Chapter 10
Teaching with Design Thinking: Developing New Vision and Approaches to Twenty-First Century Learning

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> *Give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking; learning naturally results.*
>
> –John Dewey

What will the world be like in 2026? Predications are not easy, but it is easy to count on change as a huge factor. Economic, social, natural, and political forces are in flux and will continue to defy our traditional models and processes for thinking and acting. By 2026, another eight technology innovation cycles will have occurred. Jobs will have shifted even more towards science, engineering and technology sectors. The 50 million K-12 students in public schools will have moved through the education system on their way to further education, work, and adulthood. The year 2026 is around the corner, and it is imperative for learners to be prepared for a continually evolving and changing world. Can schools respond as needed? The skills for adapting and problem solving into the future certainly go beyond the skills and know-how that currently dominate school programs and curriculum. Calls for movement beyond what is currently taught in schools have persisted for years, and its recognized that students are likely to need competencies such as communication and collaboration, research and information fluency, critical thinking, creative problem solving, decision-making, digital citizenship, and technology operations and concepts (Pellegrino and Hilton 2012). It is imperative to integrate these new skills and know-how into the K-12 curriculum. Teachers are the front line professionals of twenty-first century education and are key to how students will be prepared. Helping teachers integrate current and new teaching practices is critically important. Our direction has been to understand how the standards can be seen as a blueprint for a twenty-first century education and how design thinking, which embodies many of the twenty-first century competencies, can be integrated into the K-12 schools. This

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chapter takes a detailed look into how we imagine design thinking can work in K-12 and how we bring it into focus with teachers. We take three directions. First, we describe design thinking, discuss its features and its potential, including how it corresponds with and supports the current standards, and why it is appealing to educators. Second, we describe two cases from the work we have been doing with teachers to review how they make design thinking a reality for their students and a resource for learning. Finally, we discuss the characteristics of professional development that we have found successful for helping teachers consider design thinking pedagogies.

Design Thinking and How It Works in K-12?

The particular version of design thinking that we are implementing is an approach to teaching and learning that fosters students' abilities to find answers to complex problems that have multiple viable solutions. It develops students' skills, dispositions and mindsets, so they can become active participants in a changing world with many problems to solve. It also has a focus on developing creative competence in teachers and students--an ability to tap into principles and strategies that help people approach and solve problems throughout life (Kelly and Kelly 2013).[1]

We take this conception of design thinking and show teachers its potential and malleability in the K-12 learning context. Design Thinking is a human-centered enterprise, and the process is defined by deep and radical collaborations, rapid prototyping, feedback and revision. Design thinking can take on "wicked problems" that may be ill defined or ill structured (Rittel and Webber 1973), and may not be conducive to conventional or incremental methods for problem solving. Tried and true solutions might be absent, and in some cases, the resources for problem solving might seem insufficient (Cross 2006). As an approach for teaching and learning, design thinking embraces active problem solving in the world and aims to create change (Dewey 1916). It is deeply reciprocal and nets outcomes for both the design recipient and the design thinker.

Design thinking is similar to project–based and learning, but it is useful to distinguish between the two. Both project-based teaching and learning and design thinking engage students in sustained, in-depth investigations in topics of real-life importance. They embody twenty-first century teaching and learning competencies such as critical thinking, collaboration and communication, and use of technologies. Design thinking differs on several fronts. It is always driving towards an innovative solution rather than predetermined or pre-understood outcomes. The version of design thinking that we ascribe to at Stanford always takes a human-centered approach to problem solving and change, so in-depth research and learning is put to

[1] The design thinking approach we use is adapted from the one that was developed at IDEO by David Kelley and Tom Kelley and taught at Stanford University.

use in relation to a person's needs. We believe that this empathy factor helps to establish relevance, supports engagement, and offers an answer to the age-old question, "Why are we doing this?" A student who is doing design thinking never solves a problem as a mere intellectual exercise or by designing for his or her own needs; a problem is always being solved for the actual needs of another as they are observed and their needs are unpacked by the designer. The user-centered aspects can be engaging for students who might not be intrinsically disposed to complex problem solving. Finally, design thinking promotes commitments to inter-disciplinary collaborations and teamwork. The process offers outlets for all types of learners to participate successfully and scaffolds involvement regardless of language status, learning preferences, areas of expertise, or personality. The process and outcomes are not about individual achievement; they are about the synergy of people with diverse ideas, approaches and talents. Design thinking benefits the problem solvers by helping them develop new mindsets, which are deeply engrained ways of thinking, orienting to problems, and acting on them (Goldman et al. 2012). Becoming a design thinker is a process that can be defined by moments or experiences of insight or shifts in a person's understandings and dispositions. We like to help learner's accomplish these "*mindshifts*" (e.g., being human-centered and empathetic in their approaches to problem-solving, working in deeply collaborative ways, and recognizing that failure can be a powerful part of the learning process).

Our particular approach integrates and aligns the conceptual and process-related underpinnings of STEM learning and design thinking such as collaboration, deep critical thinking, active problem solving, and a bias towards action. Teachers and students engage in hands-on design challenges that focus on developing empathy, promoting a bias toward action, encouraging ideation, and developing metacognitive awareness (Carroll et al. 2010). Design thinking fosters active and iterative problem solving and solution generation, making it relevant to problem-solving projects in STEM subjects while adding an inventive, innovation-imperative that is highly consistent with the development of twenty-first century competencies. These include innovation, creativity, critical thinking, problem solving, communication, and collaboration skills, which all seen as the basis of a twenty-first century education (Partnership for 21st Century Skills 2008). Design thinking facilitates the learning of skills such as working in groups, following a process, defining problems, and creating solutions. Vande Zande (2007) characterizes design thinking as a means of creative problem solving that relates thought and action directly and dynamically.

There are no easy recipes for how to teach with design thinking and implement it in K-12 classrooms. With its process, skills, and mindsets, there is much to learn and accomplish to make it a reality, integrate it into the subject areas, and to instantiate it as a classroom staple. We explore what is possible with children, teachers, teacher leaders, parents, and educators in supplemental settings such as after-school, summer school, and camp settings. We are specifically interested in how design thinking can be a resource for twenty-first century learning *and* its accompanying challenges. While it is relatively cavalier to say that teaching must change to meet

the demands of the future, we are aware that this is an extremely difficult goal. Teaching is an incredibly complicated and diverse set of epistemologies, experiences, skills, practices, and mindsets that are influenced by the many factors and pressures affecting the profession and in-classroom practices (Berry et al. 2011). Teaching practice takes into account individual and community practices and resources, pressures, and imperatives. Change is complex, and innovation in terms of twenty-first century competencies is sometimes difficult to achieve (Chen 2010; Goldman and Lucas 2012; Hess et al. 2009), although predictions imagine these changes are possible (Berry et al. 2011).

We are optimistic about making change on the ground with teachers. Over the past 6 years, we have been working with teachers in order to introduce them to teaching and learning with design thinking, showing them how it connects to standards, helping them start implementation in their classrooms and schools, and trying to understand both their accomplishments and frustrations. We have done the bulk of this work with teachers through *d.loft STEM Learning*, a project devoted to bringing design thinking to interdisciplinary STEM topics.[2] The inspiration for *d.loft STEM Learning* is the "Design for the Other 90 %" movement (Smith 2007), which consists of engineers, designers, scientists, technologists, architects, and mathematicians engaged in designing low-cost innovative solutions for large portion of the world's population who do not have access to basic services and products. We emulate that work by introducing design challenges that engage participants in relevant STEM topics such as access to, and conservation of water, energy, shelter, and food.[3]

Our process with teachers is to immerse them in a design thinking challenge that engages them in creating solutions for interdisciplinary STEM challenges. Usually, a workshop is a 2-day experience where a topic such as access to or conservation of clean water drives the design thinking challenge. The teachers are put into a "team" that is introduced to a "client" or "user", and it is their job to design for that person's water-related needs. We step them through the design thinking process (see Fig. 10.1), from understanding the problem space, to developing knowledge about their user, to learning how to develop empathy and gain insights, to creating a needs statement for their user, to brainstorming, prototyping and gaining feedback from the user about their solutions.

Through the process, the teachers experience new ways to solve problems and learn, reflect on new ways to teach, and even experience design thinking relevant *mindshifts*. The teachers are often pleasantly surprised that their team solution is so creative and appropriate for their client; they are also impressed with the diverse solutions presented by other teams. Some have experienced *mindshifts*, and see the value of them such as being empathy driven, rethinking failure or gaining insights

[2] Read more about d.loft STEM at dloft.stanford.edu. D.loft STEM is an NSF ITEST project, number 1029929. Any opinions or research reported on is the authors', and are not the opinion of the NSF.

[3] We also produce curriculum materials on these topics. They are available at: http://tinyurl.com/designthinkingcurriculum

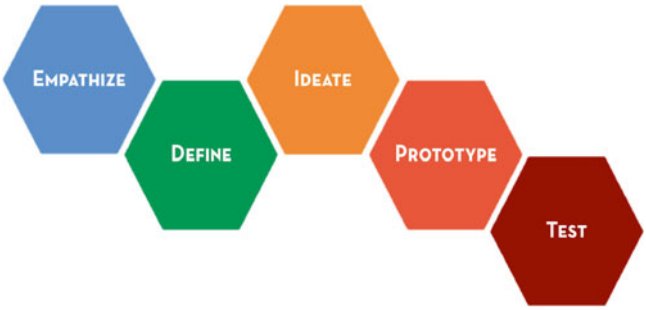

Fig. 10.1 Stages for learning design thinking
We teach six stages of the Design Thinking Process as represented in this graphic. Starting from an open-ended problem space, students go through the Empathy process in order to Define a concrete design problem to be solved. In the Ideate, Prototype and Test stages they generate, refine, and communicate possible solutions in an iterative fashion

	Common School Value	Value from *Mindshift*
Assignments	Scripted problems	Authentic challenges
Problem-Solving	Solution-driven	Human-centered and empathy-driven
Valued Outcome	Correct Answers	Innovative Solutions
Evaluation	Polished final products used to assign grades at the end of an assignment	Low-resolution prototypes used to elicit feedback throughout the project
Nature of Work	Independent work or team work with individual grades	Deep collaboration in service of innovation
Feedback	From your teacher, feedback explains your grade	From specific user, feedback drives iteration
View of failure	Failure, F, a grade that is not passing, something you are ashamed of and wish to forget or hide	Failing forward- failure offers key information for your next steps, to be learned from and be proud of, breeds persistence
Audience	Teacher, possibly other students	People, community members, specific users
Goals	Learn specific content, hope for later application	Learn content, make contributions to meet people's needs, develop creative confidence and efficacy

Fig. 10.2 Design thinking *mindshifts*

about why prototyping solutions can be powerful (see Fig. 10.2). Learning design thinking can be a very exhilarating process, and we capitalize on that positive energy to reflect with teachers about how design thinking can be generative or integrated in school subjects and disciplines. The last part of the professional development experience is to give teachers to time to sit together and reflect, then do some active planning for how they might bring design thinking back to their students.

Through this process, we provide educators the opportunity to engage in an experiential and hands-on process for creative problem solving that both models and is inclusive of twenty-first century skills. We have them experience the tools they need for taking some aspects of design thinking back to their classrooms and schools. Then, we follow up with teachers in several ways. One form of follow up is to invite teachers to the next level of workshops focused on designing lessons so they can further develop design thinking skills and learn to coach or train other teachers. Another involves periodically checking in with the teachers to offer them support and coaching regarding the implementation of design thinking in their classrooms, a method that helps us understand the successes and challenges associated with implementation, mitigate the challenges, and promote further successes. We understand that even expert design thinkers are always in learning mode, and we do not expect that it is easy for teachers to come from one professional development experience and then be willing or ready to replicate it in their classrooms. We do encourage teachers to bring any aspect or tool of design thinking they are comfortable with into their classrooms or schools. This has produced a diverse set of post-workshop experiences. We have had teachers who attended a workshop in a school team implement a design thinking project for their entire 9th grade. Several other teachers at the same workshop used brainstorming approaches back in their classrooms. A few others began using empathy mapping with their students, which is a particularly powerful tool we teach for the development of perspective taking. We have also had teachers who tell us they consider design thinking and apply it to their own lives, and feel comfortable with this as a starting point before applying it within their classrooms.

Design Thinking and the Standards

We work with K-12 teachers, educators working in supplemental settings such as after-school programs and museums, and their administrators. We have worked with over 300 educators to date. We have found that an effective way to engage teachers in the potential of design thinking is to apply it to the challenges they face back in their classrooms. We connect design thinking practices to curriculum challenges in the context of the current accountability demands, including the implementation of the Common Core Standards (CCSS) and the Next Generation Science Standards (NGSS). We believe that each document contains a critical mass of standards that are well aligned to the design thinking process and mindsets and as such, teachers have a warrant to apply these methods in their classrooms in service of the standards. This connection for teachers is crucial to their consideration of design thinking in their work with students.

The Common Core Standards for Literacy across the Content Areas (CCSS)

How do the standards support design thinking? The *Common Core Standards for Literacy Across the Content Areas* (CCSS) privilege specific academic skills such as multiple perspective taking, the synthesis of information from multiple sources, and in the disciplines, the application of understanding through argumentation & justification. As you will see in the case of work we do with educators in Salt Lake City, Utah, these practices are integral within design thinking.

Additionally, the CCSS "offer a portrait of students who meet the standards set out in this document" (National Governors Association Center for Best Practices & Council of Chief State School Officers 2010: p. 7). In this portrait, writers of the standards present seven capacities of students demonstrating college and career readiness in speaking, listening, reading, and writing across the content areas. These capacities are elaborated more specifically within the standards themselves. We believe that design thinking practices and mindsets have the potential to directly support the development of four of these seven capacities. This is not just evident in the presentation of the capacities themselves but also in terms of the individual standards that are aligned to each. Figure 10.3 names the four capacities of college and career readiness that we feel are explicitly aligned to design thinking, examples of standards that are representative of the capacities, and examples of activities within design thinking that can be used to build students' capacities.

In our professional development sessions, we teach the design thinking process as a hands-on fast moving set of steps. We feel that it is helpful for teachers to complete an embodied experience of the process in order to gain insights about how these tools can be applied to their practice. The teachers engage in the design thinking process primarily as learners, working collaboratively with others to solve real-world problems using tools specific to design thinking, and as such, have the experience of learning aligned to the core. We help teachers identify the ways their design thinking experience is aligned to the standards. By providing them with scaffolded discussion connecting their experience of design thinking to current standards, we avoid preaching a pre-specified fit that feels misaligned, and instead, afford the opportunity to visualize and plan for how this pedagogy could both fit into their current practice and meet the standards. Over several years of workshops, we have come to understand that the capacities and standards detailed in Fig. 10.3 are those most commonly identified by educators as core-aligned.

With regards to the modalities delineated in the core standards—that speaking, listening, reading, and writing are the domains for student engagement—our introductory workshops typically involve prioritizing tools for maximizing engagement in speaking and listening while educators learn the design thinking process. Then, when teachers develop an application of design thinking to their classrooms and instructional environments, we present examples of design thinking curricula that directly engage students in all four domains for engagement. Additionally, we provide one-on-one coaching, access to teacher developed resources, and connections

Capacity for College and Career Readiness	Sample of Standards Aligned to Capacity	Relevant Stage, Tool or Mindset used in Design Thinking
COMPREHEND & CRITIQUE: "Students are engaged and open-minded—but discerning—readers and listeners. They work diligently to understand precisely what an author or speaker is saying, but they also question an author's or speaker's assumptions and premises and assess the veracity of claims and the soundness of reasoning."(pg. 7)	CCSS.ELA-Literacy.SL.6.1c Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. CCSS.ELA-Literacy.SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes. CCSS.ELA-Literacy.WHST.6-8.2d Use precise language and domain-specific vocabulary to inform about or explain the topic.	EMPATHY: ⇒ Interviewing ⇒ Note-taking during field observations ⇒ Note-taking during interviews ⇒ Collaborative sharing of notes from observations interviews ⇒ Do and say portion of the empathy map. ⇒ Capturing user feedback from multiple sources. PROTOTYPE, TEST: ⇒ Developing and presenting solutions.
VALUE EVIDENCE: "Students cite specific evidence when offering an oral or written interpretation of a text. They use relevant evidence when supporting their own points in writing and speaking, making their reasoning clear to the reader or listener, and they constructively evaluate others' use of evidence." (pg. 7)	CCSS.ELA-Literacy.SL.6.3 Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not. CCSS.ELA-Literacy.WHST.6-8.2b Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. CCSS.ELA-Literacy.W.6.1b Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.	EMPATHY: ⇒ Using "do" and "say" quadrants of the empathy map to make inferences recorded in the think and feel quadrants. DEFINE: ⇒ Writing and revising point of view statements. TEST & ITERATE: ⇒ Collecting user feedback from multiple sources ⇒ Iterate on prototype using information from user testing.
ESTABLISH KNOWLEDGE BASE: "Students establish a base of knowledge across a wide range of subject matter by engaging with works of quality and substance. They become proficient in new areas through research and study. They read purposefully and listen attentively to gain both general knowledge and discipline-specific expertise. They refine and share their knowledge through writing and speaking." (pg. 7)	CCSS.ELA-Literacy.CCRA.W.7 Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. CCSS.ELA-Literacy.CCRA.W.8 Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. CCSS.ELA-Literacy.CCRA.W.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.	EMPATHY: ⇒ Interviewing ⇒ Note-taking during field observations ⇒ Note-taking during interviews ⇒ Using fiction and non-fiction text as a data source to inform the problem space DEFINE: ⇒ Writing and revising point of view statements. IDEATION: ⇒ Collaborative brainstorming based on point of view statement PROTOTYPE: ⇒ Building low-resolution prototypes to meet a users need within a problem space TEST & ITERATE: ⇒ Presenting prototypes to users ⇒ Gathering feedback from users ⇒ Making changes based on feedback

Fig. 10.3 Design thinking in the common core state standards for english language arts and literacy in history/social studies, science, and technical subjects. First two columns are quoted text from National Governors Association Center for Best Practices & Council of Chief State School Officers (2010b)

UNDERSTAND OTHER PERSEPCTIVES & CULTURES: "Students appreciate that the twenty-first-century classroom and workplace are settings in which people from often widely divergent cultures and who represent diverse experiences and perspectives must learn and work together. Students actively seek to understand other perspectives and cultures through reading and listening, and they are able to communicate effectively with people of varied backgrounds. They evaluate other points of view critically and constructively. Through reading great classic and contemporary works of literature representative of a variety of periods, cultures, and worldviews, students can vicariously inhabit worlds and have experiences much different than their own" (pg. 7)	CCSS.ELA-Literacy.SL.6.1d Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. CCSS.ELA-Literacy.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.	Perspective taking is accomplished not only via addressing this capacity but also as an extension of the each of the capacities & activities presented above. MINDSETS ⇒ Perspective taking through user cantered design. ⇒ Perspective taking through radical collaboration. ⇒ Perspective taking through interviewing and empathy mapping. ⇒ Perspective taking through iteration based on feedback

Fig. 10.3 (continued)

within a network of educators who are applying design thinking in service of students' mastery of the core standards.

Next Generation Science Standards (NGSS)

Design Thinking pedagogy also attends to and aligns with the Next Generation Science Standards (NGSS). NGSS were developed as a coherent companion to the CCSS but the utility of design thinking to these standards is not limited to it's shared relevance to the CCSS. Our work in design thinking has concrete relevance to many of the disciplinary ideas, crosscutting concepts, and science and engineering practices that are broken down in the NGSS. For example, in an international water challenge, design teams read a user profile detailing the struggles of an intergenerational family of farmers from Hyderabad, India. This firsthand account describes the need for ever-deeper wells as water continued to grow scarcer because of government drilling and water overuse by humans in a climate not suitable for farming. This introduces students to the disciplinary core idea in ESS3.C[4] of the NGSS, "typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on the earth unless the activities and technologies involved are an engineered otherwise." In this activity, students first define the problem from the perspective of the user, a task that necessitates discussion of specific behaviors and their effects over time on the ecosystem (thus addressing crosscutting concepts cause-and-effect and systems). Next, they engage in the science

[4] http://www.nextgenscience.org/ms-ess3-3-earth-and-human-activity

and engineering practice "apply scientific principles to design an object, tool, process, or system" as they brainstorm and prototype solutions to meet the users needs while also taking into account the environmental constraints.

In another design task, the water filtration exploration, learners interrogate disciplinary core idea ETS1. B. This standard is explicated in performance expectation MS-LS2-5,[5] which indicates that in covering this standard, learners "Evaluate competing design solutions for maintaining biodiversity and ecosystem services". Water purification, an ecosystem service, is explored as design teams plan, prototype, and test filtration devices that use different combinations of natural materials. As the students compare and evaluate designs within and across teams, they take up a key science and engineering practice: engaging in argument from evidence. Design teams work together to identify the best possible design drawing on evidence recorded during the challenge. This relates to the crosscutting concept of stability and change as designers have the opportunity to observe firsthand how small differences among purification systems can result in large changes in outcome. Through these and other activities, the water curriculum provides teachers with a proof of concept regarding the application of design thinking to support knowledge development around disciplinary core ideas and crosscutting concepts in the NGSS.

While uptake of the disciplinary core ideas and crosscutting concepts is absolutely integral to our work, the strongest alignment between design thinking and the NGSS is definitely in the science and engineering practices listed for each standard. This section of the standards explains broadly what a teacher should do, but there is no elaboration on the methods or pedagogical tools needed for operationalizing these steps. By contrast, our design thinking professional development provides teachers with specific tools, processes, and strategies for building students' capacities to engage in these practices. Figure 10.4 shows several Science and Engineering Practices that should be used in instruction of the Motion and Stability standards for middle school students. The first, asking questions and defining problems, indicates that teachers should have students ask questions that can be answered in local contexts and, if appropriate, follow up with observations and hypotheses. This leaves a reader wondering exactly how this is done. You cannot just tell a middle school student to go out and ask answerable questions. The process and mindsets utilized in design thinking provide teachers with a set of tools, strategies, and coaching techniques for this and other engineering practices. These practices are addressed in the international water challenge and filtration exploration described above. While these activities are from our curriculum for students, teachers are first introduced to the tools during workshops where the curriculum is not the focus. As an example, we take the NGSS practice "asking questions and defining problems". At the start of a 2-day workshop, teachers are given a grand challenge and, as learners, they are introduced to structured protocols for observation and graphic organizers for synthesizing data and evidence. Facilitators coach teams through a multi-step process

[5] http://www.nextgenscience.org/msls-ire-interdependent-relationships-ecosystems

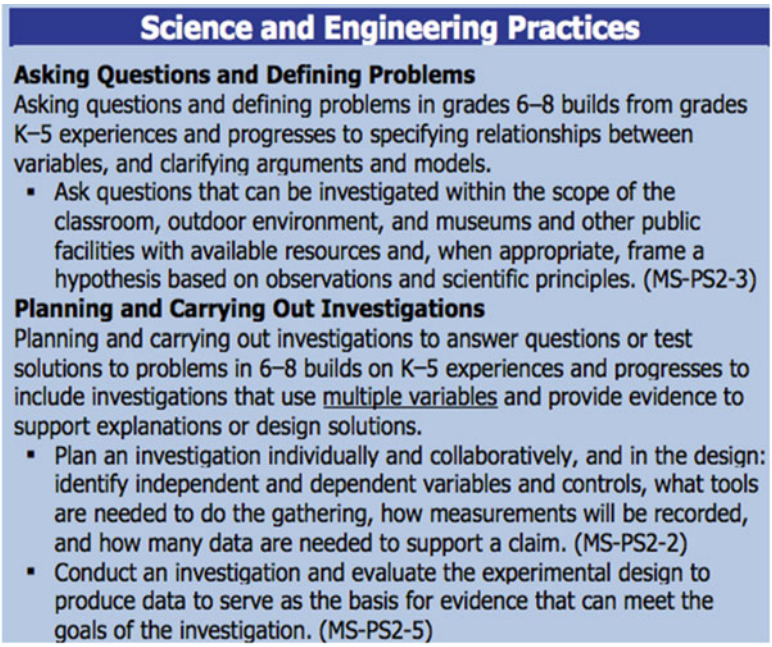

Fig. 10.4 Example of science and engineering practices (Excerpted from: Achieve, Inc., Disciplinary Core Ideas (2013))

for developing context-specific problem statements. Through firsthand experience and reflection, teachers develop a clear understanding of one way for students to ask answerable questions and define problems. Since the engineering practices in the NGSS and the design thinking process are each informed to some degree by the engineering design process, the relevance of our tools is not restricted to asking questions. Various techniques are introduced for each phase of a design challenge, and through this variety in method, teachers develop a robust pedagogical toolkit (See Fig. 10.5 for additional information about the link between design thinking and the NGSS Science and Engineering Practices).

We do not contend that our tools are the only ones that can be used to accomplish the engineering practices, only that they are suitable, contain sufficient detail to be actionable, and can be used flexibly (as a collective set or one at a time as needed). By sharing some examples, we are drawing attention to the applicability of design thinking to the new standards. Furthermore, we are making the claim that the inclusion of science and engineering practices in the NGSS provides a warrant for the use design thinking and alignment details as evidence that design thinking is a highly relevant process to teaching of both the CCSS and NGSS. Teachers, often exhilarated by the tools we offer, should see the new standards as opening the door for applying design thinking in service of the new standards.

Science & Engineering Practices in NGSS	Relevant Stage and Technique/Tool used in Design Thinking
1. Asking questions (science) & defining problems (engineering)	DEFINE: ⇒ Characterizing the user ⇒ Characterizing the needs of a user ⇒ Writing and revising point of view statements
2. Developing & using models	PROTOTYPE: ⇒ Building low-resolution prototypes to meet a users need
3. Planning & carrying out investigations	This occurs when a project covers each stage of the design thinking process and includes some or all components associated with EMPATHY, DEFINE, PROTOTYPE, TEST, ITERATE
4. Analyzing & interpreting data	EMPATHY: ⇒ Triangulating evidence in "do" and "say" quadrants of empathy map to make inferences recorded in the "think" and "feel" quadrants. DEFINE: ⇒ Making deep, user specific inferences explaining tendencies of a particular user by triangulating data collected during empathy phase IDEATION: ⇒ Organizing potential solutions into categories ⇒ Rank ordering potential solutions based on specific criteria TEST & ITERATE: ⇒ Synthesizing feedback gathered during testing ⇒ Engaging in collaborative decision making about iterations to models and prototypes based on this feedback
5. Using mathematics	N/A
6. Constructing explanations (science) & designing solutions (engineering)	PROTOTYPE: ⇒ Planning for low-resolution prototype ⇒ Building low-resolution prototypes to meet a users need within a problem space ⇒ Increasing resolution of prototype after numerous feedback driven iterations
7. Engaging in argument from evidence	EMPATHY: ⇒ Justifying inferences recorded in the "think" and "feel" quadrants using direct observations recorded in the "say" and "do" column IDEATION: ⇒ Using point of view statement and evidence from empathy map to identify, discuss and select most relevant solution(s) to prototype
8. Obtaining, evaluating, & communicating information	EMPATHY: ⇒ Interviewing & field observations ⇒ Note-taking during field observations and/or interviews ⇒ Collaborative sharing of notes from observations interviews IDEATION: ⇒ Collaborative brainstorming of hundreds of possible solutions for a problem statement PROTOTYPE: ⇒ Dialogue supporting collaborative development of prototypes TEST: ⇒ Presenting prototypes to users, clients, and other design teams ⇒ Collecting user feedback from multiple sources

Fig. 10.5 Alignment between design thinking and NGSS science and engineering practices

Two Case Studies

We present two case studies of work we have done with teachers. They are meant to be snapshots of the professional development experiences we have been creating and where teachers have taken them. The workshops are an active and engaged process for the teachers. They introduce design thinking process, techniques and mindsets through interdisciplinary STEM topics as we are aware of how important

it can be for professional development to do so in relation to content (Garet et al. 2001). As discussed, we provide opportunities to understand how design thinking aligns with the standards. In each instance, our work draws on strategic partnerships so that the workshops we offer teachers do not end up being stand-alone in nature. We also include opportunities for school or team planning and conversations with other teacher coaches and mentors (Lieberman 1996), and then we work with our partners on follow-up, in the hopes that workshop essentials can develop within the educators' practice.

The two cases represent different partnerships and models of how professional development with design thinking can be implemented. They are not meant to be the only ways we can imagine bringing teachers to design thinking integration. In fact, we have tried other models, including stand-alone workshops with entire school faculties and "apprenticeship models" where we teach design thinking side-by-side with individual teachers. We concentrate on two cases because they exemplify efforts for which we have seen positive results. Even so, they surface issues about the challenges that lie ahead with design thinking as pedagogy in K-12 classrooms. The first case tells a story of how design thinking can influence pre-service teacher education while also impacting veteran teachers and students. In the second case, we discuss the work that we have done in Salt Lake City, Utah with in-service teachers, and profile how one teacher who attended our workshops has fared with design thinking. The two cases illustrate how and why we work with teachers, how they can innovate with design thinking based on the situations and conditions in their classrooms, schools, and school communities, and how to see some of the issues teachers face. These cases inform the discussion that follows them.

Case 1: The Introduction to Teacher Education

The 8th grade classroom is buzzing with students huddled in groups at tables and desks. They are intent on solving a design challenge. They are making "boats" and seeing how much weight in pennies their boats can carry without sinking as they float them in a huge tub of water. Their boat material is aluminium foil. The first round brings results shouted from around the room: 68! 92! 47! Their teacher tells them to try again, redesigning their boats on the basis of observations from the first round. Pre-service teachers from the Stanford Teacher Education Program (STEP) are mixed in the groups. They are observing and coaching the students, helping them reflect on what happened in the first round as they plan for their next, hopefully, better performing boat. Five minutes later the groups are chanting their counts as they place pennies one-by-one in the new boats. This time some students are more careful to place pennies in one at a time. One group is strategic about where in their boat they place each next penny. They are talking around the topic of surface area as they place coins. Some students are now confident that their boats will be more successful. "Ms. G, we already have 100 and our boat is holding." A second group has 115 pennies. Another couple of groups are on their third boat. Finally, a

group puts the 158th penny on and the last boat sinks. Time has run out. Cheers go up, and then the students start to figure out what made their second round designs more successful. The students come up with ideas based on the experience. They discuss density and surface area as it pertains to water. They also discuss the prototyping process and what was learned from each cycle of design and iteration.

After class that day, the master teacher met with the STEP students to reflect on the day's activities and plan for the next few days. The novice teachers were curious. They were excited about the eighth graders enthusiasm and know-how. When asked about how they were feeling about the class, one young teacher-to-be responded that she had never seen anything like this: "The students have not picked up one textbook, yet they are learning so much from the activities and each other. I don't know how this is happening." We talked briefly about the content being considered by the students, then moved quickly to a discussion of the range of teaching methods that are possible in classrooms. As we talked, it was revealed that most of these novice teachers had been taught with traditional methods when they were in school. What they were part of now was strange to them, but they were curious and felt engaged. A few related how students were excited about the class activities and thought they were generating reasonable solutions and ideas about them in the activities. Over the next 4 weeks and 80 h of summer school, they were exposed to how design thinking presented new possibilities for how activity in the science classroom could be structured to increase engagement, involvement and active learning.

This practicum experience for pre-service teachers provided one route to introducing design thinking in the classroom. Even with prospective teachers there is a need to experience new and varied ways of teaching STEM topics, and before this class, design thinking was not on their radar. The design thinking summer school classrooms were a relatively low-stakes way to give the pre-service teachers an immersion view of new practices that have potential for shaping their professional vision. We were hoping that it would provide a foundational experience.

The teacher education program at our university works in partnership with a local school district. It is committed to having theory and practice meet in the classroom, and the summer practicum is one of the first sites for new pre-service teachers to begin understanding the complexity of teaching. With immersion of all pre-service teachers in one school's summer school classrooms, the program takes aim: "The links between theory and practice, university and school, experience and standards, are the links of learning" (STEP website 2013).

The *d.loft STEM Learning* team developed the design thinking-based curriculum units that were used as the summer school science curriculum. The summer school serves rising 5th through 7th graders in the district, and the science classrooms serves up to 250 students in any given year. The summer school has an extremely diverse population that mirrors the district diversity, which is: 19.7 % white, 2.5 % Black or African American, 42.0 % Hispanic or Latino, 23.5 % Asian, 7.6 % Filipino, 4.7 % other races or mixed race. Within the district, 36.5 % of students are English Language Learners and 47.6 % of students receive free and reduced lunch. The science faculty for the school consists of four veteran teachers who have super-

visory experience and capability. Added into the yearly mix are 15–20 newly enrolled pre-service teacher education students with interests in science teaching.

While we were able to observe in summer school and talk with all of the teachers, it was difficult to find out how the in-service teachers incorporated design thinking into their work in classrooms. Anecdotally, we learned that several did complete lessons or planned their required teaching unit with design thinking. We are finding ways to do more to reinforce the early learning of the pre-service teachers and we are working with the STEP program to figure out how to better supplement the summer experience, given the intense requirements and fast pace of this 1-year masters level program.

While it has been difficult to track how the pre-service teachers were affected by the summer school experience, we have been able to see the effects that the design thinking approach has on the summer school master teachers. In our first year, the master teachers were also new to design thinking, yet had taken the positions knowing they would have the chance to teach it integrated with science. The master teachers attend a 1-day workshop where we experienced a design thinking challenge, discussed it in concept and practice, and then completed a read through of the curriculum unit that our project team developed. Our team answered questions about specific activities and more general ideas in design thinking. The teachers then set up their classrooms and prepared to help the pre-service teachers to fit in as observers and helpers. Their model is very similar to an apprenticeship model in approach, with master teacher orchestrating the classroom and novices observing and helping.

And what happens to the master teacher? Over the 3 years that we have held this partnership we have worked with nine master teachers and 45–55 pre-service teachers. We hope that the work benefits everyone, from student, to teacher education student, to master teacher. The teacher education students get to experience firsthand new, twenty-first century teaching and learning, and to see how powerful it can be for students. It starts to help them learn new possibilities for teaching that go far beyond the ways they were taught. Even though we think that those entering the profession are digital natives or products of standards-based teaching, we learn that their schooling experiences were predominately traditional in style. Master teachers tell us they were there to enhance their abilities to add new teaching ideas and practices to their repertoires as they supervise novice teachers. There are learning goals and new horizons being sought for all involved.

One master teacher, Claudia, became very enthusiastic, and following the summer, took design thinking back to her school in a nearby district. She entered into collaboration with another teacher, and together they established a new after-school program that was STEM focused. Twenty-five students were chosen to participate in design thinking, leadership and teamwork activities. The teachers loosely based their program on the *d.loft STEM Learning* water curriculum that Claudia had used in the summer school. They worked on a global warming challenge that involved designing ways to conserve water and energy at their school.

Students utilized data collected by the district to improve the amount of energy the school saves by focusing on the shutdown of electronic devices before extended

weekends and vacations. Once the children came up with designs, they educated others in the school about their program by visiting every classroom. With implementation, the school actually improved its energy conservation significantly. The program won high marks from all involved, and the *San Jose Mercury News* featured an article about the program (Wilson 2013). In the article Claudia was quoted: "It's always about targeting those other ways of thinking in kids that can help them learn something more"…"The whole concept revolves around energy conservation, which they can bring home and expand it, replicate it and use those skills in real life. That's every teacher's goal."

Claudia was not alone. Another mentor teacher returned for a second year, and was joined by three new mentor teachers. The mentor teachers who taught in public schools were looking forward to using design thinking back in their classrooms. Like Claudia, we are hoping that the experience of being a mentor teacher in partnership with a teacher education program helps build the capacity for leadership with other colleagues. We consider this a strategic and useful way to introduce and spread design thinking practices.

Case 2: The Utah Experience–Supporting the Utah Core Standards Implementation

Melinda, a 6th grade teacher, sits in a chair facing 20 other teachers in the middle of a school multi-purpose room. She's been asked to tell them her story of how she came to teach with design thinking. She explains how she attended a workshop and then started using a few design thinking-based lessons in her classroom. In speaking about what really invested her in design thinking, she recalls they ways her students responded to an after-school design thinking class she began offering 2 days a week. Through that class she:

> …got to look a lot at the different parts of the process and skills, and the kids loved it. They kept saying, "Oh could we do this more in the classroom, more in the classroom because we are so engaged. This feels real to us, this is real." It made me think, well, when they get into the workplace, this is real, this is what it will really be like. So I started putting more [design thinking] in my classroom and writing more and more lessons and unit plans that dealt around the whole thing.

While the appreciation of the students for how they were learning was impressive, Melinda was also encouraged to go further because of how she saw design thinking aligning with the standards and how she might engage them in the classroom. From the first workshop she attended, she saw the connections between design thinking and the standards:

> I'd been working with the ELA core standards for a bit. The whole way through every new step that we did, I'm like, oh my heavens, there's inferencing, there's taking multiple perspectives, there's providing evidence. So I could see the core standards were just built into the whole process, but at a deep, using level. So I'm like, Oh, this is how I'm going to

deepen my instruction in my classroom for the depth of knowledge. I'm going to put these pieces in.

Melinda took the initial connections she saw between design thinking and the standards and began to work at pairing them systematically in her classroom. She brought individual aspects of design thinking into play such as observation, brainstorming and empathy mapping. During a follow-up workshop focused on curriculum construction, Melinda worked with our team to construct a design thinking workshop for the school-community council; this was a strategic effort to demonstrate to parents the benefits of design thinking for their children and the school community. The resulting success with the community council got the attention of her fellow teachers and administrators, prompting their attendance to the next available design thinking workshop offered by our team. Melinda left this workshop having planned a design challenge on Ancient Egypt, a required set of standards in her 6th grade curriculum. In this challenge, her students designed an Egyptian museum that was visited by the entire student body, teachers and parents.

The teachers at the workshop asked Melinda questions about how she made these connections with design thinking and how she gained the support of her principal. She admitted that her principal had been skeptical when she first was suggesting after-school classes, parent workshops, and family fun nights. His interests changed when parents began approaching him with excited comments about what their children were doing. When the students' test scores, that had been flat for the prior few years, showed significant improvement, the principal was officially on board.

Melinda explained that she was an early adopter of the new core standards because she saw them as a more rigorous approach. She started planning lessons that would help her students achieve the new standards, and her students told her they then had an easy time with the high-stakes tests (that still measured the older standards). When design thinking came along, it gave her a way to deepen the implementation of these standards by affording relevance and engagement with the new skills and competencies required. As a result, her students' test scores rose. She emphasized that what she did was not about test scores; it was about approaching the comprehensiveness and deep conceptualizing of the core standards in a meaningful way.

The museum challenge and the improved test results sparked the interest of the other 6th grade teachers, and they came on board and helped plan three standards-based design challenges that would take place in the upcoming school year.

Another example of how Melinda and her grade team plan shows how they accomplish the implementation of design thinking with standards in an interdisciplinary course of study that is both STEM and language arts based. Melinda noticed that every year, her students did not score well on the state standards related to the phases of the moon and seasons. She and the others thought about how they could incorporate some "deeper" learning since they were not performing as well as on other concepts. In the design challenge the plan was for the students to take up one of the two topic standards, ask some essential questions, and conduct background research. Then in design teams, the students would interview second graders, who

also have those topics in their core. The interviews would lead the older students to plan and write informational texts about the moon and the seasons. Melinda feels that if the sixth graders can interview, do the research, create the narrative stories and informational texts, and read them with the younger students, they will learn the science.

In Melinda's words, "it just keeps snowballing." She claims she is not an extraordinary teacher

> And like I say, I don't consider myself a fabulous teacher or anything. I just take the things that I have—the cognitive rigor matrix, the design thinking. "Where are my students low? What can I do to impact that area and help them out? So design thinking has really hit a lot of those areas.

Many would think that Melinda is very humble, and that she is actually exceptional teacher. Melinda is certainly an early adopter and a teacher who like to get done what she is responsive to her students' needs. She uses the tools she has available, in this case, the Utah Core Standards, the cognitive rigor matrix,[6] available data on her students' progress, and the support she can get from others to implement a practice of design thinking pedagogy. Even though she is modest, she may be the definition of the kind of teacher we need to really prepare kids as twenty-first century learners. When she tells other teachers how she does what she does to help her students learn, it makes sense to them. They ask her questions about how they might get started, and double-check that she said this helped raise her students' test scores.

The work that Melinda does in her classroom and what she does by helping to work with other teachers and after-school educators is extremely important. The amazing part of her story is how far she stretches to help others with design thinking. In the 2 years since she was first introduced to design thinking, she has run a year-long after school program and a week-long camp at the Utah Museum of Natural History, and facilitated design thinking workshops for after school educators. She goes "on the road" to do workshops. She is creating and on-line professional development course for other 6th grade teachers that profiles design thinking and standards integration. She is early adopter who is energized, and loves to spread the word. She does this advocacy work because she thinks it is so important to find ways to help children become accountable and successful learners. She wants the students to be ready for whatever comes next in their lives, and for right now, design thinking is one of the big ways she is helping them achieve that kind of learning. She wants to help other educators get on board because the needs are great.

Melinda does not standalone. In the time we have been doing design thinking workshops in Utah, 150 teachers have attended our introductory workshop, and 25–30 have returned one or more times to learn more design thinking and learn to coach others. The teachers who have returned have made strides in incorporating design thinking into their schools and classrooms. One group of six to eight from a STEM magnet school have done several design thinking challenges in their school, from having the entire 9th grade complete a school-wide challenge, to incorporating

[6] See Hess et al. (2009).

lessons based on design thinking methods such as developing empathy and creating empathy maps into classroom subjects, and creating an design thinking themed elective period. There have been partnerships among the science and language arts teachers at the school around design challenges. Three or four of the teachers have returned to workshops to coach others and talk with them about the nuts and bolts. Other teachers have developed an online course for teachers who teach British Literature, so they can learn to create design challenges inside of their language arts classes.

While we can't be sure of what every teacher takes away from the design thinking experience, we have been able to learn why the teachers who have returned are doing so. The teachers seek out the workshops and the follow up implementation experiences because they are hoping to better meet the learning and life needs of their students. They are hoping to find ways to have their students develop an interest in varied ways of learning, to love learning, and to be prepared for what happens outside of school. They are hoping that students can make more progress than they have to date. They are mission driven, and aware that the record in Utah needs improvements.

Public education in Utah provides a context of need. There are almost 600,000 students in Utah with 77 % white, 15 % Hispanic, and the other 8 % divided between American Indian, Asian, African-American, Pacific Islander, and multiple races. Fiscal year 2011 shows Utah spend the least amount of money per pupil of any state in the country at only $6212.00 (Governing the States and Localities 2013). The average pupil-teacher ratio in Utah is 22.0 as compared the national average 15.4 students. The high school graduation rate is 79 % with 59 % of those seniors who drop out being English Learners (National Center on Educational Statistics 2013). Almost 60 % of high school graduates enter college, yet the University of Utah reports that the graduation rate is lower, especially among women who lag behind the US average (University of Utah 2007). Salt Lake City is a US designated refugee settlement city, and also has many students who are new to the country and US culture. Utah educators at all levels of the state and partner organizations have made a commitment to creating innovative approaches to marshaling resources to benefit the children and youth of Utah from pre-kindergarten to post-secondary education. A huge issue is how to develop opportunities for all Utah students to be career and college ready (Prosperity 2020 Initiative (2015)).

It is against this backdrop, and in support of the new standards that our group has partnered with the Utah State Board of Education to offer a design thinking approach. We have tried to leverage our partnership so that it can reach beyond the typical boundaries that exist around the academic subjects by reaching out to teachers, school leaders, supplemental educators, and those working across the subject areas.

Melinda and the other Utah teachers have been part of activities to help see design thinking as a viable form of pedagogy that connects to content, the standards, and the outcomes they would like for students. They are supported through the professional development workshops they attend, the time, resources and support that they are given through the State Office of Education and in their districts and schools

for individual and team planning and implementation work. Several teachers have been working on the standards implementation and assessments have attended the workshops, reinforcing the connection between the standards and activities such as design thinking. With the support given by our team, state office personnel, the welcoming staff of the Utah Museum of Natural History and the Museum of Natural Curiosity in terms of facilities and access to scientists and designers who can help in design challenges (as experts and users concerning environmental topics such as those we introduced), the professional development of after-school educators, we have set in to motion the goal of making design thinking one of the viable pedagogies available to Utah teachers.

Discussion and Conclusion

As the cases illustrate, trying to make design thinking a choice in teachers' toolkits is a lofty goal, and there are many pathways that are possible. We take several in our professional development work. The cases share some features: (1) they each take an approach to immerse teachers in design thinking as learners; (2) they introduce teachers to interdisciplinary teaching and learning, providing opportunities for discussion, reflection and planning; and (3), they leverage partnerships with organizations that have the capacity to help the teachers carry forward and amplify the work. We discuss each feature with regards to how it contributes to the potential for strengthening teacher practice through the uptake of design thinking.

Immerse Teachers in Design Thinking as Learners

Educators who engage in our workshops experience authentic twenty-first century instruction as learners. Our model of professional development honours the fact that teachers, like their students, are independent thinkers and learners who develop mastery based on authentic experiences, collegial collaborations, and opportunities to reflect. When asked what they liked about our professional development in a post workshop evaluation, we received many comments along these lines:

> [I liked] how well playing the role of student helped me to understand ways to teach the material to my students and made the workshop more fun!
>
> –*French Teacher*, *10 years experience*
>
> I loved how it was facilitated through movement laden non traditional techniques. We not only reimagined education but [also] the classroom, a sense of time, & what it means to work as a group.
>
> –*School Administrator*, *5 years experience*

These comments are echoed throughout the evaluations and strengthen the notion that teachers benefit from experiencing new educational practices as learners prior to being asked to adjust their teaching. In the workshops, the teachers learn design

thinking through completing a design thinking challenge. In teams, they were introduced to a problem space (such as designing an energy solution). They discussed interviewing, then prepared questions and interviewed an energy user. They processed the interview information by being guided to create an empathy map that helps them draw insights about their user, and then to more specifically define their user's energy needs. They then brainstormed possible solutions and chose one solution to prototype. Once they constructed a prototype, they tested it with their user and had a chance to revise it. At every step in the process, they learned how to take the steps, and saw how those steps could be taught in a classroom. There were times for questions and answers concerning the process and how to teach it. Once the design challenge is completed, we extend the authenticity of the professional development by asking teachers to imagine how they could use the design thinking tools to meet the standards, thus further honouring them as learners.

Finally, rather than providing them a detailed implementation guide, full of constraints, we let groups of teachers work together to develop personal plans for implementation. One technique we used was to ask teachers to examine a lesson they will teach in the next week by seeing how it aligns within the four levels of the Cognitive Rigor Matrix (Hess et al. 2009). Once teachers mark the level of their lesson by skill, we suggest to them that they try to use some design thinking processes to move the activity to a more complex level of work for the students. An example would be: In level 1, students "Recall, recognize, or locate basic facts, details of events, or ideas explicit in text." A teacher might have been planning to have students describe a character in a story. Instead, the teacher revises that plan to create an activity where students use an empathy map. The empathy process would drive students beyond simple recall of facts about a character in a story to generating inferences about the character based on their interpretations of what the character said, did, and even felt. This switch to an empathy activity would take the lesson from being a level 1 activity to a level 2. Our aim in having teachers alter an upcoming lesson and vet it with their colleagues helps them to make use of what they learned about design thinking and some of its tools back in their classrooms. Throughout the workshop, teachers are learning about the design thinking process, how it applies to the standards, and how to apply it in a small way in their classrooms.

Provide Teachers Interdisciplinary Teaching and Learning Experiences

We bring teachers together from a variety of disciplines and experience levels who teach at schools with a range of nationalities, socioeconomic statuses, and language statuses. We place teachers who work closely together on separate design teams, because we want teachers to check their everyday baggage at the door. At first, some teachers groan about being separated from each other and question the relevance of

learning outside their school site teams (teams we let them return to for the reflection and lesson implementation portions of the workshop). Despite the initial complaints, we are thanked for this opportunity at every workshop. Here are just a few examples:

> [I liked the] cooperative opportunities, collegial atmosphere, passion of instructors, relevance of problem, "next day" applicability.
> –*Social Studies Director*, *12 years experience*
>
> [I liked the] collaboration, feedback process, [it provided] encouragement that pushes to keep [us] doing more.
> –*Science Coach*, *13 years experience*

While the comments do not capture the complexities of cross-disciplinary collaboration, they do demonstrate that what is first thought to be an uncomfortable request is beneficial to the outcome of the professional development. Cross-disciplinary teams afford their participants the opportunities to "try on" different approaches and disciplinary views. Teaching is often an isolated profession with islands of innovation separated by oceans of mandates. Allowing teachers new collaborators offers exposure to the way others are parsing the mandates as well as demonstrates design thinking's idea that radical and unusual collaborations lead to innovation (Goldman et al. 2013).

Furthermore, twenty-first century problems, for example, the aftermath of the earthquake in Haiti, do not occur in specific domains such as language arts or in Algebra 1. Real world problems cross boundaries, however messy that may feel. For this reason, we integrate STEM topics such as access to and conservation of water, energy, and shelter to illustrate how various disciplines can make contributions to the topic and solutions for users. We try to show how teachers from vastly different subjects such as science, math, social studies and language arts can all find ways into the materials and activities of the design challenges. Experiencing successful problem solving on interdisciplinary teams gives teachers an experience they might start to model with their students. This involves synthesizing input from multiple areas of expertise to develop a working solution to a real (and complicated) problem. Design thinking scaffolds multiple vehicles for valid participation as well as tools for taking the perspectives of others. Not only does this open the possibility of more learning for the participants, it leads to more nuanced, multifaceted solutions that are better equipped to stand up to the complexities of the real world.

Leverage Partnerships

We seek partners who share commitments to teachers, some ideas about best teaching and learning practices, support of the standards, and helping students move though schools towards happy and productive futures. The strategic partnerships we have been able to form exponentially magnify our ability to bring deep experiences with and about design thinking to K-12 teachers. Two of our partners were

highlighted in the cases: the partnership with a teacher education program, and the partnership with colleagues at the State Office of Education.

Our partnership with the Stanford Teacher Education Program helped us place pre-service teachers in apprenticeship roles with teachers who are teaching design thinking. The fact that pre-service teachers have their very first, 20-day, intensive practicum with a design thinking pedagogy is foundational and it is a statement about the nature of twenty-first century classrooms (Stanford Teacher Education Program 2014). It is both symbolic and practical in nature. It predates pre-service teachers entering their student teaching experiences where the full pressure of the existing system is pressing into the new teacher's classroom realities and psyches. We are delighted that we have the chance to make impact at such a formative time for new teachers.

The partnerships in Utah have helped us gain access to sustained work with in-service teachers. The State Office of Education organizes a huge number of activities in support of the Utah Core Standards, from content-based workshops, to e-text and book development, development of state assessments, to workshops on design thinking. Our colleagues there are committed to developing capacity in teachers who are implementing the standards. Their work with us is designed to help teachers realize that huge changes in practices are necessary for meeting the standards, and that business as usual in the classrooms will not meet the goals. Our advocate at the State Office sponsored our PD workshops and invited schools and teachers. She has provided support for follow-up and planning sessions for teachers, and reached out to school principals, representatives of city, county, and state-wide education initiatives to spread the word about design thinking.

She secured venues and brokered relationships with other Utah partners such as The Natural History Museum of Utah and the Museum of Natural Curiosity as partners. Both museums opened their doors to workshops, helped us create challenges that drew on their expertise and exhibits, and had their staffs participate in the design workshops as learners and experts. The combined efforts of various partners provided momentum and resources for follow-up, helping teachers to develop further experiences with design thinking, and developing teachers into design thinking mentors and coaches.

We cannot underestimate the impact of these partnerships on the success of the work we have done, and we see them as essential to seek out and develop.

Overcoming Obstacles

We have observed that teachers who facilitate design thinking in their classrooms are generally pleased. We profiled two teachers who were especially successful at implementation. Yet we recognize that there were frustrations that surfaced in each of the cases and that each teacher took a different route in instituting design thinking into her professional practice. We realize that it is important to have many pathways to adoption. Not all teachers will implement whole design challenges after

attending the professional development. We advocate that teachers build their competency with design thinking in the classroom over time. They might start with a small challenge, or by implementing a part of the process such as brainstorming or empathy mapping. They need to see themselves as designers, their students as "users," and build on what they are doing based on feedback. They may need to see bits of design thinking return as "results" such as content-engaged and accomplished students, complementary parents, or supportive administrators. They may need to enlist their colleagues, and have time to plan for implementing new strategies.

Our biggest advice to teachers is that they try out part or all of the design thinking process and witness the impacts in their students. Sometimes the impacts seem tiny such as when a student participates with new enthusiasm. Other times, the impact can be unexpected such as when an evaluation was conducted on Melinda's after-school design thinking program and students reported better attention in school classes once they participated in the design thinking course. Teachers may be required to take a leap to develop confidence that teaching towards innovation, rather than back-to-basics, may be what their students need. Our work is primarily about helping educators to embrace that change in mindset.

Conclusion

It is still too early to know what the 300+ teachers who we have introduced to design thinking will accomplish. Melinda and Claudia have jumped in enthusiastically, and some of the other teachers who have attended professional development have dabbled in design thinking, implementing parts of the process when and where they see the fit. And we know of a few who have done little in their classrooms. Those teachers cite various reasons: they need to stay on basics, they cannot get support from the administration, there is no time, and design thinking seems like a huge reorganization for them.The new standards have recently begun to be implemented, and the first high-stakes testing began in 2014. For many of the teachers, design thinking is an attractive theoretical possibility rather than a concrete strategy for helping students to accomplish standards-based learning. Once the new standards and assessments are in place, we expect some additional shifts to take place as teachers develop strategies that work for their students. We are seeking new ways to address teachers' needs as they evolve.

If schools are to prepare students for the world they will face in 2026, a significant change in teacher practice is necessary. Business as usual will leave students ill prepared for life and work in twenty-first century. The wave of new standards is introducing new possibilities. We believe the introduction of design thinking into K-12 education has the potential to support student development as engaged, adaptive, deep learners, creative individuals, and productive citizens. We utilize teacher professional development as one means towards these ends. We have learned valuable lessons about professional development generally and specifically through

bringing design thinking to teachers. In providing professional development, we have gained traction by forming partnerships with relevant community organizations and leveraging them to create a space for teachers to be learners, engaging in hands-on work with non-traditional interdisciplinary teams. While facilitating this process we have seen first-hand the power and relevance of design thinking for addressing new standards, affording concrete strategies for the development of twenty-first century competencies, and increasing teachers' creative confidence. By supporting educators through user-centred design, we give them the time, space, and experience needed to begin thinking differently about their practice. While this is not the only way to stir the winds of change, our work has illuminated the process and mindsets of design thinking to be powerful tools, suitable and effective, flexible and robust, ready for use today in support of a better tomorrow.[7]

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[7] We offer curriculum units that have been created, tested and revised based on their use in a range of classroom and after-school situations. In some ways, the curriculum challenges are our tried and true resources that we bring forward. We also develop and share formats for professional development that can be put into practice by others once they have been introduced to design thinking. Visit http://tinyurl.com/designthinkingcurriculum for more information.

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