Reflective Tools for Capturing and Improving Design Driven Creative Practice in Educational Environments

Adam Royalty, Helen Chen, Bernard Roth and Sheri Sheppard

Abstract Many educational institutions teach design thinking as a way to enhance student creativity. But does design thinking really promote a creative practice? By comparing a design thinking process to a creative process we argue that, when done well, design thinking does promote creative practice. Furthermore, we present both a student-centered tool and an instructor-centered tool that capture design driven creative practice.

1 Introduction

Design Thinking is an approach people and organizations take to solve ambiguous problems in creative ways (Kelley and Kelley 2013; von Thienen et al. 2017). In light of its growing popularity, it is important to ask, *does teaching design thinking actually promote creative practice? And if so, how can design driven creative practice be captured and measured?* These are the two primary questions we will address.

This chapter has four sections. The first is a basic overview of design thinking, including a brief history and how it is related to the field of design. That will clarify what aspects of creativity design thinking attempts to promote. The next section compares the design thinking process to the creative process. This includes investigating

Bernard Roth and Sheri Sheppard are Principal Investigators (PI) for this chapter.

A. Royalty (✉) · B. Roth
Hasso Plattner Institute of Design (d.school), Building 550, 416 Escondido Mall, Stanford, CA 94305-3086, USA
e-mail: aroyalty@stanford.edu

B. Roth
e-mail: broth@stanford.edu

H. Chen · S. Sheppard
Department of Mechanical Engineering, 475 Via Ortega, Stanford, CA 94305, USA
e-mail: hlchen@stanford.edu

S. Sheppard
e-mail: sheppard@stanford.edu

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the behaviors design thinking relies on. In the final two sections, we present two tools for measuring design driven creative practice: one focused on student outcomes, the other focused on academic settings.

2 What Is Design Thinking?

The phrase "design thinking" grew in popularity in large part due to Richard Buchanan's article *Wicked Problems in Design Thinking* (Buchanan 1992); though as Buchanan notes, much of this way of working was articulated by John Dewey in the early 20th century (Buchanan 1992). An earlier article, Designerly Ways of Knowing, outlined the value of problem solving like a designer (Cross 1982). In the article Cross argues that the creative ways that designers approach problems can be utilized by others. This suggests that design, like creativity (Scott et al. 2004), can be taught. In fact, it has been demonstrated that non-designers can learn and implement design (Royalty 2018). For this chapter we define design thinking as a practice where (primarily) non-designers use a design process with the goal of solving an open-ended challenge in a creative way.

It is clear that design is a creative field and that designers are generally creative individuals. Ray Eames, for example, is one of the 20th century's greatest creative luminaries (Kirkham 1998). Leonardo de Vinci was a spectacular designer and arguably the most prolific creative in human history. Although design does not have an agreed upon definition, one of the most popular is, *a course of action aimed at changing existing situations into preferred ones* (Newell and Simon 1972). Compare this to one definition of creativity, *a response or product determined to be both original and relevant* (Runco and Jaeger 2012; Stein 1953). "Seeking preferred situations" is nearly identical to a response or product as being "relevant"—sometimes alternatively described as useful. "Changing an existing situation" implies seeking something "original." This means that design is creative by definition (at least by these common definitions).

If design is creative, then must it follow that design thinking is also creative? Unfortunately, it is not that straightforward. Design thinking is the practice of problem solving like a designer. It does not guarantee that the practitioner actually succeeds at designing. Because the practitioners are non-designers, they need assistance. Design thinking has a number of scaffolds to support successful implementation of design (Royalty et al. 2015). The design thinking process is the most common scaffold. Therefore, to determine if design thinking really promotes creativity, it is necessary to study how it is taught and applied by non-designers.

The Hasso Plattner Institute of Design at Stanford University (d.school) was one of the first groups in higher education to explicitly teach design thinking. Its methods are used around the world (von Thienen et al. 2017). The d.school has roots in industry; it shares a co-founder—David Kelley—with the leading global design thinking firm IDEO. As a result, the design process taught at the d.school is virtually identical to a leading design process used in industry. This paper examines the design thinking

process taught at the d.school for our analysis. The next step is to determine what aspects of creativity to use in this comparison.

The d.school was founded, in part, to *develop a sense of creative confidence in students* (Kelley and Kelley 2013). Courses use a design thinking process and experiential learning to help students solve real world problems, often with project partners (Dym et al. 2005; Mitroff et al. 2013; Royalty 2018; von Thienen et al. 2017). d.school students have produced a number of highly creative outcomes including a low-cost infant warmer for the developing world, an innovative app purchased by a major tech company, and a redesign of the pediatric MRI scanning experience (Kelley and Kelley 2013). However, the teaching goal of the d.school is not to create world-changing products but rather to help people solve problems creatively in their lives.

Using 4-C model of creativity developed by Kaufman and Behetto, it is clear that the intent of design thinking is to impart little c or mini-c achievements (Kaufman and Beghetto 2009). The idea is that the "little" creative accomplishments will help people be better, more creative problem solvers over the course of time. There is evidence that d.school alumni do demonstrate little c and mini-c accomplishments (Royalty et al. 2012). Alternatively, some might argument is that organizations should employ design thinking to bring about radical change, which would fit into the Pro C or Big C category. Although design thinking can help organizations innovate (Brown 2009; Royalty and Roth 2016), the 4-C model of creativity applies to individuals. This chapter focuses on the extent to which design thinking promotes creative practice in a person.

To summarize Sect. 1, the design thinking process codified at the d.school is what this chapter will compare to a creative process. In addition, the outcome of little c and mini-c achievements inform the measurement goal discussed in Sect. 3.

3 The Design Process Versus the Creative Process

The design thinking process taught at the d.school (Fig. 1) has five steps; Empathize, Define, Ideate, Prototype, and Test. Although the process does not have to be followed linearly, most courses, workshops, and projects in industry tend to follow the steps (von Thienen et al. 2017). Each step employs a different set of tools and dispositions. Tools refer to specific types of actions or activities like low resolution prototyping, and dispositions are how people approach work within a specific step. In this way dispositions are reminiscent of de Bono's six thinking hats (de Bono 1995). However, while solving problems through design, one is much more likely to explicitly identify the process steps than the disposition. Some dispositions, like always keeping user needs at the forefront (human-centered) tend to permeate the entire process (Goldman et al. 2012). Other dispositions like rapid idea generation sifting through ambiguity are specific to one or two steps.

The creative process used for comparison is Preparation, Incubation, Illumination, and Verification (Wallas 1926). We used the four phase creative processes over

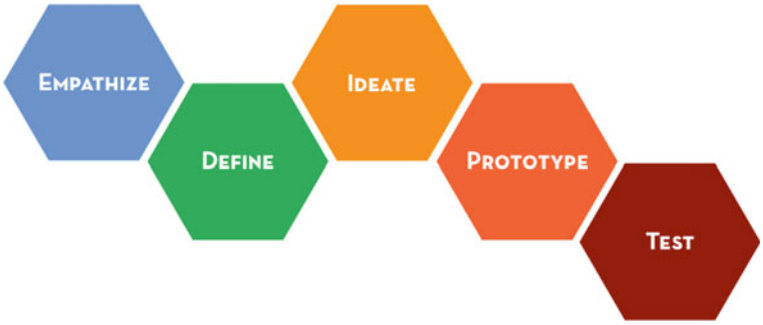

Fig. 1 Stanford d.school design thinking process

a similar five phase creative processes which ends with Elaboration–where the idea is implemented. The design thinking process leads to a nearly identical implementation phase (Buchanan 1992; Cross 1982; von Thienen et al. 2017). Therefore, we did not feel it was necessary to include Elaboration. The analysis presented in this chapter uses the design thinking process as a baseline (as detailed below), then draws connections to the creative process.

Empathy

Design thinking typically addresses challenges that are open-ended and ambiguous, meaning there is not a clear direction or deliverable. The challenges frequently involve people—customers or users. The first step of the design thinking process—empathize—encourages exploration of the problem space, particularly by understanding how the challenge impacts people (Mitroff Silvers et al. 2013). It is a time of intense data gathering through tools like interviewing, observation, and secondary research (Mitroff Silvers et al. 2013). The dispositions this process step encourages are curiosity, openness, and empathy (von Thienen et al. 2017). The outcome of the empathize step is a large amount of unstructured data. This includes quotes, interview transcripts, photos, sketches, internet reports, and more.

Define

Define is the second step of the design thinking process. The data collected during the empathize step are organized, categorized, and sorted. There is not a prescribed way to do this. There are several different tools available including 2×2 grids, user empathy maps, and POV statements (Mitroff Silvers et al. 2013), and the actual data collected suggest what tools to use. The dispositions required are slightly different from the empathize step. Integrative thinking, associative thinking, and Janusian thinking (Rothenberg 1971) help practitioners make sense of the data. The goal of the define step is to sift through the ambiguity of the challenge and create a clear problem objective to be solved. This often happens by identifying one or two critical needs of the people affected by the challenge (Mitroff Silvers et al. 2013; von Thienen et al. 2017).

Ideate

Idea generation happens in the third step, ideate. Participants generate multiple ideas to address the problem objectives articulated during the define step. The primary tool used for this is brainstorming (Osborn 1953; Mitroff Silvers et al. 2013). However, variants like bodystorming and recombinant generation also exist. Ideate requires open, unfiltered, and energetic dispostions. The goal is to come up with as many ideas a possible—regardless of feasibility or viability—then select one to three to move to the next step (von Thienen et al. 2017).

Prototype

The prototype step is where the ideas are first created physically. That is not to say that all the ideas have to be products, as services and experiences can also be prototyped (Mitroff Silvers et al. 2013). The actual construction usually begins by creating a few low-resolution versions (von Thienen et al. 2017). These might be made in 15 min or less out of materials like paper, tape, and post-its. The dispositions associated with this process step are inventiveness, openness, and resourcefulness. It is important to note that construction skills, like those professional designers or engineers have, are useful but not required. In design thinking initial prototypes can be made regardless of technical ability (von Thienen et al. 2017). At the end of the prototype step, participants have one or two prototypes ready to test.

Test

The final step is test. The prototype or prototypes are tested with users and iterated upon. There are different types of tests; A|B testing, usability testing, and experiential testing. For each type, the goal is to learn what aspects of the prototype work and what aspects do not. Analytic thinking and synthetic thinking are necessary for the test step. After this step is complete the design process cycle may begin again to refine the concept. Alternatively, if the idea is ready, it may be implemented.

Each element of the creative process Wallas described has its own purpose. All the constraints and relevant problem information are collected during the preparation phase. During the incubation phase a person consciously and unconsciously processes the problem while searching for solutions. The solution unveils itself during illumination. Finally, the appropriateness of the solution is explored as part of the verification stage.

So, how do these two processes compare?

Empathize appears to overlap significantly with preparation. Both are about collecting relevant information. It is important to highlight that empathize tools tend to focus on people and understanding their needs. The preparation phase does not dictate how one collects data—anything goes. Therefore, empathize might be a type of preparation.

Define, like empathize, overlaps with preparation, although this part of the design thinking process is not about collecting data. It is about organizing data in a way to prepare participants to solve a problem. Define may correspond with the activities one performs in the latter part of the preparation phase. This suggests that empathize corresponds with activities at the beginning of the preparation phase.

Ideation partially aligns with incubation. The idea generation tools in design thinking where participants explicitly generate new ideas connects with the conscious work theory (Runco 2014). Furthermore, recombinant idea generation intentionally links ideas that are not obviously connected. This is similar to Synectics (Gordon 1961). The goal is to activate more remote associations, a very creative practice (Mednick 1968). However, design thinking does not actively promote unconscious work or, a related, recovery from fatigue theory (Runco 2014). This is not to say that a participant's subconscious does not work on the problem during design thinking, but the ideation phase typically happens quickly without much time to incubate internally. It is also the case that ideate is often when the solution arises, meaning that it aligns with illumination as well.

The combination of prototype and test relate to verification. A prototype is the manifestation of an idea created explicitly to test it. As with verification, the goal is to see if the solution actually solves the problem.

The analysis above suggests that the design thinking process is extremely similar to the creative process. Empathize and ideation each partially map to the creative process. It may be that the design thinking process is a subset of the creative process. It is also likely that some differences are more difficulty to detect. To gain more clarity, this chapter will perform a second comparison based on when each process leverages convergent and divergent thinking.

Another representation of the design thinking process is a flare/focus diagram (Fig. 2). It describes what parts of the design thinking process call for more ideas (divergent thinking) and what parts call for driving towards a clear goal (convergent thinking). This can be compared to when the same types of thinking happen in the creative process.

Through this comparison, the connection between empathize and preparation is not so straightforward. Empathize requires divergent thinking, whereas preparation requires convergent thinking. In this analysis define, and its associated convergent thinking, appear to be the stronger link. The large flare occurring during ideate does correspond with the divergent thinking in incubation and illumination. Prototype,

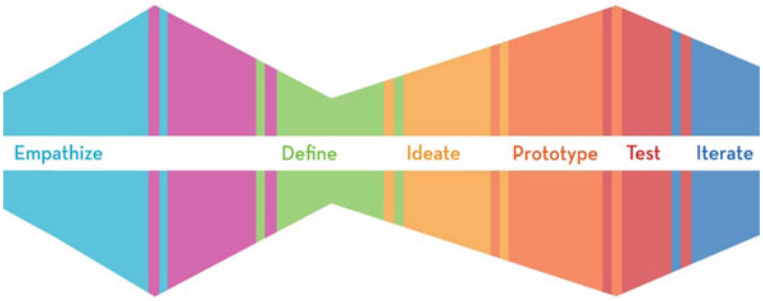

Fig. 2 The flare/focus design thinking process

which uses divergent thinking, appears to overlap less with the convergent thinking of validation. Test, however, is still a match.

This analysis suggests that prototype might connect more closely with incubation and illumination. One can argue that the act of prototyping is not simply representing a conceptualized idea (Beckman and Barry 2007). Making necessarily involves generating new ideas because physical constraints inspire improvisation and modification. One phrase often used to describe prototyping is "build to think" (Carroll et al. 2010). In this case, test would be the only design thinking step that connects with validation.

The way empathize relates to the creative process is now less clear. Is it a form of pre-preparation? Can it be that preparation involves *some* divergent thinking? Even though empathize is an exercise in divergent thinking, we argue that it is still a part of the preparation phase because the primary goal is to gather relevant data that will undergo a convergent thinking process during define.

Ultimately, neither the design thinking process nor the creative process are completely rigid (that wouldn't be very creative!), which is another commonality they share. This means that it is not possible to map the processes on to each other in every context. However, there is a great deal of overlap which suggests that, from a process perspective, design thinking could promote creativity.

It is worth taking some time to comment about two behaviors the design process evokes and comparing them to known creative behaviors. One is the energetic behavior of brainstorming. When participants brainstorm the environment is very positive and active. This is reminiscent of a manic state which is linked to creativity (Andreasen 1997). The major difference being that the energetic state design thinking calls for is artificial and does not last nearly as long. The second behavior is openness to new ideas. This is a personality trait that predicts creativity (Puryear et al. 2017). In the first analysis of the design thinking process, openness was the most common behavior—found in three of the five steps. Although a complete behavioral analysis is needed, initial findings suggest that design thinking promotes at least two very powerful creative behaviors.

Based on the evidence above, this chapter concludes that design thinking, if practiced well, does promote creative practice. Moreover, the design thinking process may be a subset of the creative process. There are, however, ways for design thinking to improve how it promotes creativity. More support of unconscious idea generation is needed. Also needed is an emphasis on what innate personality traits might be conducive to strong design thinking practice. It will be interesting to see how design thinking evolves. Does it stay fixed in its approach to creativity, or does is grow to incorporate new creative practices?

4 Measuring Design Driven Creative Practice

4.1 Background

Having established that design thinking can lead to strong creative practice, we turn our attention to measuring that practice. This is an important question because the ability to improve instruction and better support creative design in organizations depends on measuring creativity.

Capturing and assessing creative work faces a number of challenges. Many researchers do not agree on what criteria of creativity to assess (Plucker and Makel 2010). Furthermore, most of the existing creativity assessments were developed to use in a controlled setting, often research experiments (Amabile 1982; Carson et al. 2005; Guilford and Merrifield 1960; Torrance 1988; Welsh and Barron 1959). This extends to many assessments of design thinking (Hawthorne et al. 2016; Royalty et al. 2014; Saggar et al. 2015). We wanted to capture student work in an ecologically valid environment. Furthermore, because both the design process and creative process involve several steps performed over time, it is important to observe how students repeatedly practice creative work during the duration of a d.school course. To this end we developed a tool called Reflective Design Practice (Royalty et al. 2018). RDP was tested with 19 students at the Stanford d.school over three quarters. The following sections describe the tool and the output students generate while using it.

4.2 Materials

Students completed a weekly reflection throughout the 10-week quarter. They were asked to take a photo of an artifact they created that week while doing work for a d.school course and respond to three to five prompts about how the artifact was created. An artifact could be a physical asset like a prototype or a whiteboard after a brainstorm. It could also be an experience like interviewing users or a team meeting. Students uploaded their photo and corresponding reflections onto a Google Slide Template (Fig. 3). Midway through the quarter each student participated in a semi-structured 45-min interview with one of the instructors. The questions were divided into four general categories (Table 1). During the interview students were asked to look back through their entries to provide concrete examples in response to the questions. In the last week of the quarter students shared their entire set of reflections in small groups.

Fig. 3 Reflective design practice weekly reflection template

Table 1 Reflective design practice mid-quarter interview protocol

Category	**Environment—understanding how space, instructors, peers, and time constraints affect a creative practice**
Questions	What aspects of the environment supported the creation of the artifact?
	What aspects of the environment were **barriers** to the creation of this artifact? Why did they act as barriers?
Category	**Contrast—understanding how a creative practice differs from other working practices a student engages in prior to and after a design-based curricular experience**
Questions	How is the artifact different from what you might normally create in another (non-d.school) course?
	How did the d.school style of working enable (or not) the creation of the artifacts?
	How does this different from the style of working non-d.school courses enable?
	How would you approach integrating this process into one of your non-d.school courses?
Category	**Personal comfort/discomfort—understanding what parts of the design-based curriculum feel personally comfortable or uncomfortable to a student and why**
Questions	Which artifact was created using a style or way of working that felt comfortable or familiar to you?
	Which artifact was created using a style or way of working that felt the least comfortable or familiar to you?
Category	**Themes—noticing how certain themes appeared across multiple artifacts**
Themes	Comfort/discomfort with ambiguity
	Rapid prototyping
	Intangible behavior

4.3 Output

Over the course of the quarter, a student completes 10 Google Slide Templates. Each slide captures an example of actual creative work. The work can come from any part of the design process. For example, one student captured the result of a team synthesis session where they defined user needs that they felt compelled to address. Another student shared a prototype her team created in a campus dining hall aimed at helping students make more informed nutritional choices. The accompanying reflection describes how and why the artifact was made. All together the slides present a perspective on a student's journey through a d.school course. The mid-quarter interviews help students and instructors key in on areas of struggle and growth.

4.4 Conclusion

RDP is a flexible tool. Reflections can be assigned multiple times a week or scattered throughout a term. The prompts accompanying each photo can be modified to focus on a particular topic. What is important is that students capture real work and think deeply about how they created it. Furthermore, it is essential that students spend time reflecting across multiple entries. The ultimate goal is for students to develop insight into their own creative practice by observing it grow over time (Royalty et al. 2018). There is strong evidence that reflections prepares students to better transfer learning from an academic context to a real world context (Bransford and Schwartz 1999; Flavell 1979; Greeno et al. 1993).

The output of RDP can help instructors better understand how students experience a course as a whole. Because the reflection documents an entire learning journey, it can complement other reflections focused on particular techniques, class sessions, or projects. RDP can be useful to researchers, as they can code the interviews and slides using a number of different frameworks.

5 The Influence of Academic Settings on Design Driven Creative Practice

5.1 Background

The previous section illustrated a tool designed to capture student work. This section outlines another tool that instructors can use to describe their pedagogical approach to supporting design driven creative work. Building off of last year's work (Royalty et al. 2019) we sought to understand the how design instructors manipulated a learning context to better develop design practice within their students. We iterated

on data gathering techniques used in previous studies (Royalty et al. 2014, 2018) to create a new tool for capturing how instructors teach. The tool has three general parts; perceived student journey, connectedness across campus, and environmental variables. Instructors begin by mapping out what and how they believe students learn design. Then they focus on the variables of the environment that most impact that journey.

We surveyed 27 instructors with experience teaching design-based curriculum. They were all participants at a conference of design educators. The instructors represented 13 universities and 5 colleges. Seventeen of the 18 institutions are located in the United States, with the lone international school being in Mexico. The median amount of experience teaching design was seven years.

We chose this group to study because we wanted to collect data from people committed to teaching design-based curriculum. At the same time, we wanted to include a wide range of academic contexts into our sample. Had we surveyed 27 instructors at the Stanford d.school, there is a good chance their responses would have been similar. Instead we wanted to be expansive and leverage the continually growing network of educators.

5.2 Materials

Our goal was to understand how context impacts the journey instructors take students on. That entails understanding—from the instructor's point of view—where students are at the beginning of the journey, where they are at the end, and what happens along the way. We asked the questions in that order because we wanted them to focus on learning outcomes first, then map those to how the students actually achieved those outcomes.

It is important to note that a student's journey learning design is not contained in the interaction with one teacher. So, when we say beginning and end we mean the beginning and end of the time the instructor has direct influence on that student—most often through teaching a course. We decided to scope this so that we could more easily compare responses across instructors and courses. Additionally, we asked instructors to think of a particular student rather than a generalization of students so that they could add specific details. They were given the option of mapping the journey of two students.

Figure 4 shows the worksheet instructors use to articulate where they believe students are before and after a design-based learning experience. This includes expressing what the learning goals and the emotional goals of instruction are. In both the before and after case instructors identify students' conception of design and creativity. They also list students' approach to problem solving and learning.

A journey map, Fig. 5, illustrates how instructors move students from the before state to the after state. We asked them to capture any design-based learning experience that a student might engage in at their institution. This could include courses,

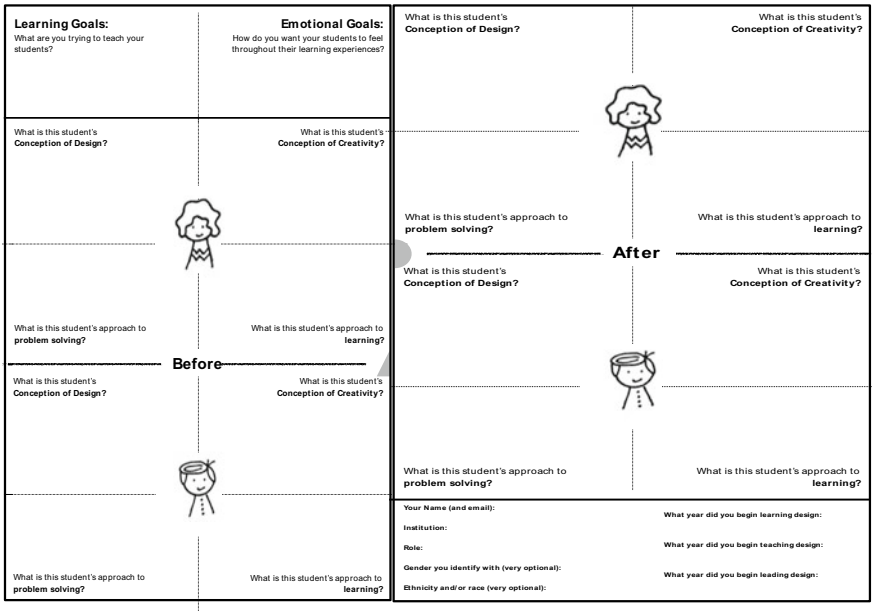

Fig. 4 Worksheets capturing instructors' perception of how students conceive of design, creativity, and problem solving before and after a design-based learning experience

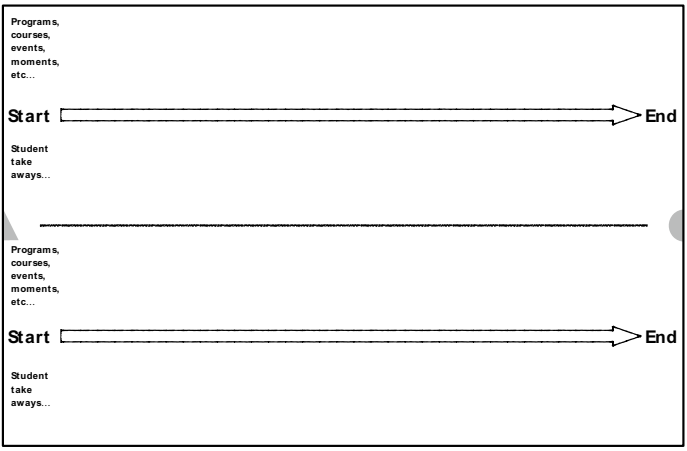

Fig. 5 A journey where instructors listed the different learning experiences students typical engage in; as well as, a desired student take away

workshops, coaching, etc. With each entry, instructors also wrote what key lessons they intend student to take away.

The second exercise we asked instructors to complete was an ecology illustrating how their institute, department, or course connects with the rest of the university (Fig. 6). This gives us data on the type of design efforts in different institutions. We can then compare contexts across institutions—and how those institutions relate to the rest of their university. For example, the environment in an institute like the d.school is different from a place that has a single design course without a dedicated space.

Finally, we asked instructors to list what variables they control while creating a design experience, see Fig. 7. They were given five minutes to list as many variables they play with, account for, or otherwise design into their learning experiences. The full paper (Royalty 2018) has more details but we will summarize the findings in the results section.

In the end, each instructor created a single Design Practice Canvas (Fig. 8) connecting students' learning journey and the variables used to support instruction. This proved to be a useful tool for the instructors to reflect upon the work they do, much of it implicitly, to develop students' design practice. This suggests that the canvas could be extended for use in non-academic contexts to help leaders better create environments that support design work.

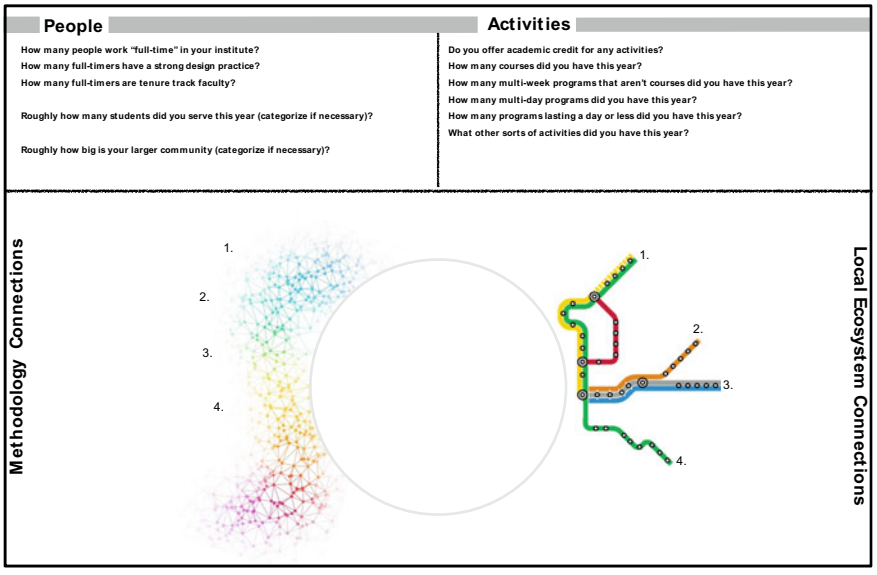

Fig. 6 Design ecology illustrating connections between design-based experiences and the university at large

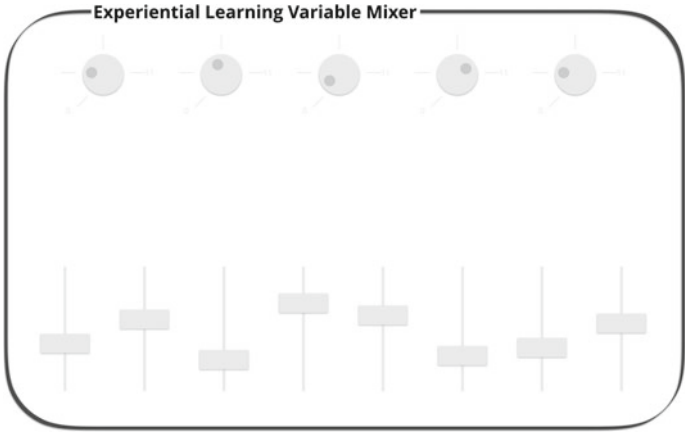

Fig. 7 Worksheet capturing variables design instructors use to create a design-based learning experience

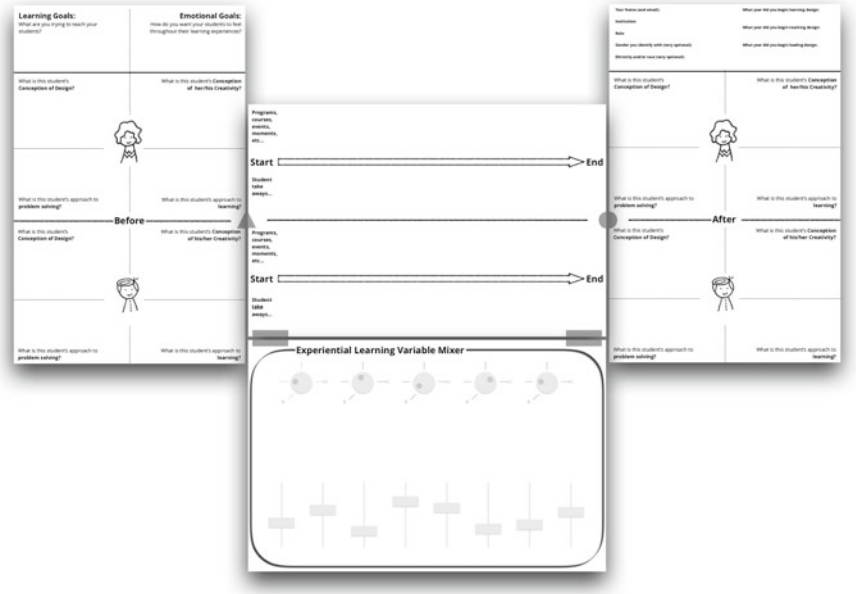

Fig. 8 Design practice canvas

5.3 Output

We are still in the process of analyzing the Design Practice Canvas output. A major aspect of the analysis focuses on the creative dispositions instructors try to teach their students. We will code the before and after sections of the journey maps and look for patterns between creative dispositions and the type of institution. One potential finding is whether or not environments that support prolonged student engagements (e.g. full semester courses) seek to teach different creative dispositions than environments that focus on short term engagement like workshops. Another question is what are the most common activities instructors employ to increase design driven creative practice.

The design ecologies will be analyzed for patterns across different institutions. It is already clear that no two institutions teach design-based curriculum the same way. A cursory review shows that some places offer multiple courses, others a single design-based course, and a few offer no credit bearing experiences. This is not a measure of success or impact. It simply helps the community understand the current diversity of approaches.

5.4 Conclusion

The Design Practice Canvas was created to help an institution articulate its approach towards teaching and how it exists relative to the larger college or university. This can help instructors be more intentional about how they evolve design-based curriculum. It also helps them understand what resources and partnerships the can seek within their broader ecosystem. Beyond these two benefits, a larger goal is to help instructors better learn from one another by understanding the varied contexts in which people practice design-based pedagogy. Ultimately our hope is that we can provide different models for organizations seeking to implement design-based pedagogy.

6 Conclusion

This chapter began with a definition and brief history of design thinking. We then compared a design process to the creative process by mapping two different representations of the design process used at the d.school to a well-known creative process. The analysis determined that design thinking does promote creative practice. Finally, we shared two different tools for understanding design driven creative practice. Analysis of the data collected already through these tools should give us further insight into how people teach and learn design. Moreover, we designed the tools to be useful for instructors looking to improve their own teaching practice.

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