiences are designed to support students learning through making. One of these types of experiences is called an Immersive Design Challenge, or IDC. We will explain the design of the IDC experience and present an example in this paper.

CONCEPTUAL FRAMEWORKS
When designing IDCs, we ground our design decisions in several theories of learning: constructivism, constructionism, and sociocultural theory. Constructivism, developed by Jean Piaget, posits that learners construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences [1]. This theory is central to the IDC framework because IDCs are highly student-centered and driven by the students’ ideas and outputs. Constructionism, an offshoot of constructivism developed by Seymour Papert and Idit Harel, states that students learn best through building artifacts that are tangible and shareable [2]. This theory is represented in the DIG in general and in the IDC framework in particular because all the learning experiences facilitated in the DIG are oriented around making tangible objects. Sociocultural theory, developed by Lev Vygotsky, asserts that an individual’s cognitive development progresses as he or she interacts with more skilled individuals [3]. In particular, the concepts of zone of proximal development and scaffolding (key components of Vygotsky’s sociocultural theory) play an important role in IDCs. For example, we design experiences that push our students to achieve beyond their current abilities. In addition, to support all student’s learning, the DIG staff purposefully selects a mix of experienced and inexperienced students to participate in each IDC, so that the more experienced students can teach their peers how to use the tools and software in the space. By doing this, we also set the foundation for building a community of practice [4]. In communities of practice, participants learn from interacting with more knowledgeable peers who, over time, invite novices to become full participants.

IMMERSIVE DESIGN CHALLENGE FRAMEWORK
IDC’s are 5–7 day, sprint-based challenges in which students work with corporate and/or social impact partners within the community to solve a real world problem. Each challenge typically hosts 15-20 students who are selected for the project team through an application process, and who participate voluntarily without receiving any course credit or compensation. The focus of the challenges can vary from human-centered design sprints to more technically focused, client driven projects. Although the Deason Innovation Gym is housed within the engineering school at SMU, the student teams assembled for IDC’s are interdisciplinary and represent a spectrum of students from across the university.

During the initial planning phase of an IDC, it is important to collaborate with the project partners in developing a challenge around a problem without a predefined form factor. For example, a project brief that suggests taking an existing charging station and adding a solar charging capability does not allow for much design consideration of the end user. Likewise, it is also important that the problem not be so general that students won’t be able to synthesis a single optimum solution. For example, design a product that allows anyone to charge a device at any time. After a suitably scoped challenge is determined, our general process for executing learning experiences includes:

A. LAUNCH THE CHALLENGE
Frame the scope of the problem, lay out the timeline for the project, answer questions about the constraints and engage with the client, if necessary. We usually launch the challenge through a document we call a Design Brief.

B. GET INSPIRED
Whether through personal experiences, seeking inspiration from other designs or getting new perspectives through human-centered design research, we also work to provide the students with inspiration to drive their design process.

C. RESEARCH SYNTHESIS AND PROBLEM REFRAMING
What is this challenge really about? What are our aspirations for our end product? What is possible given the constraints?

D. DESIGN SYNTHESIS AND IDEATION
Based on our aspirations and a well-defined problem statement, we generate lots of ideas. This is the time for divergent, generative thinking. We leave the evaluation of ideas until later.
E. SELECTION AND TEAMING
Once students have been free to dream big and think creatively, we ask them to select for the elements of the design that are non-negotiable as well as stretch goals. Based on those elements, we help students break into sub-teams with clear deliverables.

F. GET TO WORK!
Students work in their sub-teams to delegate work, troubleshoot and check progress.

G. BENCHMARKS AND CHECK-INS
Whether we come back together as a project team to have “stand-up” check-in meeting or whether we are meeting with the client to solicit feedback, we try to make clear benchmarks for sub-teams to meet to ensure progress across the board. Feedback in-process is key.

H. TESTING
Once we have built something (usually the first iteration is a low investment, low resolution prototype), we test it. Whether we are testing the fidelity of the engineering or the desirability of the idea, we head out into the real world to learn about our solutions before we get too invested.

I. BRINGING IT ALL TOGETHER
Once we have tested ideas and are ready to move toward the final deliverable, we bring the team together to make sure everyone is on the same page and we are ready to integrate the sub-team’s work.

J. FINAL SHOWCASE
Whether for a client or for ourselves, we always have a final benchmark that requires everyone to push to finish. This typically involves a student presentation that encourages them to reflect on the process to better articulate the final output.

IMMERSIVE DESIGN CHALLENGE PROJECT: SOLAR CHARGING STATION FOR PUBLIC SPACES
In January 2017, 20 Southern Methodist University students from multiple disciplines collaborated with Better Block Foundation, an urban planning nonprofit, and Good Faith Energy, a local solar energy installer, for a seven day IDC to address the issue of how to design a digitally-fabricated, flat-packed solar-powered charging station that also enhances urban spaces. At the end of the seven days, the students produced technical schematics, a working prototype, a proposed budget for full scale fabrication, a marketing strategy, and plans for implementation.

The IDC design process began through mentorship from the nonprofit and corporate project partners. The team was directed on how to think about designing for urban spaces, and was challenged to consider the technical constraints of solar power when designing the charging station. They engaged in field research as an effort to incorporate human-centered design principles into their work, and observed and interacted with potential users of the charging station at various locations around the city.

Human-Centered Design, or HCD [5], is a popular approach to design that companies and institutions have used to create consumer products, healthcare systems, retail spaces, fundraising events, curricula, and much more. The core principle of HCD involves developing a first-hand understanding of the human needs and behaviors related to the system for which you are designing. Once a designer understands the system, he or she follows by making decisions based on inspiration from the humans operating within the system. In addition, HCD relies heavily on a willingness to learn your way to the right solution and a bias toward taking action rather than planning for action. In this case, by brainstorming opportunities and constraints as they related to the human, form, and solar factors of the project, the students crafted open ended questions that led to insights to help script the narrative of their design.
After synthesizing the design research, they began a prototyping process that required skill building in hand-sketching, and both digital and physical modeling. The students would share their ideas in the medium that each felt most comfortable, and would vet each design using the values that they arrived at through the design synthesis phase. As the design gained greater depth, they would incorporate new tools to create the prototypes as a way to effectively convey and test their ideas. Through the use of laser cutters, 3d printers, vinyl cutters, a CNC router, and numerous hand tools, the team was able to create a fully functioning, full scale prototype of the final design iteration.

The end product, the ModPod, is a beautiful, flexible and functional solar-powered charging station, but it is much more than that. The modularity of the final design makes it adaptable to many use cases, and more importantly, adaptable to the space which it inhabits. The body of the design is a piece of public furniture (a Pod) that can be oriented or combined with other modules in many different ways. The team also designed individual ‘Mods’, such as standing desks, logos, planter boxes, hooks, and even a locking bike rack that can be added to the main ‘Pod’. In fact, the solar panel and outlet boxes are also designed as mods that can be attached to a location of the user’s discretion with recommended configurations showcased in the user manual. The iterative design and prototyping process ultimately led to a working design that is publicly available through an open-source online platform for anyone to create for their community at their local makerspace.

By engaging with a client on a real problem with potential impact, students were motivated to work hard, build skills and push to create something meaningful for others. Students struggle with ambiguity of solving this problem but the motivation of working in an interdisciplinary team, the inspiration of human-centered design research and the help of professional mentors, push them to consistently achieve beyond what anyone imagines. Students with experience have the opportunity to teach and coach students with less experience to help them build the skills they need to make a contribution to the project. Because of the diversity of the students involved, each student can apply the skillsets, tools, and techniques that they learned in the IDC in different ways. This project has provided many takeaways not only regarding skillsets in digital CAD modeling and tool use, but also regarding self and societal awareness. Due to the intensive nature of the project timeline, the students experienced first-hand how the insights from Human-Centered Design, and maker education can be directly translated into a final product with practical application.

ASSESSING WHAT STUDENTS LEARN

The DIG is an informal learning space and students are not evaluated or given credit for participating in programming hosted there. Because the DIG is not required to complete formal assessments, we rely on two approaches to assessing the success of a project and the learning outcomes of students. Our first approach to informal assessment is focused on the output of the project. While IDCs are open-ended and do not have a “right answer,” we ground the project in a real-world client as well as user experiences. This allows for maximum creativity and innovation while also creating enough constraint to help students progress in such a short amount of time. Feedback from the client often involves critique of craftsmanship, design and technical aspects of the project.

Our second approach relies heavily on students reflecting on their own learning and articulate both the hard and soft skills they gained from participating in the project. We send out a survey at the end of the experience that asks students to give us feedback as well as reflect on their own learning. Here are some examples of anonymous responses we have received:

- “teaming with people who are very different than oneself is extremely interesting, fascinating how much you can learn from everybody”
- “At first, I didn't know that there was so many parts that needed to be taken into consideration. Now when I look at a desk or something as simple as an instruction manual we all take for granted, I really appreciate it because I can see all the work put into it.”
- “I felt empowered and capable of effectively being part of any team or creating a great proof of concept.”
- “Helped me learn how to break down projects into bite-size and manageable pieces.”

These quotations demonstrate the kind of impact we are having on our students’ learning. Students express growth in team work, collaboration, project management, problem-solving, resilience and many more skills and mindsets.
CONCLUSION
We believe that Immersive Design Challenges that leverage Human-Centered Design methods offer unique learning opportunities for users of our makerspace. We use this model of sprint-based projects to engage students with a variety of skills and motivations to develop both hard design skills as well as affective skills like resilience, collaboration, curiosity and creative confidence. By partnering with an external client on a real project, students not only develop proficiency in skills but we also give them a purpose for how and why to use those skills they are learning. We believe this combination of developing proficiency and giving purpose, motivates students to learn and achieve in ways that are unique to an informal learning space such as the DIG.

REFERENCES