CHAPTER 9

COMPLICATING DESIGN THINKING IN EDUCATION

A University-School District Partnership to Design a School for the Future

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"Design thinking" is one of the latest buzzwords in education (Kimbell, 2011; Korn & Emma, 2012; Lahey, 2017; Razzouk & Shute, 2012). Proponents argue that design thinking is a tried and tested process for fostering innovation in education while critics suggest that it is the latest fad to sweep through, and will, like others before it, fade away (Hernández-Ramírez, 2018). Irrespective of where one stands on this issue because educational institutions and structures are human-created, they are amenable to design (and redesign). Thus, design thinking may be a useful tool for educators to explore. There is, however, less clarity on how design thinking unfolds in complex educational contexts.

Design Thinking:
Research, Innovation, and Implementation, pp. 187–210

The most common model of design thinking describes it as an iterative series of steps or stages that, if followed, lead to innovative solutions to complex problems. Like all models, it simplifies a complex process to provide clarity in representation and communication. Thus, it is important to ask whether these formulations of design thinking are consistent with the *actual* process of design, particularly when they are brought into educational contexts. In this chapter, we argue that most design thinking process models fail to adequately describe the richness, unpredictability, and messiness of design work as it plays out in the real world. We suggest that it may make sense, given the complex nature of the phenomena under study, that design researchers be open to multiple theories and perspectives to better understand design in education. More importantly, using more than one approach provides a deeper and more nuanced view of design. We ground our argument in an analysis of a specific case: a university-school district partnership that attempted to use a design thinking process to create a new model of school. In the rest of the paper, we contextualize design and design thinking in two types of frameworks, or what we call process and domain models. We follow this by describing a design case, and the complications that emerged, through these two lenses. We explain how these two design frameworks both support and enrich each other. We conclude with suggestions for future work in this area.

UNDERSTANDING DESIGN

Design is quintessentially human (Nelson & Stolterman, 2012) and has been described as "an art of deliberation essential for making in all phases of human activity" (Buchanan, 1995, p. 46). Simon (1969) contrasted design with the natural sciences, suggesting that the natural sciences study what *is*, while design seeks to find what *could be*. Although design has always been central to human existence, deliberately applying design processes to domains such as business and education is a relatively new idea (Kimbell, 2011; Razzouk & Shute, 2012).

One of the earliest uses of the term *design thinking* comes from Peter Rowe's (1991) book of the same title. Rowe highlighted the similarities in the inquiry practiced by architects, urban planners, and traditional designers. More recently, Nigel Cross explored these ideas through his books *Designerly Ways of Knowing* (2006) and *Design Thinking: Understanding How Designers Think and Work* (2011).

Design thinking became popular in the early 2000s when Todd Kelly and Tim Brown, owners of a design consultancy agency, began promoting

a design process model they called design thinking (Brown, 2008). Design thinking was quickly popularized and, to a large extent, commercialized first through business training programs and later in other fields such as education. In the remainder of this chapter, our use of the term design thinking will refer to this popularized form.

Design scholars have debated the benefits and drawbacks of the popularization of design thinking. Some claim design thinking brings useful tools to new areas of human endeavor, providing "a new framework upon which to view the world" (Norman, 2017, p. 345). Others have critiqued design thinking for oversimplification or presenting an unexamined notion of innovation, discounting the importance of expertise, and focusing more on commercializing the process than driving impact (e.g., Hernández-Ramírez, 2018; Jen, 2017; Kolko, 2018). Design thinking promoters d.school (Hasso Plattner Institute at Stanford) and IDEO have recently revised their design models, attempting to move beyond a process-centered approach by focusing on mindsets and emphasizing the nonlinear nature of design (Carter & Stariha, 2019).

In this study, we map two kinds of design models (process and domain) to a two-year university-school district partnership focused on designing a new school model. We explore how the design process led to an integration of stakeholder ideas into a new sociomaterial design for learning. Our analysis describes how different representations of design thinking map onto the reality of the partnership. It highlights the complexities inherent in multistakeholder design in education, and we suggest that unitary representations of the design process fail to adequately describe the richness and complexity of design thinking in practice.

ANALYSIS FRAMEWORKS: PROCESS AND DOMAIN MODELS OF DESIGN

To explore the design process as it occurred in the partnership, we analyzed artifacts created during the design process. The data consisted of slide decks used in the design sessions and presentations, team planning documents, and project reports. University design team members reviewed the analysis and provided clarification where needed.

We molded our analysis around two different ways of conceptualizing design. The first is through the lens of *process models,* such as the d.school model or the double diamond model (IDEO Design Thinking, n.d.). These models describe design as a process that includes a series of steps or stages and focus on *how* design happens. In contrast, process models are what we call *domain models,* which identify the space or domain within which design occurs (e.g., Buchanan, 2019; Golsby-Smith, 1996; Warr et al.,

2020). Domain models offer ways to think and talk about design in terms of *where* design occurs. Before presenting our analysis, we briefly describe each type of model.

Process Models

Design thinking process models present design as an iterative process that includes various stages, phases, or modes that seek to capture how design occurs. Below we describe two popular process models for design thinking: the d.school model and the double diamond model.

The Hasso Plattner Institute of Design at Stanford (d.school) model describes five "modes" that are the "components of design thinking" (Design Thinking Bootleg, n.d.; see Figure 9.1). Table 9.1 provides the components and definitions for each mode based on d.school's Design Thinking Bootleg toolkit. In addition to design phases, design thinking is also described as a combination of divergence (creating choices) and convergences (making choices; IDEO Design Thinking, n.d.). In another process model, design thinking consists of cycles of divergence and convergence. One commonly used model includes two diamonds, one for the problem space and another for the solution space (Stickdorn et al., 2018; "What is the Framework," 2015). The first diamond represents the problem space. It begins with a general problem, diverges through understanding or research, then converges in define. Definition specifies the problem which then moves design forward to the second triangle—the solution space. In the solution space, ideation diverges, then prototype and test converge into a solution (see Figure 9.2). These models are just two out of a wide range of such process models that have been used to describe design thinking (Hoffman, 2016).

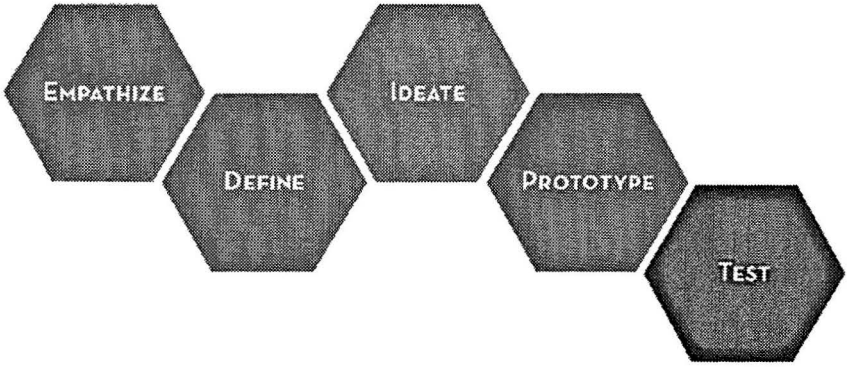
Domain Models

Domain models, by contrast, focus on *where* design occurs. Examples include Buchanan's (2019) five orders of design, Golsby-Smith's (1996) four domains of design, and the five spaces for design in education (Warr et al., 2019, 2020; Weiner et al., 2020). Each of these models seeks to identify "places of invention ... where one discovers the dimensions of design thinking by a reconsideration of problems and solutions" (Buchanan, 1992, p. 10) thus "widening designerly ways of thinking" (Golsby-Smith, 1996, p. 5).

The five spaces for design in education framework offers a specific domain model for design in education (Warr et al., 2020). Each of the five spaces (artifacts, processes, experiences, systems, and culture,

Figure 9.1

Stanford d.school Design Thinking Process Model



Note. "Design thinking modes" by Stanford d.school is licensed under CC BY-NC-SA 4.0.

Table 9.1

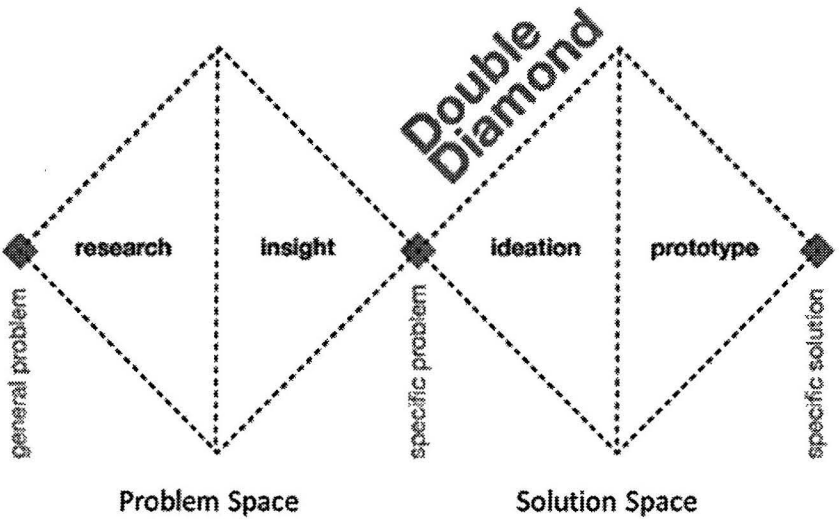
Stanford d.School Design Modes

Mode	Definition	Components
Empathize	The foundation of human-centered design; "build empathy for your users by learning their values" (p. 3)	Observe, Engage, Immerse
Define	"scope a meaningful challenge ... come up with an actionable problem statement: your Point of View" (p. 5)	Point of View
Ideate	"generate radical design alternatives ... explore a wide solution space" (p. 7)	Fluency (volume of innovative options) Flexibility (variety of innovative options)
Prototype	"gets ideas out of your head and into the world ... anything that takes a physical form" (p. 9)	Purposes: empathy gaining, exploration, testing, inspiration
Test	"Gather feedback, refine solutions, and continue to learn about your users" (p. 11)	Learn about user, refine prototypes and solutions, test and refine Point of View

Note. Quotes from Design Thinking Bootleg toolkit (d.school, Hasso Plattner Institute of Design at Stanford, n.d.)

Figure 9.2

A Version of the Double Diamond Design Process by Olga Carreras Montoto Is Licensed Under CC BY 4.0



see Table 9.2) represents an area for design. The spaces are often represented as nested circles to reinforce their interactive nature (Figure 9.3; alternative approaches to representing the model can be found in Warr et al., 2020 and at talkingaboutdesign.com). The framework provides a way to understand the designed (and hence artificial) nature of education. It also offers an instrument for identifying areas for design intervention and supports a focus on how designs interact.

The two forms of design thinking models (process and domain) provide contrasting lenses through which to understand design. In the following sections we investigate the specific case of a university-school district partnership and show how these models help us understand how design occurred. We begin with a chronological overview of the project. Then we describe four key complications that emerged. Analyzing each complication from the perspective of the two types of design models provides a richer and more nuanced view of collaborative design in education.

THE UNIVERSITY-SCHOOL PARTNERSHIP: AN OVERVIEW

The partnership between a local K–8 school district and a prominent college of teacher education began in the fall of 2017 following conversations

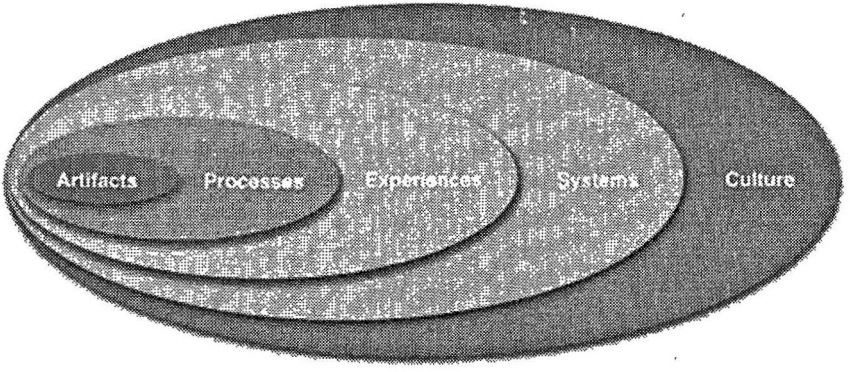
Table 9.2

The Five Spaces for Design in Education

Space	Definition	Examples
Artifacts	(Relatively) stable objects that can be perceived through the senses	Curricular materials, tools, software, manipulatives, videos
Processes	A procedure or directions that can be used to achieve a goal outside of the context within which it was created	Lesson plans, curricula, schedules, instructional theory
Experiences	A piece of time with associated sights, sounds, feelings, and thoughts	Activities, celebrations (graduation), learning communities
Systems	An organized and purposeful structure of interrelated and interdependent elements	Registration, certification system, degree program, evaluation systems
Culture	A pattern of shared basic assumptions that allows groups to perceive and interpret the world in similar ways, develop and communicate meaning, and transmit values to new group members	Perceptions of technology, schools, or education broadly; classroom culture; school culture

Figure 9.3

A Visual Representation of the Five Spaces for Design in Education



between the district and college leadership. The suburban district, with twenty-five schools and approximately 17,000 students, was facing the challenges of an aging population, declining enrollment, and potential teacher shortages. The other partner, a nationally recognized college of teacher education at a local university, had recently created a design initiatives (DI) team whose goal was to work with local schools and communities, using design thinking approaches to spur educational innovation at the local level.

The collaborative design thinking approach espoused by the DI team resonated with the district leaders who were eager to find innovative ways to better meet the needs of students, educators, and families. The goal of the partnership was to create a new model for schooling, which the superintendent of the district described as a "school for the future." The new school model was meant to address two central goals:

1. Engage students in a dynamic learning environment that promotes academic excellence and prepares them to be innovators and leaders of tomorrow; and
2. Deploy educators in nontraditional ways by creating new roles and staffing structures to attract and retain high-quality staff and reinvigorate the teaching profession.

The partners held an initial project kick-off workshop at the district office in November 2017 to recruit stakeholders (including district administrators, teachers, and community members) to join the university DI team. The resulting design team (including both the DI team and community stakeholders) held monthly meetings from January to October 2018. In the winter and spring of 2018, most of the design team's work focused on seeking inspiration from existing sources and conducting empathy research by listening to students, teachers, parents, and other community members. For example, the designers attended meetings of the district's community business alliance and parent-superintendent council meetings. They interviewed community stakeholders and conducted focus group sessions with students. Designers attempted to better understand students' experiences by shadowing students throughout a school day. Several members of the design team also visited the High Tech High charter schools in San Diego for inspiration and to see an inquiry-based school model.

During the summer of 2018, the designers synthesized their insights and created design principles to guide the design of the new school model. Additionally, in July 2018, the core design team convened a community design charrette to begin ideating and conceptualizing what the school model might look like. The charrette brought together a larger group of community members and the design team to discuss possibilities for the school model.

In the fall of 2018, the design team continued to refine its vision for the school model. As the vision became clearer, it became apparent that the scale and scope of the project would make full-scale implementation difficult to achieve in the time previously allocated. After consultation with district leaders, it was decided to shift the rollout into two phases: a pilot to launch in fall 2019 and a larger-scale school launch in fall 2020.

The work of the design team, district leadership, and community members resulted in a pilot model for a new school that included (1) a cohort of up to 120 students in third and fourth grade who learned in (2) an open, flexible physical environment, led by (3) a collaborative team of educators who collectively designed and facilitated (4) a learner-centered curriculum emphasizing experiential, project-based learning. After approval by the school board in spring 2019, the pilot went live in the fall of 2019.

THE EVOLVING ROLE OF DESIGN THINKING IN THE PARTNERSHIP

The design team of the university-school district partnership planned their work from a design thinking process perspective. The manner in which design thinking was presented, however, evolved throughout the project. For instance, at the kick-off session in November 2017, design thinking was defined as "a process to figure out a way, when we don't know exactly where we are going or even where we need to go." It was further described as an iterative process with five stages: empathize, define, ideate, prototype, and test—evidence of a design thinking process orientation. The DI team also identified certain key mindsets that underlie the process such as being human-centered, collaborative, optimistic, and experimental.

In January 2018, the design team began to emphasize the active side of design thinking as well as a recognition of the existence of multiple design thinking models. For example, a slide entitled "*The* design thinking process" was changed to "*A* design *doing* process" to emphasize this fact. As is typical in collaborations centered on design thinking process models, participants engaged in a design *sprint*, a type of rapid design thinking session in which participants respond to a given challenge with co-creation and rapid iteration and prototyping. Participants were told the goal was to "Work through each phase of a design cycle, gaining experiences with the process and developing comfort with high-velocity, experimental decision making."

By March 2018, an additional description of the design process made its appearance. Now, in addition to the existing stage-like process, the design process was also summarized through three meta-stages: understand, design, and build (see Figure 9.4). The same slide was included in

future sessions with two changes. In August 2018, the first "prototype and test" was replaced with the phrase "develop prototypes." And, more significantly, in a report from January 2019 the words "prototype and test" were removed entirely from the timeline, replaced by the phrases "build model and prototype scope" and "pilot planning" (see Figure 9.5), reflecting changes in the overall plans, timing, and scope. The evolving representations of design and subtle changes in wording suggest a recognition of the complexity of the task and that the DI team's vision of the process evolved over time.

A review of the data suggested that rather than a five-stage design process, the actual design process might be better understood as four iterative stages of increased focus (Figure 9.6). The initial design brief provided by the district framed the work from November 2017 to May 2018. In June 2018, designers narrowed the focus by identifying design principles that would guide the development of the school model. In September 2018, more detail was once again added when designers enacted design principles through four "buckets": staffing, curriculum, operations, and physical environment. Finally, the design was instantiated through a pilot program in the 2019–2020 school year. That said, it must be added that the somewhat linear narrative of the process hides some of the complexities and complications experienced throughout the design process, including *how* the process moved the design forward. It is to this that we turn next.

Figure 9.4

Outline for Design Process Presented as in April 2018

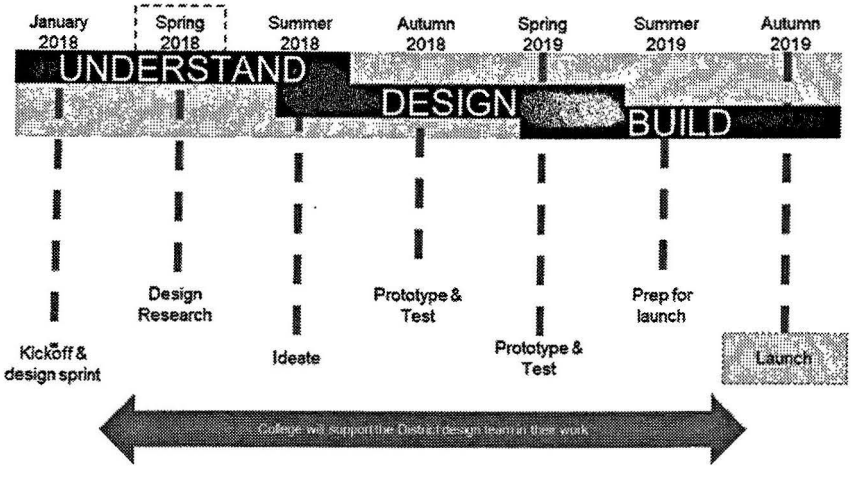


Figure 9.5

Design Process as Presented in January 2019

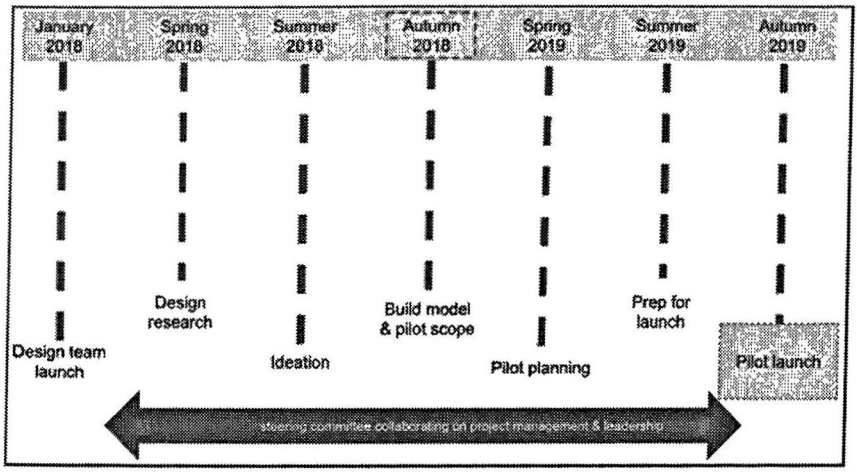
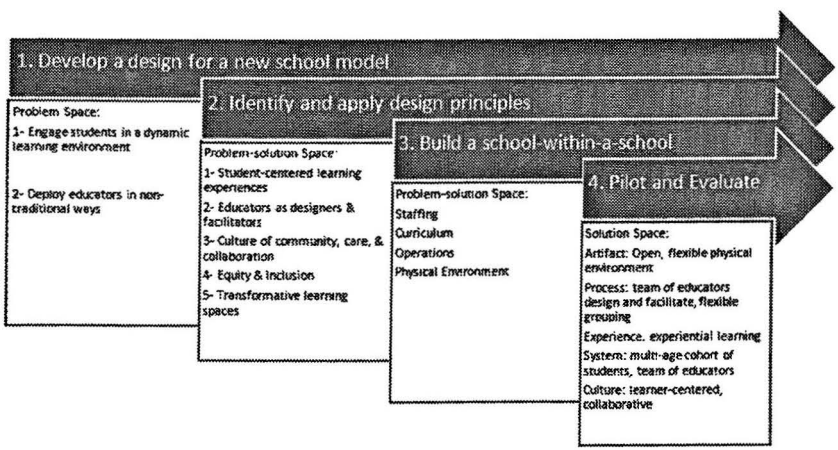


Figure 9.6

The Design Process as Enacted



COMPLICATING DESIGN THINKING

The realities of the actual process of design—its contingent, ever-evolving nature as well as the external factors that influence the design process—are often elided when speaking of the design process in the abstract. In the section below we take a deeper dive into the actual process of design in terms of identifying and describing a series of complications that emerged through our analysis (as listed and described in greater detail below):

- Finding the problem was the biggest problem
- Ideation is not just about finding potential solutions
- Design does not occur in a vacuum
- Designing systems cannot be done piecemeal

In the sections below we describe each of these complications in greater detail and examine each using the two types of design models (process and domain) described earlier.

Complication 1: Finding the Problem Was the Biggest Problem

In this section, we consider how the problem and solution were identified and defined in this partnership. In contrast to most design thinking models, academic design literature often describes problems and solutions as developing simultaneously, each informing the other (Dorst, 2011; Wiltschnig et al., 2013). This is because design often focuses on ill-defined or wicked problems (Buchanan, 1992; Rittel & Webber, 1973). Wicked problems have no clear formulation and no criteria for when they have been solved. In fact, the problem is defined through the development of the solution. As Rittel and Webber (1973) explained, "The problem can't be defined until the solution has been found. The formulation of a wicked problem is the problem!" (p. 161). We use the term "problem-solution space" to emphasize the symbiotic relationship between problem and solution (see Maher et al., 1996).

The design challenge presented in November 2017 provided a broad outline of an initial problem-solution space, hinting at general solutions and problems, but remained open to interpretation. In essence, what was to be designed was not known and the process of solution seeking was happening at the same time as the problem itself was being understood. The process and domain models of design thinking provide us with different

ways of thinking about how designers navigate such open-ended problem-solution spaces.

Process Models and Complication 1

From the point of view of process models of design thinking, the place to start with understanding the problem space is through a research stage (empathy, research, and/or exploration), which is where the design team focused in winter and spring 2018. They tried to better understand the problem through attending community meetings, interviewing stakeholders, conducting focus groups, and shadowing students.

However, although design thinking process models separate problem exploration and solution finding, in this case the problem and solution were explored simultaneously. For example, during the design research phase, designers explored potential solutions, such as studying innovative school models and visiting High Tech High. Similarly, the July 2017 design charette explored challenges inherent in a one-teacher-per-classroom workforce model (the problem) and challenged participants to find new ways to staff schools (potential solutions). Although most design thinking process models would envision defining a problem before identifying potential solutions, in this case potential solutions—a new staffing model and existing school models—contributed to how the problem itself was framed.

Domain Models and Complication 1

Domain models such as the five spaces for design in education can help designers identify where problem-solution spaces lie in complex systems such as schools. For instance, design domain models can help break down the *what* of the problem-solution space, particularly since the details of what a learning environment and staffing structure look like were left for the designers to determine. The five spaces of design in education framework suggests that meeting the challenge of creating a dynamic learning environment works within all five spaces. Designing a new school involves reimagining across each space for design, such as artifacts (the physical building, digital technology devices and programs, and curricular materials); processes (pedagogical methods, schedules, and lesson plans); experiences (the sense of wellbeing and engagement during learning activities); systems (both internal, e.g., disciplinary system; and external, e.g., accreditation, financial, and legal systems); and culture (norms and expectations about learning and schooling both within and outside school

walls). Moreover, these spaces are not discrete; design moves often span multiple spaces and interact with each other.

The data indicate that the design team explored multiple design domains throughout the year-long design phase. For example, the July 2018 design charette included activities centered on several areas for design, including experimenting with new staffing structures and the physical design of a school. In September 2018, designers addressed the question "who can help us," bringing in larger systems and culture into the school model plan. Teams of participants were also asked to create a school model that addressed four "buckets": staffing, curriculum, operations, and physical environment, each of which can be seen as a problem-solution space needing its own design.

Design thinking process models provided some direction for beginning to understand the problem-solution space, while domain models helped designers break down what types of designs might become part of the solution. The challenge that remained, of course, was that without further definition of the problem-solution space, it was unclear how the designers would move forward to ideation—what would they ideate about? A new building? A new teaching or learning method? A new kind of teacher? This is explored further in Complication 2.

Complication 2: Ideation Is Not Just About Finding Potential Solutions

The ongoing process of defining the problem-solution space was a challenge for the design team that was further aggravated by the multidimensional nature of the task. The fact that problems and solutions were intertwined meant that ideation had to occur throughout the design process. Instead of simply being a process for identifying potential solutions as is commonly described in design thinking process models, in this case ideation was more about collaborative creativity and meaning making.

Process Models and Complication 2

Process models of design thinking often present the "ideation" phase as a second divergent phase coming after researching and defining, and prior to prototyping and testing (most clearly represented in the double diamond model [Figure 9.3]). In this partnership, however, these distinctions were not so clear. Ideation was not isolated to one part of the process. In fact, the practice of ideation—where designers think broadly and attempt to widen the problem-solution space—happened *throughout* the design

process, starting from the very first kick-off activity. Furthermore, creative activities were not just about thinking of new ideas; they supported collaborative creativity and sense-making, building shared meanings of the design space.

For example, in the kick-off session in November 2017, designers participated in a brainstorming activity where they responded to questions about what students will need as adults and how schools can address those needs. Participants brainstormed first individually and then in teams. They reviewed ideas from other groups, discussing their thoughts and discoveries with each other. This process continued in March 2018 when the design team explored metaphors by comparing schools to other scenarios, such as a space mission or emergency room. In July 2018, they identified tacit assumptions about schools and brainstormed ways to transform schools without those assumptions. Ideation occurred in each of these instances, but, importantly, the activities also helped the design teams construct a shared understanding of what the new school model could be.

Domain Models and Complication 2

Design domain models help us recognize that what is to be designed is not a single thing, but a combination of things—a sociomaterial interaction. This means *what* should be ideated about is a set of designs that combines physical and social structures, not an individual artifact or product. For example, artifacts such as the physical classroom space interact with processes such as learning theories and systems such as staffing structures to produce new experiences for students and teachers.

Two design activities highlighted the interaction between spaces, allowing the design team to think broadly about how design spaces should work together. First, in June 2018, designers defined design principles for the school model. Rather than attempting to describe what each piece of the design would consist of, the design principles suggested results of the interactions. They provided an underlying frame from which designs in each space, and the interactions across spaces, could be evaluated, thus providing a holistic perspective on a complex problem. Similarly, in August 2018, designers imagined "core learning experiences" that students would have in the new school. Centering on learners' experiences meant that each of the other spaces (artifacts, processes, systems, and culture) now needed to work to support this aspect of the design. By identifying core learning experiences, designers could begin to envision the elements that would be needed to support those experiences and how the elements would interact.

In these analyses, we see how ideation is more complex than brainstorming a list of solutions. Ideation activities support shared meaning making.

Furthermore, ideation for complex designs often involves envisioning the results of the interactions of designed spaces. However, not all these designed spaces are under the control of the designers; external contexts (those not originally included in the design process) have a significant effect on the design process and what is designed. We turn to this next.

Complication 3: Design Does Not Occur in a Vacuum

Design thinking is often discussed as an insulated process controlled by designers; external contexts and events are rarely referenced. Design, however, does not occur in a vacuum, and the external world steps in and complicates the design process. Thus, the final design is shaped by external forces as much as by the design process itself. In fact, in the design partnership analyzed here, even the initial project goals were influenced by external factors. For example, the challenge to "deploy educators in nontraditional ways" was undoubtedly influenced by the college's emphasis on developing new workforce models for educators. Next, we explore additional external impacts on the project through a process and domain model lens.

Process Models and Complication 3

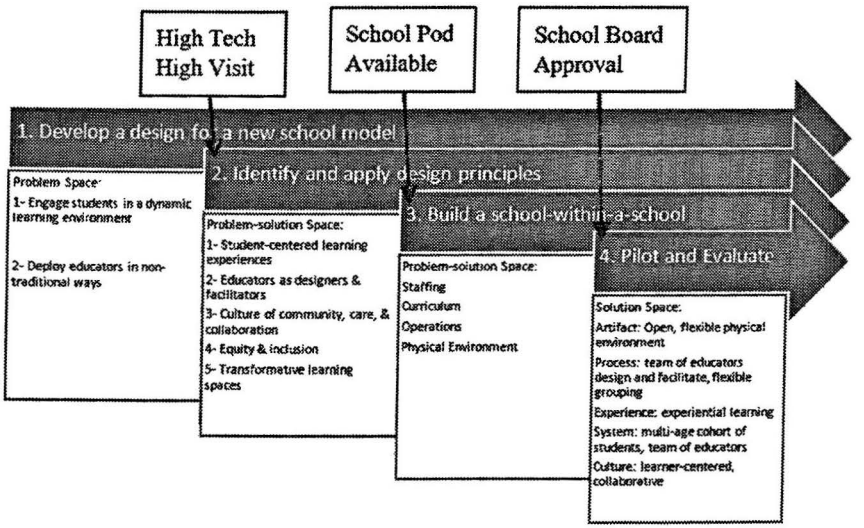
From a process model perspective, external events had a significant effect on defining the problem-solution space. In process models, defining a problem enables a transition from problem exploration to solution formation; it moves the design process from the problem space diamond to the solution space diamond (see Figure 9.2). As we discussed in Complication 1, in this case the problem and solution codeveloped throughout the entire design process. However, there is evidence of several shifts in problem-solution space framing, illustrated in Figure 9.7 as redefinitions of the problem-solution space. The events that sparked these transitions were not part of the original design process plan. They were unexpected, and often external, events. These events—not the design process itself—reframed the problem-solution space and provided a more concrete perspective for moving forward.

One example of such an event was the June 2018 visit to High Tech High, and the discovery of the idea of design principles. Though the visit was planned, how it impacted the design process was unexpected. The slides for the June design session clearly demonstrate how the visit helped the designers reframe the problem-solution space. The slides began with a review of the design research phase, including results from surveys and

interviews—a representation of the current problem-solution space. Then, the DI team shared pictures of their visit to High Tech High, including High Tech High's design principles and how the school embodied them. The DI team latched onto the idea of creating design principles that would focus the design process. The remainder of the June session concentrated on creating design principles for the new school model, an initial, yet important, reframing of the problem-solution space. Figure 9.7 includes these design principles.

Figure 9.7

Design Progress as a Result of External Event



A more critical example of an external factor that influenced the design process was when, in fall 2018, the school district identified a physical space where a new school model could be piloted as a school-within-a-school. The physical space was a school pod: an area in an existing school that included six classrooms, two storage rooms, and a meeting room. The design team now had a new frame and the design process moved from a focus on design principles to what those principles would look like if instantiated in this specific space. Within a few months, designers completed a concrete proposal that brought to life key elements of the model (staffing, curriculum, operations, and physical environment), and presented the proposal to the school board and community. After school board approval, designers turned their attention to the design of the elements needed to enact the

model. This particular school model could not have been implemented if this space had not been identified as a possible space for innovation.

Domain Models and Complication 3

Domain models provide a way to look outside of the design partnership processes, highlighting how external systems and culture impact the design process. The external factors described earlier (when a school pod was made available and receiving school board approval) relied on systems outside of the design partnership. This reflects complexities of the design spaces and the need to work with larger systems. The school model could not be piloted until outside systems aligned. The school board (the governing body for the school district system) needed to approve the movement of the design from the aspirational to the concrete. Nothing could be prototyped with users until it was aligned with the outside system. Furthermore, what could actually be prototyped depended heavily on resources available in the school district, including the school pod that was made available.

Thus, despite the fact that at times during the design process the team was instructed to brainstorm wildly and not worry about "typical time constraints, structures, and requirements," the fact of the matter was that these constraints very much existed and, indeed, shaped their design efforts. For example, despite initial brainstorming about how the pilot design might include students spending some days learning outside of school, seat time policies and safety concerns scuttled this idea. Furthermore, time constraints such as the need to coordinate with broader school-system schedules (transportation, lunch, etc.) needed to be factored into the design. Finally, although design sessions did not focus on financial sustainability, this was very much a part of the presentations to the school board to ensure that the model fit within current financial systems and district resources. Thus, a design domain model allows for thinking outside of the immediate context of the design process, in particular the interaction with broader systems.

Complication 3 highlighted two results of external influences on the design process. First, from a design process perspective, external events moved the process along by helping the designers reframe the problem-solution space in more specific ways. Second, from design domains, any new solutions needed to work within larger systems. This systems perspective on design has another implication: It changes what it means to prototype and test solutions, the issue at the heart of Complication 4.

Complication 4: Designing Systems Cannot Be Done Piecemeal

Designing a new model of school is complicated because it involves coordinating with multiple stakeholders and includes designing across multiple design domains and within multiple systems. Furthermore, the design itself impacts multiple stakeholders. This has implications for what it means to prototype and test, and the scale at which this can happen.

In this context it may be useful to contrast evolutionary and revolutionary approaches to change, particularly in educational contexts (Christensen et al., 2008; Cuban et al., 2001; Ellsworth, 2000; Rogers, 2000). Evolutionary change happens piecemeal through gradual, step-by-step improvements while revolutionary change happens across the system, all at once. In this partnership, the DI team initially perceived the project as evolutionary in nature. A team member explained:

> The charge was to design a school. But I don't think all of us ever truly believed that—or at least believed it would take a long time for it to happen. So the idea was that we could recruit teachers to test and prototype different ideas in their classroom ... I think for the longest time we were evolutionary. But it felt inadequate, since the system would still be the same.... When [the school site was identified] was when suddenly everything shifted. It became revolutionary.

Evolutionary and revolutionary perspectives on change have implications for both process and domain models.

Process Models and Complication 4

Traditional design thinking processes are evolutionary by nature; they focus on iterative processes of divergence and convergence, where the design gradually becomes more defined and refined through prototyping and testing. However, as the scale of this project was actualized, it undermined a foundational aspect of design thinking: the need to experiment and iterate on solutions.

This did not mean that prototyping and testing disappeared entirely; it just took a different form. We argue that the designerly idea of sketching (Pendleton-Jullian & Brown, 2018) may provide a bridge between evolutionary and revolutionary work. Sketches, within the context of design, are representations that afford exploration and evaluation of an evolving design. Sketches support an active exploration of ideas, a way to put something out in a concrete form and examine it. In the context of this partnership, sketches included both representations created during design

sessions and more refined artifacts such as the design principles, reports, or presentations, which allowed for collaborative meaning making and iterative experimentation of the ideas. None of these sketches were complete in and of themselves, but they were each micro-spaces to explore the consequences of design decisions.

Creating and reflecting on sketches was part of the design practice from the very first session, when participants wrote lists of what students will need in the future and discussed these lists with one another. Other sketches were more refined artifacts. For example, the design principles created in June 2018 provided a way to both represent the school model as well as explore potential solutions. The January 2019 design meeting provides another example: the slides for the meeting described four key components (student learning, learning spaces, educator workforce, and program operations) that served as the starting point for further discussion that could be collaboratively explored and built upon.

Domain Models and Complication 4

Although the complete school model might not be amenable to rapid prototyping, domain models such as the five spaces framework could be used to break down the model into different elements. This raises the question of whether each part of the design might be explored in an evolutionary way—piece-by-piece rapid prototyping. For example, could a pedagogical model like problem-based learning (a process), or a flexible classroom space (an artifact), each be developed separately through rapid prototyping, then combined later? Although this might seem logical, the history of educational reform suggests otherwise. Problem-based learning is not new; it has already been developed and used with varying degrees of success (Hmelo-Silver, 2004). Furthermore, in the 1970s, many schools in the United States were designed with open, flexible floorplans, but the experiment resulted in very little school reform (Cuban, 2006; Horwitz, 1979). Thus, the individual pieces of the school model are less significant on their own; it is the interaction of the pieces (the interaction of the five spaces for design) that provides something new. In other words, what is novel is the combination of artifacts, processes, experiences, systems, and culture. This suggests the need for an emergent version of revolutionary change.

In the process that was followed in this partnership we can see two instances of how this worked in practice. The first has to do with the articulation of the design principles that opened a discussion on how the pieces should interact and what they should produce, resulting in a refinement of the problem-solution space. Similarly, describing core learning experiences

concretized the problem-solution space, providing a tangible description to reflect and build upon. The design principles and core learning experiences each described interactions of spaces for design and allowed for reflection on the revolutionary design before actual implementation.

Although design thinking process models focus on an evolutionary approach to design, complicating the process by reconsidering what it means to prototype and focusing on the interaction of design elements might provide a way to bridge from evolutionary thinking to revolutionary change. The four complications and the manner they played out in the actual practice of the partnership indicate that the design thinking process is complex and that each of the models (*process* or *domain)* provides a unique yet complementary perspective on navigating the problem-solution space.

PROBLEMATIZING DESIGN THINKING

Design is a complex human activity and any attempt to capture it through abstracted representations (whether process models or domain models) is doomed to fail. That is not to say that these models are not useful. Moreover, we are not the only scholars to note the limitations of design thinking process models or consider the role systems play in design. Many designers and design scholars have criticized design thinking for trivializing the role of critique, expertise, and design craft (Hernández-Ramírez, 2018; Jen, 2017; Kolko, 2018), assuming outputs will be appropriate and effective (Hernández-Ramírez, 2018; Jen, 2017; Vinsel, 2017); taking a naive perspective on empathy (Kolko, 2018); and over-simplifying design (Hernández-Ramírez, 2018; Jen, 2017; Kolko, 2018; Nussbaum, 2011).

Our analysis, however, shows that these models do have value. For instance, even though design thinking process models failed to fully represent the design process enacted in the university-school district partnership, the core ideas embedded in process models (exploration and ideation, problem framing, and evolutionary prototyping) could be seen in the partnership. Exploration and ideation provided divergence and broad thinking while at the same time supported the development of a shared understanding of the problem-solution space. Reframing (or redefining) the problem-solution space supported convergence to a solution; however, events outside of the design process seemed to play a more significant role in redefining the problem-solution space than internal design activities did. Finally, examples of sketching—a concept similar to prototyping—can be seen throughout the design process.

Design domain models, such as the five spaces for design in education, provided a different perspective on the project by talking about what was

designed: a sociomaterial context resulting from the interaction of elements from different design domains. What was created was not (just) new ideas in pedagogy, classroom design, or educator staffing, it was the *interaction* of old and new ideas. Designing for interaction challenges the evolutionary nature of design thinking; piece-meal prototyping will provide limited feedback on interactions. In the example case, however, progress was made through sketches that increased in complexity. First, design principles and core experiences outlined the desired interactions. The design was then broken down into pieces (staffing, curriculum, operations, and physical environment) which were put together with reference to the design principles. Finally, all the pieces were enacted together in a pilot program. The pilot program offered a way to test the entire model at a smaller scale (one group of 120 students instead of an entire school or school district), supporting further reflection and study of the interaction of elements.

In this chapter, we have highlighted the complexities of design thinking as they played out in a specific case. Neither design thinking process nor domain models fully accounted for the complexity of the design partnership. However, as design thinking matures as a process and becomes part of broader educational discourse, we envisage that design thinking process and domain models will also mature and become more sensitive to the actual context within which educational design functions. By combining these two models—one focused on a collaborative process of understanding and redefining problems and solutions, and the other supporting a systemic perspective for thinking and talking about what is designed and the interactions across and external to the design process—we can develop a more nuanced understanding of design in education and support effective design in educational spaces.

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