DESIGN FOR FLUIDITY
HOW DIFFERENT PROJECT TIMELINES DEVELOP STUDENTS' PROFICIENCY IN THE DESIGN PROCESS

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1. INTRODUCTION

The Integrated Product Design Programs (IPD) at the University of Pennsylvania teach students from design, engineering, and business backgrounds a human-centered design process to create new products and experiences. The diverse backgrounds of students in the program enable students to learn from each other and creates an environment where teams can draw on deep knowledge from a range of fields to ensure that the products that they create are desirable, feasible and viable (Brown 2009). Teaching students from diverse backgrounds requires program directors and faculty to provide the students with a common language to work with – in this case that language is the human-centered design process. Over the course of two years, students go through the design process multiple times. Over several years of developing in-class and extra-curricular learning experiences, the faculty has found benefit in assigning projects in which students deploy the design process over a range of timelines – from 24-hour sprints to 9 month projects (a full school year). This article describes the different project timelines, and articulates what students learn from each. It also highlights the special support students need to succeed in each timeframe. By engaging in a range of projects with different timelines, students develop fluidity with the design process and start to define their own process and practices.

2. DESIGN PROCESS

Any search for a description of the product design process will turn up several versions of a similar diagram – one that begins with understanding stakeholder needs, includes a wide-ranging ideation phase, and articulates the need to prototype and test before implementation. Over time the IPD program has moved to using the UK Design Council's Double Diamond diagram of the design process. That diagram articulates four project phases: Discover, in which the designer generates insight into the problem, Design, in which a focus area is articulated, Develop, in which potential solutions are generated and Deliver, in which the optimal solutions are selected, iterated and implemented (UK Design Council 2018). This diagram is used for two reasons. It clearly describes activities that are most critical to human-centered design, including reframing the problem statement. It is one of the few diagrams to visually articulate the shift between divergent thinking and convergent thinking that is critical to successful design. The diagram does not capture the extent to which the phases are not steps in a linear process but rather describe the primary type of activities in which students will conduct at a given time. Designers are often well served by generating ideas early in the process or they might choose to (or need to) go back and do additional discovery and problem definition even as they are developing and delivering their solutions.

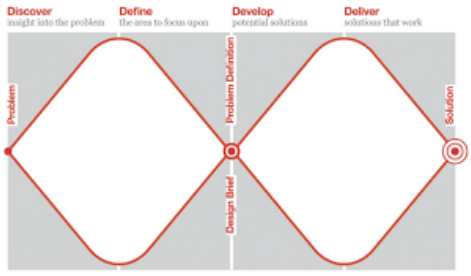

Figure 1. The UK Design Council's Double Diamond Design Process

Students who graduate from the program are expected to have deep knowledge of the design process, and some choose to develop particular expertise in either of the diamonds – either taking on roles at the front end of the process in user experience, design strategy or design research or taking a stronger lead in the back half of the process as product designers or design engineers. To develop this expertise, they take a core curriculum consisting of four studio courses structured around the design process.

3. TYPOLOGY OF DESIGN PROJECTS

While students may easily understand the design process as a concept, proficiency in executing the process requires several attempts at practicing the process. Program faculty have found that increasing timeline diversity promotes student learning as it enables faculty to provide a range of experiences. The factors that change include the following.

- Project Brief: Short projects require a faculty to define the brief while longer timelines enable students to define their own briefs.
- Project Schedule: Short projects require highly structured schedules imposed by the faculty. Longer projects enable students to manage their own timelines and set interim milestones.
- Definition of Complete: Short projects either require tradeoffs in terms of how 'finished' each part of the project becomes or lend themselves to rough prototypes. Longer projects allow the students to hone the craft of multiple facets of a project.
- Iteration: Longer projects allow for more iteration and, if necessary, more discovery and redefinition.
- Type of learning: Shorter projects can teach a single new skill or refine existing ones while longer projects enable students to experiment with new skills and develop their own practices and processes.

There are four primary types of projects that students engage in, described by time (see Fig. 1). Each teaches different things. By developing skills through a good mix of project types, students develop fluidity in the design process. Given that short design projects are already called sprints, let's continue the metaphor calling the four project types Quick Sprints, 5Ks, Marathons and Triathlons.

	Quick Sprint	**5K**	**Marathon**	**Triathlon**
Time is measured in	Hours or Days	Weeks	Months	Year
Key Benefits to Students	Teaches students how to make decisions and move forward Highlights linkages between parts of the process	Allows exposure to and learning in each part of the process Can provide a deep dive into one half of the diamond	Gives students ample time to learn each part of the process Offers enough time that students can iterate and move back and forth between phases	In depth exploration of each part of the process Provides time to experiment Provides time for reflection and course correction
Outcomes		Observations of stakeholder needs	New frame for the problem	Refined product design

	A kernel of an idea or reframe that can be further developed later	Potential to reframe the problem Initial design ideas	Refined designs	Looks like/works like prototype Fleshed out information about desirability, feasibility and viability
Skills Development	Leverages existing skills Teaches decision making Teaches the value of each part of the process	Exposure to new skills and refinement of existing skills Enables students to better understand linkages between project phases	Develop new skills in design Begin to learn project planning, project management, teamwork	Learn new skills and develop deep expertise in multiple aspects of the process Experiment with a range of skills Define one's own learning experience and develop new practices
Challenges	To generate meaningful outcomes in a short timeframe Overcoming design fixation	To go beyond the obvious in problem definition and idea development	To keep forward momentum and not spend too much time in discovery Manage team dynamics	To make decisions and take ownership of the project and process To maintain energy and excitement throughout the project To manage team dynamics
Requirements	Well defined brief Well-structured time Access to all required resources is provided	Low project complexity/ easily accessible stakeholders Timeline to keep projects on track Well-defined deliverables	Rich project topic with many potential directions Openness to a range of outcomes and deliverables	Undefined brief Interim deliverables Flexible expectations of progress

Figure 2. This chart outlines the benefits and challenges of different project timelines.

3.1 QUICK SPRINTS: 24 HRS – A FEW DAYS

Design sprints are best used to introduce the process, highlight the linkages between parts of the design process and give students experience with intuitive decision making. These fast 24-hour to multi-day exercises are gaining in popularity with the rise of Hackathons and their promotion by companies like Google. Google Ventures recently published a book called Sprint which outlines a five-day process to answer business questions and generate solutions rapidly. While the Sprint methodology works well with internal teams, Quick Sprints with students have slightly different requirements. Finding an outside partner to pose a design challenge helps motivate student teams and creates an achievable goal: success is students' ability to bring new perspective to their clients through either reframing the problem or generating new ideas. Defining success in this way provides a sense of accomplishment in a short time and shows students how a design perspective can open new ways of thinking for those that are embedded in the problems explored in sprints.

Penn's IPD program has been working with directors of similar programs from other schools as part of the Integrated Design Innovation Consortium (IDI). Members include Northwestern University, Carnegie Mellon University, Massachusetts Institute of Technology and Stanford University. One of the key activities of the consortium is to gather students from our schools together in a collaborative 24-hour design sprint. These sprints, developed by the University of Pennsylvania's Sarah Rottenberg and Northwestern University's Amy O'Keefe, have promoted community building across schools and are great learning experiences for students (O'Keefe, Rottenberg and Giese 2014). Over the years, IDI has partnered with pediatric hospitalists, allergy specialists, and hospital cafeteria operators. These were

good partners because they could help students access the resources they need to successfully build empathy. They also gave feedback on in-progress work to help students quickly through the process.

Defining topic areas that are concrete, specific and time-bound enables students to get up to speed quickly and constrains the field of potential solutions in a way that helps students make progress in a Quick Sprint. For example, instead of focusing broadly on designing for people with disabilities' transportation needs, the 2017 24 Hr Challenge focused on the first mile and the last mile – how disabled people can access transportation and navigate from public transportation to their final destination. Tight problem definition, coupled with strong facilitation that guides student activity, helped students navigate the design process quickly.

Participating in Quick Sprints offers students who are already familiar with the design process an opportunity to lead novice teams, facilitate the process, try on different roles in teams and experiment with new methods. They experience how much they already know and become more articulate about design.

One challenge in a quick sprint is that students may fall into design fixation (Crily and Cardoso 2017). Design fixation describes the phenomena where designers become attached to a set of initial ideas in a way that limits their creative ability to generate a wide range of different ideas. In a quick sprint, students easily become fixated on one way to address the problem they have identified and dive quickly into creating prototypes of that idea that are surprisingly elaborate. Given the tight timeline, it is often difficult for a coach or advisor to convince students to broaden their set of ideas. A remedy to fixation can come when students present their idea to potential stakeholders. In each of the IDI 24-hour design challenges, the organizers built in a time for outside stakeholders to engage with prototypes of the ideas. Engaging with actual stakeholders helped students realize when they were fixated on a solution that did not meet stakeholder needs. In-person feedback from stakeholders was highly successful at encouraging students to take a step back and rethink their key ideas. This moment highlighted for student teams the linkages between different parts of the design process – their ideas were only as good as their problem definition – and demonstrated the value of rapid idea iteration through feedback on prototypes.

Figure 3. A student team testing an experience prototype with a potential user. In this case, students found that their ideas were too complicated and needed to be simplified.

3.2 THE MILE: 2-4 WEEK PROJECT

Quickly progressing through an entire design process in a matter of weeks is typically used to introduce concepts and activities to students who are newer to design. It can also be used as a recap, to remind students of the value of each stage of the process and allow them to test out their skills.

In an article on 'Designettes' in an engineering design capstone course, the authors refer to brief introductory projects as "learning scaffolding" (Cooper 2015). This is an apt metaphor for projects that take a matter of weeks at the beginning of a year or a semester of study. The shorter timeline necessitates professors to provide much of the structure for the project – dictating activities and deliverables on a week by week basis. It also requires that the selected topics be easily accessible for

graduate students – focusing on activities that they already understand with stakeholders who are easily accessible. In IPD's Problem Framing course, a course focused on teaching students design research and design strategy, these initial projects are focused on routine activities that contain observable processes and have emotional resonance. Students in this class have designed for sleep, pet ownership, eating dinner, and home organization. These projects expose students to the activities and skills required in each phase. They are long enough for students to move through each phase of the design process, with a small amount of time for iteration and a tight enough timeline that students must maintain forward momentum. There is time for both generative and evaluative design research and for refining concepts. When used as introductions, 5Ks are great at exposing students to methods, helping them see the value of each part of the process, and providing them with guidance on how to move forward. They build confidence for students as they move into more complex projects.

Projects lasting a matter of weeks can also be used to reinforce learning. When students come back to school after a summer off, assigning a project that takes weeks is a way to remind students of what they know and give them a chance to flex their muscles. When students have stronger skills, 5Ks are long enough to get to a satisfying outcome but short enough that students must use their time wisely.

In 'The Nature of Design Thinking,' Kees Dorst describes two critical aspects of designer's process: abductive thinking that allows designers to make intuitive leaps and imagine new ways of delivering value and framing and reframing a problem in a manner that opens new types of solutions (Dorst 2010). When novice students conduct 5K projects they are trying to learn and manage many more concrete skills. It can be challenging for them to reframe the problem and bring abductive thinking into the mix. More experienced students who have already practiced abductive thinking and experienced the value of the reframe may have an easier time achieving it in a short timeframe.

Figure 4. Even in a short time, IPD students Danielle Lashley, Grace Moore, and Eric Tepper could use multiple research methods to understand how people experience lunch at work.

3.3 MARATHON

Projects that are measured in months are the at the core of many design studios. Whether the timeline ranges over a semester or a quarter, a project that takes 2-4 months allows students to dig into the design process and explore each phase in detail. In the Discovery stage, projects of this timeline allow use of multiple design research methods and enable students to truly engage in participatory design, working with different end users, experts and people with experience implementing solutions in the space. There is time for rich analysis of the research data, to develop frameworks that help students understand the problem and communicate the reframe visually. There is time for multiple rounds of ideation, and for project teams to generate ideas individually and as a group. Testing, iterating and refining prototypes can lead to better solutions that are ultimately refined to a much higher level of finish than in shorter projects.

Marathon project can also tackle more complex topics with stakeholders who may take time to engage. In the second semester studio projects in IPD, program faculty partners with Penn Medicine to source real-

world projects that expose students to the role that design can play in the healthcare context. This requires students to engage with complex problems and consider the needs of multiple stakeholders in their design interventions. It also highlights the potential impact that they can have as designers and helps them see how their training can offer a valuable perspective to other disciplines.

Topics addressed in IPD Studio Marathon Projects
Improve organ donation rates amongst minority populations
Engaging 20-30 somethings in end-of-life planning
Improving patient experience in waiting rooms
Improving communication between infertility patients and specialists
Improving education for people having hip or knee replacement surgery
Managing falls in the hospital
Redesign the experience of getting medication to patients from the hospital pharmacy
Improve communication about medicine to improve post-discharge medication adherence

Fig. 5 Students collaborate with the Penn Center for Healthcare Innovation to work on complex problems that can truly impact the healthcare experience.

As in training for a running a marathon, the ability to pace oneself is as important as the ability to run. Because the schedule is more generous, the faculty can set milestones but teams need to manage their own timelines. A common pitfall is getting stuck in one phase of the project and failing to move into the next phase. Teams may struggle with knowing when the problem is properly framed, or keep generating new ideas instead of prioritizing, testing and refining existing ones. Alternatively, students may race through the problem definition phase of a project and find themselves without interesting springboards for ideation. They must then go back and conduct additional discovery or problem definition work. Faculty can help prompt movement, but the teams need to take the initiative to truly move the projects forward. This enables students to develop some of the skills that they'll need to succeed outside of academia: project management, scheduling, team communication and leadership.

3.4 TRIATHALON

Many programs end with capstone projects, where students have up to a year to complete a final project. In the IPD program, students work in teams over the course of two semesters to deliver a project that is fully fleshed out from design, engineering and business perspectives. Teams start with the domain they want to explore – some recent examples include designing for hurricane survivors, elderly gardeners, women who think they may be pregnant, breastfeeding working moms, kids who want to play without screens (and their parents), and people caring for critically ill family members. They then employ the double diamond process to discover stakeholder needs, define the problem, develop a wide range of possible solutions and deliver an innovative solution. At the end, they have a works like/looks like prototype with complete industrial design, engineering models, business models and often, a compelling brand identity. Students must truly explore the interaction between the disciplines – redesigning their products so that a revenue model becomes viable, defining their target market based on needs they identify and the features and benefits of the products they are designing, specifying components that address the type of use required and the design criteria.

The triathlon is an apt metaphor for Integrated Product Design students because they work through projects from three perspectives – design, engineering and business. But even for students who are focused solely on the design aspect of their project, truly mastering each phase of the design process requires transitioning between different types of activities in conditions when performance in one phase impacts their ability to succeed in the next. Having dabbled in project planning and timeline management on Marathon projects, students working on Triathlons become even more adept at scheduling activities, knowing how much time things will take and creating buffers for creativity, inspiration and roadblocks.

In this generous timeframe, team members can explore new approaches to project leadership. In "Innovation as a Learning Process" Sara Beckman and Michael Barry argue that people with different

types of learning orientations and skills can be successful leaders of different stages of the design process (Beckman and Barry 2007). Often, in professional contexts, it can be challenging for teams to implement rotational project leadership because roles are more fixed. In a year-long student project, team members can experiment with different approaches to teamwork, shifting project leadership so they can match individual skills with specific parts of the design process.

Leadership and team dynamics can be the most challenging aspects of these projects for students. Without the structure of an official project lead, it can be difficult for teams to agree on how the team will work. And with team members from a range of different backgrounds, it can be challenging for teams to find the best ways to harness the skills of everyone on the team. To facilitate successful year long team projects, faculty must bring in tools that students can use to work together successfully. The IPD program uses the Strengthfinders tool to help students understand what they bring to the project and where their teammates are coming from (Buckingham and Clifton 2005). Other tools that faculty provide include decision making models, techniques for goal setting, and process for ongoing feedback and team alignment to give teams a better chance to successfully collaborate.

The long timeframe gives students the opportunity to define what they want to learn more of and build those activities into their projects. They can experiment with new methods of design research. They can create more robust works like prototypes to gather feedback on their ideas. They can learn new modeling techniques to communicate their designs. As they take ownership over their projects, they begin to shift from a faculty-directed team into self-directed teams, creating stretch goals for themselves and challenging themselves to meet them. In the IPD program, faculty have observed that students who do not create these goals for themselves during a long project can often lose momentum towards the end of their projects. They stagnate in their own growth and their projects stop progressing. Students who continue to accept or initiate new challenges (such as continuous testing and iterating of prototypes, employing advanced methods for concept validation like conjoint analysis, or designing a package to go with a physical product) continue to create more value and continue to learn in their projects even in final weeks of a 9-month long project.

Given almost a full year to work on their projects students are finally able to move from a project mindset to a process or practice mindset. In *Understanding Design*, Bryan Lawson and Kees Dorst describe four distinct levels of design, ‘project’, ‘process’, ‘practice’ and ‘profession’ (Lawson and Dorst 2015). Projects are the core focus of design work and the are the primary focus of design education. The process level is the next level up, and is described as the level at which ‘designers learn from their projects and develop their own approaches to design problems,’ taking moments of reflection that enables them to create design expertise (Lawson and Dorst 2015. p 62). The next level, practice, begins to formalize that expertise into ‘attitudes, interests, and principles’ that guide their work (Lawson and Dorst 2015. p 64). As graduate students in design, IPD students are expected to develop their own philosophies of and approaches to design beyond just a project point of view and start to articulate their own individual processes and practices. This is enabled by both having tackled several different projects with different timelines and topics and engaging in a Triathlon project, where students are encouraged to select the types of activities they engage on, direct their work, and reflect on their work.

4. CONCLUSION

Each type of project provides different benefits for students – with shorter projects providing experiences where students can learn about the overall design process and the interplay between phases and longer projects offering more opportunity for robust skills development and experimentation. Each project type does come with its own challenges for students. Faculty should make sure they have the right type of support in place to help students succeed in each of the timelines.

To form design curriculum employing a variety of different project timelines, consideration should be given to how to order the projects. A triathlon requires a variety of skills and should be used as a final or

capstone project. Students would struggle with such a project without prior experience. Training with a Marathon provides students with enough experience to be able to manage a Triathalon. But projects should not just get longer throughout a student's academic career. Varying the sequence, enabling students to experience short projects, longer projects and then short projects again will help them develop their overall proficiency and fluidity in the process.

The IPD curriculum varies the timelines of the projects throughout two years, as is outlined in Fig. 6. This is not the only order that projects can follow, but it has proven to be successful for IPD students. It helps them build robust understanding of the process and the activities within each phase while also providing them with portfolio pieces that they need to secure internships and jobs. Students finish Year 1 with up to five portfolio projects from their studio courses alone. When they apply for summer internships they have completed at least three projects. At the beginning of Year 2, they will have up to seven completed projects, giving them a range of stories to tell as they pursue their design careers.

	Fall Semester	**Spring Semester**
Year 1	Quick Sprint, (optional sprint) Marathon	5K, Marathon
Year 2	5K, (optional sprint) Triathlon	

Fig. 6 The chart above describes the project timelines of the core IPD studios, courses that all IPD students take.

The IPD program is designed to help students from three different disciplines develop skills in the human-centered design process and to give them the tools to create their own design process. Experiencing several types of projects throughout their course of study gives students exposure to many ways of approaching their work and provides them ample opportunity to test out their own approaches. As the role of designers in industry becomes increasingly diverse, design schools are called upon to train students who have versatile skill sets and can demonstrate fluidity with the design process. Students graduating from Masters programs in Design will fulfil a variety of professional roles. In each context, timelines vary. Giving students the experience of working across a variety of timelines will better prepare them for the work that they will do in the future.

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