Innovation in the Classroom:
Design Thinking for 21st Century Learning

Swee Hong "David" KWEK

Abstract

This qualitative study seeks to explore how design thinking as a new model of learning is used in classroom learning. The participants for this study are the school leader and teachers from a public middle school in the San Francisco Bay Area. Through lesson observations and interviews, this study aims to develop a fuller understanding of the motivations that drive teachers to adopt this innovative approach and the considerations they have when using it in the teaching and learning of core content. The findings showed that the teachers were not passive recipients of this new pedagogical tool and have "appropriated" it in multiple unique ways – to suit different purposes, different learning contexts and their different subjects. Another key finding is that mastery of academic core content still drives how design thinking is used to intersect with classroom learning. This study thus emphasizes the need to promote 21st century skills and academic content knowledge as similarly important student outcomes. The cultivation of a broader set of skills and dispositions beyond core content knowledge is critical, and they merit the investment of more time in the classroom.

Cite as: Kwek, S.H. (2011). Innovation in the Classroom: Design Thinking for 21st Century Learning. (Master's thesis). Retrieved from http://www.stanford.edu/group/redlab/cgi-bin/publications_resources.php

Introduction

The Current Educational Landscape

The profile of our learners has changed. They are digital natives weaned on video games and Web 2.0, and have been described as "marching through our schools, carrying a transformational change in their pockets in the form of powerful multimedia handheld devices" (Chen, 2010, pp. 213). Without the constraints of classroom relevance and test accountability, these digital technologies have changed the traditional pedagogical paradigm, bypassing the educator to reach the student directly and revolutionize their learning experiences. While many educators today lament that these learners are impossible to engage, game designers are solving with enviable success the dilemma that educators still grapple with: getting students to master something that is time-consuming and challenging, and derive pleasure from it. Gee (2003) made the plea for educators to build schooling on better principles of learning, which currently comport poorly with the theories of learning in good video games. For a long time, school has been endured rather than experienced by students as "a series of exciting explorations of self and society" (Aronowitz, 2004). More recently, Prensky (2010) asserts in *Teaching Digital Natives* that what today's kids do have a short attention span for are "our old ways of learning" (pp. 2). Against such persistent portraits of student disaffection, it is time to reflect if our curricular and pedagogical approaches are congruent with the learning styles of this generation.

Today pockets of innovation are sprouting up across the educational landscape, but many schools continue to keep at arm's length the democratizing imperative of "giving voice" to the students, asserting instead a singular top-down authority in the classroom (McWilliam, 2008). The underlying assumptions and organization of the school into classrooms, hallways, and departments that were instituted so long ago also remain unchanged, and "the basic instructional approach of teachers talking to students as they sit passively in their seats" continues to be the main teaching strategy (Kelly et al, 2008, pp. 12). This could be attributed to the educational policy in the United States, which continues to shape curriculum to reflect the realities of priorities: academic performance is taking center stage especially when many countries are clamoring to join international tests like TIMSS, PISA to benchmark their education systems with the best in the world in their quest to create world-class education systems – based on test scores. Yet Asian countries like Singapore and South Korea known for being frequent high flyers in international comparative studies are exerting great efforts to allow more autonomy at the local level and reduce the pressure of testing because "they know very well the damage that results from standardization and high-stakes testing" (Zhao, 2009, pp. 63).

Indeed the current culture of testing shapes curricular ideology and often subordinates teachers to the role of drillmasters. The unintended consequences of high-stakes testing are the narrowing of curriculum and instruction to focus on test preparation (Herman, 2004), excessive enforcement of attendance policies, repetitive class and grade-level assignment, and a generally non-supportive environment for low-achieving students (Vasquez Heilig & Darling-Hammond, 2008). Today the accountability movement continues to limit the opportunity for time in the school day to engage learners in activities that require creativity, innovation, critical thinking, and problem solving – the same competencies that Partnership for 21st Century Skills identified as essential for our future workforce. In addition, academic rigor is traditionally equated with mastery of academic content alone, and these 21st century skills are still perceived as "nice to have" rather than "must have" in education (Kay, 2010,

pp. xx).

Yet the message from the work place is a compelling one: Our learners will not be working on routine information seeking and routine problem solving; they will forge new, dynamic relationships and tackle novel challenges with sophisticated technology (McWilliam, 2008). The challenge for educators thus is to move beyond the convergent-thinking tasks of multiple-choice and recall assignments that are dominating educational practice. In fact, the call for educators to remain responsive to these shifts is an inevitable one because "because of education's inevitable relationship with the young and the newness of the demands they bring with them and that shape their lives, such responsiveness is itself part of the nature of education as a living, intergenerational project" (Friesen and Jardine, 2010). Learning is the core business of schools – and today it should be strengthened by classroom instruction that works for the 21st century learner. Schools whose curriculum and pedagogy fail to engage our younger generation as active learners and meaning creators are thus not doing justice to a nation's development, especially when knowledge has become power in a globalized world.

A Need for 21st Century Curriculum and Pedagogy

Today, the capacities that can be carried out by machines, or far more cheaply in other parts of the world, will cease to be at a premium in the developed nations. The 21st century, according to Pink (2005), will be dominated by a different way of knowing, being, and doing, and right-brain capacities will come increasingly to the fore. This view is endorsed by Howard Gardner, who highlights "a robust temperament, and a personality that is unafraid of assuming reasonable risks, cognitive and physical" as key dispositions that will mark the future creator and must be developed early in life (Gardner, 2010, pp. 28). Such dispositions demand curricular change, and Heidi Hayes Jacobs delivers this vision in *Curriculum 21: Essential Education for a Changing World* that "curriculum should not only focus on the tools necessary to develop reasoned and logical construction of new knowledge in our various fields of study, but also should aggressively cultivate a culture that nurtures creativity in all our learners" (pp. 17).

To meet 21st century expectations, educators therefore need to depart from the ideas and pedagogies of yesterday and become bold advocates to develop the sorts of learning dispositions needed for our learners and their work futures. This means spending less time explaining through instruction and investing more time in experimental and error-tolerant modes of engagement. This situation, Freire (1970) would have us believe, necessarily involves a process of inquiry. According to him, the teacher should not think for her students, nor can she impose her thought on them, for "the teacher's thinking is authenticated only by the authenticity of the students' thinking" (pp. 77). Dewey (1938) emphasized the role of the student in the educational process and the role of the teacher in guiding the student through a rigorous academic routine that matches both the individual inclination and ability of the child. He suggested that experience is "educative" when useful knowledge develops through cooperative inquiry in an authentic context within a community of practice (pp. 138). The notion that learning involves students as co-creators and collaborative problem-solvers is indeed an important one, and teachers and schools that work to capitalize on the generational characteristics of sharing, researching, evaluating, and collaborating with peers, are more likely to enact and inspire teaching and learning practices that emulate the forms of sharing and social engagement that are flourishing in the 21st century world.

Reeves (2004) issued the call for teachers to examine their professional practice and their impact on student achievement and transform educational accountability from "a destructive and unedifying force to a constructive and transformative force in education" (pp.

6). In the spirit of student-centered accountability, a 21st century education must thus be tied to outcomes and proficiency in both core subject knowledge and 21st century skills that are expected and highly valued in and beyond school. In other words, rigorous academic standards should drive learning and provide the context for learning 21st century skills. In "Catching Up or Leading the Way: American Education in the Age of Globalization", Zhao (2009) outlines five core assumptions which can be used to guide decisions about what schools should teach:

1. Skills and knowledge that are not available at a cheaper price in other countries or that cannot be rendered useless by machines;
2. Creativity, interpreted as both ability and passion to make new things and adapt to new situations;
3. New skills and knowledge that are needed for living in the global world and the virtual world (examples include foreign languages, global awareness, and multicultural literacy, and knowledge to cope with the global world, and digital or technology literacy for the virtual world);
4. High-level cognitive skills such as problem solving and critical thinking;
5. Emotional intelligence - the ability and capacity to understand and manage emotions of self and others, the ability to interact with others, understand others, communicate with others, and manage one's own feelings (pp. 150-151)

These five assumptions are not unfamiliar and support much of the ideas of leading theorists and researchers prior to Zhao. The question however remains: How can schools and teachers provide for this type of learning?

Design Thinking to Optimize Student Learning

Historically, curriculum has been conceived as an instrument of school reform but changes in schools that require "new repertoires" are likely to be met with passive resistance from teachers who have defined for themselves "an array of routines they can efficiently employ" (Eisner, 1992). If reform were to take place, the seeds of change would have to be planted in the classroom. That is why Clandinin and Connelly (1992) reconceived the role of teachers as "curriculum makers" – beyond being curriculum transmitters or implementers because they are an "integral part of the curriculum constructed and enacted in the classroom" (pp. 363). To move away from the convergent-thinking tasks that are currently persistent in the system, it is thus incumbent on teachers to design instruction to engage students in "divergent thinking to generate multiple and varied approaches to problem solving" (Hardiman, 2010, pp. 231). Although the recent shift toward standardized, subject-specific, back-to-basics curricula driven by high-stakes testing across the nation makes it difficult to implement any alternative progressive visions, we do not have to throw up our hands and mourn the end of a holistic, constructivist, child-centered approach to education. One way, Drake (2007) suggests, of increasing relevance of students' learning while maintaining rigor and accountability is to adopt an integrated approach. This is where the design process can come into play.

Design Thinking is an approach to learning that focuses on developing children's creative confidence through hands-on projects that focus on empathy, promoting a bias toward action, encouraging ideation and fostering active problem-solving – skills and competencies that align with the five core assumptions outlined by Zhao. In a report put together by the REDlab (Research in Education and Design Lab) team at Stanford, it was recommended that design thinking be integrated into academic content for while it may stand

alone, its power as a tool for learning comes in the ways it can support a diverse range of interdisciplinary academic content (Carroll et. al, 2010). Instruction that uses design thinking as leverage for learning can thus provide rich experiences that encourage meaning making without the imposition of a fixed set of knowledge and skills.

Through the implementation of curriculum that integrates design thinking and academic content, educators can help students develop a skill set that includes ideas generally not fostered within traditional school settings. This process would contribute to different levels of creative knowledge, creative skills and creative mindsets that can be achieved by design thinking education, culminating in a capability that is called "creative confidence" (Rauth, I. et al, 2010; Carroll et al, 2010). By applying the techniques of design to education, teachers loosen the narrow, rigid process of traditional learning and tap into students' deep wells of creativity, encouraging them to see nuanced problems from inside the very core of an issue, and make critical thinking essential to solving any problem (Barseghian, 2009). In the area of neuroscience, where much research interest has been cast on creativity, it is also now commonly accepted that activities associated with creative thinking produce differentiated patterns of activity across multiple regions of the brain (Fink, 2007, as cited in Hardiman, 2010). The co-activation and communication among brain regions that are not ordinarily strongly connected during noncreative activities (Heilman et al, 2003, as cited in Hardiman, 2010) can now be stimulated by immersing the learner in processes which encourage them to demonstrate divergent thinking. These findings thus augur well for design thinking as a learning approach in the 21st century classroom.

Dewey advocates that education be facilitated through activity-guided problem solving and the connections associated with the relationships that the problem has to the real world – essentially, exploring the relationship between reason and sense. The design thinking process moves beyond problem solving and project-based work by including a human-centered approach. With a focus on addressing user needs, learning through design thinking therefore becomes an active endeavor of students that takes place in an environment that stresses problem-solving, reasoning, and thoughtful interaction among students. Through design thinking, the learner does not simply "take in" information handed to him, but rather undergoes a process akin to what Steinberg (1998) describes as creating "knowledge and understanding by active engagement with problems and efforts at resolution that involve transforming the environment in some way" (pp. 21). From Dewey's perspective, students have already learned the habits of mind that their future requires, but they may not currently exercise these habits in the academic work in the school. Prensky (2010) also illuminates the irony: it is this generation raised on the expectation of interactivity that is finally ripe for the skill-based and "doing-based" teaching methods that past experts have always suggested are the best for learning, but that were largely rejected by the education establishment as being "too hard to implement" (pp. xv).

Through design thinking, the school can become a microcosm in which students practice the roles they must face in later life — and deal with the related problems and complications. In fact, design thinking fosters iterative problem solving and solution generation, making it relevant to projects in academic subjects while adding an inventive imperative highly consistent with 21st century skill sets. The hypothesis generation and testing that is inherent to design approaches is very effective for reducing fear, and the way to succeed, to innovate, is to experiment in the low-risk context of the school. Dweck (2006) found that students with a growth mindset seek out learning, develop deeper learning strategies, and strive for an honest assessment of their weaknesses so that they can work to remedy them. These students have continued to outperform their peers with fixed mindsets, thus demonstrating that the twenty-first century will belong to passionate and resilient

learners. Design thinking, which encourages through prototyping the constant deconstruction and rebuilding of objects and ideas that most of us accept as static and fixed, fosters the growth mindset in our students to explore, investigate and try again for each iteration will lead to even better ideas.

In the book "Design as a Catalyst for Learning", Davis, Hawley, McMullan and Spilka (1997) made reference to the "growing evidence that design is a powerful tool for transforming curriculum and accommodating the variety of ways in which students learn" (pp. xiv) but also highlighted key issues surrounding design-based curricula. These, according to the research team, are also the same issues that have been raised by those calling for educational reform and by researchers examining the effectiveness of curriculum and instruction. They are: resource allocation of time and space in schools, teacher expertise and support in design-based teaching and learning, and beliefs and assumptions about students, teachers, schools and community. It is therefore the interest of this study to examine how schools and teachers work to circumvent the constraints both inherent and resultant in the system to tap on the positive, catalytic influence of design thinking to drive students' learning.

Methodology

Purpose of study

Although design thinking today has been accorded more importance in higher institutions of learning, it is still a relatively new model of learning in K12 education. This study thus seeks to find out the possibilities and constraints inherent in the processes of Design Thinking that potentially shape the way both teachers and students use this tool for learning. An area proposed for further research is looking into the effective ways of integrating design thinking processes, educational standards and academic content information (Carroll et al, 2010). A deeper understanding of how the processes of Design Thinking can be embedded in academic content at both the planning and implementation stages can also potentially impact how teachers and schools use the approach to frame their instructional processes and practice in future. Given that teachers do not make pedagogical decisions in a vacuum, it was the interest of this study to find out their key considerations when using design thinking in the classroom. More specifically, the questions are as follows:

1. What are the key considerations that teachers have when using design thinking in classroom learning?
2. How do these factors influence the way design thinking is used in classroom learning?
3. How does design thinking intersect with the teaching of academic content? What do these lessons look like?

The Setting

The New Horizons Academy is one of the schools currently in partnership with Stanford University's d.School in using design thinking to foster students' creative learning and attain academic goals. The school district's information brochure for parents describes New Horizons as a cutting-edge school where students are "immersed in a technologically rich environment, seeing the world as a design challenge and with the eyes of a scientist, mathematician, engineer, or technologist" and "graduate with fluency in STEM (Science, Technology, Engineering and Mathematics) solutions and design thinking aptitude". Indeed the daily timetable of all sixth graders at New Horizons includes an introductory STEM-design thinking class, where students learn and apply design thinking through guided STEM

projects and challenges. The design thinking process is also embedded within the curriculum of core academic content from sixth to eighth grade in the school.

The school principal, Dr. Alice, who is also working closely with the REDlab (Research in Education and Design Lab) group at Stanford University School of Education, can be described as a leader who has a heavy hand in shaping the school's instructional program. Teachers can try to introduce innovative practices in their classes, but it is a job only half done without the support and clear vision of the school leadership. Today's school leader is expected to be the "chief learning officer", an individual with a vision for a future of the school who can articulate that vision to all stakeholders, paving the way for a collaborative school culture focused on teaching and learning (Green, 2010, pp. 3). Dr. Alice is one such leader – she is a strong advocate of design thinking and has a compelling vision of its role at New Horizons: "Design thinking should influence all aspects of school, not just the curriculum. Design thinking puts them (the students) in an environment where they are challenged to think differently. It encourages natural curiosity and 'don't fear to fail'. The vision is for everyone in the school to 'try things'."

In her conversations with students, teachers and even parents, Dr. Alice frequently uses design thinking lingo like "ideate", "empathize" and "fail early" to engage them in ideas-sharing, and explain the decisions she makes as a school leader. In fact, during the course of this research study, it was observed that the language of design thinking has found its place both in the classroom and beyond. The teachers participating in this study frequently used these words during classroom instruction, and in a meeting that Dr Alice was hosting for parent volunteers, the parents frequently used the term "design thinking" to reference classroom learning and to share about their creative ideas for events at New Horizons. On another occasion, when the earthquake and tsunamis devastated northwestern Japan, she seized the teachable moment to teach the students about empathy. Apart from making a morning announcement about the tragedy, she also went into every eighth grade class to share with the students about the lessons to be gleaned.

> When the class was ready, she (Dr Alice) started talking. She told them that it was simply a coincidence, but she was going to talk about the tragedy in Japan and then about another occurrence in the school – which is preventable.
>
> "The occurrence in Japan is calamitous, very scary. A lot of people have died and more separated. We should feel empathy. We should be involved, be caring, show our love for others. People should go beyond themselves. Personally, we should be shaken and we should be reflective. We can't control a disaster, can we? Japan is an advanced country under serious duress and sadness. Yet in school there's another occurrence that we can control. Don't use swear words. When you are in the hallway, don't use swear words, don't use profanity. This is an occurrence you can control. You can control what comes out of your mouth. I am beseeching here. You know what that means. I am pleading with you to think about how you treat each other. You hurt my feelings and then I do the same thing. These are virtual tsunamis. When you are making fun of others, think about what one can control."
>
> (14 March 2011, Amended Field Notes)

School leaders play a pivotal role in building an expectation of innovation into a school's learning and teaching strategies, and Dr Alice has shaped a design thinking culture that permeates most areas of the school by involving students, teachers and parents in creating stimulating environments at New Horizons. The organization, however, cannot flourish by the actions of the top leader alone. Fullan (2002) warned that the commitment necessary for sustainable improvement in an educational culture of change must be nurtured

in the "dailiness of organizational behavior", and for that to happen there needs to be many leaders around us – teachers as instructional leaders with the ownership and commitment to manage change in a sustainable way that can lay the foundation for improved school and student performance in the future. It is therefore also the interest of this study to gain deeper insights into the processes that are of strategic importance in building a sustained culture of innovation and facilitating the development of engaging and stimulating learning practices.

The Participants

Because the main intent of the study is to understand how teachers embed design thinking processes in classroom teaching, the key criteria of participant selection was teaching proficiency and confidence in using design thinking in classroom learning. Dr Alice thus played an important role in the recommendation of teacher participants. With her strong endorsement, I approached two teachers who knew well that their principal had already given me a favorable response and, I admit, probably felt some pressure to participate in the research. I was, however, met with warm and positive responses from both teachers who welcomed me to enter their classroom whenever I wanted.

Miss Estella was the more experienced teacher, who had been in service for seventeen years. She enthusiastically shared with me (after my first lesson observation) her rich teaching experiences and milestones both in the United States and Philippines, where she was originally from. Having taught for four years, Miss Jacqueline was still relatively young in the teaching service but recommended that I observe her class of GATE (Gifted and Talented Education program) students who were "faster thinkers" and therefore "more challenging to teach". At New Horizons, GATE students have the opportunity for acceleration to an appropriate instructional level in Math by early admission to Algebra 1-2, Geometry, or Algebra 3-4. During the duration of the study, the teachers were never defensive and did not make any effort to guard their privacy. In fact, they perceived the pragmatic value of the study as feedback for them to improve their instructional practice – to which I tried to emphasize that I would be assuming an observational role, not an evaluative one.

Another teacher I was recommended to was Mr. Lawrence, who taught the introductory STEM-design thinking class. As this foundation course is unique to New Horizons, I was curious and excited to see how students learn design thinking through projects with different engineering themes. Unlike his two colleagues, he was not trained in design thinking at Stanford's d.school because he only joined New Horizons a year after the workshop took place. However, he possesses varied credentials and what one might deem a wealth of experiences that extend beyond teaching. Trained as a high school teacher, he is qualified to teach history, language arts, science and physical education. Outside classroom teaching, he had also dabbled in teacher training, aircraft mechanics and warehouse management. Although initially less warm and mildly enthusiastic, Mr. Lawrence soon developed a more comfortable relationship with me as he anticipated my consistent presence and engaged in occasional dialogue with me.

Qualitative Study

The aims of the research and the questions that have emerged pointed to the qualitative case study as the most fitting methodology. Case study is "an intensive, holistic description and analysis of a bounded phenomenon" (Merriam, 1998, pp. xiii), involves systematically gathering enough information about a particular person or group and situation to permit the researcher to effectively understand how the subject operates or functions (Berg, 2004, pp. 251) and can "penetrate situations in ways that are not always susceptible to numerical analysis" (Cohen et al., 2001, pp. 181). Indeed the personalized and contextual

details gathered from each of the case study participants facilitated the deep analysis of complex relationships between their beliefs, experience and the unique context of New Horizons.

Lesson Observations

The lesson observations took place in late March and each teacher's classroom was visited over the course of two weeks (8 math lessons, 6 language arts lessons, 6 social studies lessons, and 6 STEM-design thinking lessons were observed). Each observation was 45 minutes long – the length of every lesson period, except on shorter days when the lesson was 37 minutes long. This study focuses mainly on the teacher as the target of observation because delivering both content and skills in a rich way that improves student outcomes requires the teacher to be knowledgeable about a broad range of topics and be able to make spontaneous decisions as the lesson unfolds. It is also a research interest to observe how the teacher simultaneously engages with content, classroom management, and ongoing monitoring of student progress – especially when design thinking is introduced in the classroom. However, the researcher also paid attention to the students' behavior, responses and interaction because they too contribute to the classroom experience, and a focus on the students provided a better understanding of the purpose, motivation and rationale behind the pedagogical choices made by the teacher.

In addition to observation field notes, a timeline of class events was developed to identify and tally recurring teacher or student behavior throughout every lesson. This provided important reference for coding and offered insight into the dominant modes of instruction and activity that took place during the lesson. I am keenly aware that lesson observations are only snapshots and students may be aware they are being observed – the Hawthorne effect might set in as they feel compelled to perform for the researcher. Therefore, I tried to be inconspicuous and sensitive to the subtle dynamics of the classroom environment and receded into oblivion by keeping a distance from both the students and activities they were engaging in the lesson.

Interviews

Observations do not by themselves explain the teachers' intentions and reasons for action for "they are not unambiguously evident in overt behavior" (Carew and Lightfoot, 1979, pp. 103). That is why the data from the lesson observations were instrumental in the development of questions to uncover "pictures of the unseen, expand understanding, offer insight, and upset any well-entrenched ignorance" (Glesne and Peshkin, 1992, pp. 67). To understand the teachers and their classroom behavior in more than a superficial sense, I was interested to find out about their educational experiences and philosophy, factors within the school that shape their pedagogical decisions, and their perceptions of the students' needs. In fact, I believed they viewed themselves as the authority and expert of their own domains and wanted them to be uninhibited in describing their beliefs and vision about teaching and learning – and more importantly their attitude toward design thinking.

In-depth interviews were conducted three weeks after the lesson observations, which were immediately followed by the school's spring break. The goal of the interviews was to discover how the school leader and teachers thought about teaching and learning in general, their experiences with design thinking and how the school had used it in classroom learning. I was interested in discovering both the general and particular desires of the school leader and teachers in relation to these, so they were encouraged to talk freely and share their opinions. Dr. Alice was interviewed once and the three teachers were each interviewed twice during the course of this study. Besides the formal interviews, I also spoke informally with

the teachers on several occasions about their lessons and what they had planned for upcoming classes.

In addition, four students were interviewed to capture their views and experiences about design thinking in classroom learning. The criteria for student selection were based on the student's willingness to volunteer and their parental consent for participation in the interviews. They were also drawn from classes that I observed so that I would not be viewed as a complete stranger. About six students volunteered but eventually only four were selected because the other two students were extremely shy and were not predisposed to sharing more than a few words even with probing. These final student participants were Asher and Jake, GATE students from sixth grade, and Osvaldo and Jessica who were eighth graders. To make the students comfortable with the process, I interviewed them each for about thirty minutes in the computer lab of the school library, which was rather isolated and free from disruption. They were each interviewed once, and during their PE lesson so that they would not miss out on the learning in their core content lessons. The interview protocols are presented in Appendix 1 (Table 1.1-1.3).

Data Analysis

The study focuses on the processes and structures that influence the teaching practice of three teachers and their approach to using the design thinking process in classroom learning. The interpretivist nature of this study means that the researcher is bound up in the situation, rather than being a detached, objective observer, reflecting the belief that "knowledge is constructed by the individual and is socially negotiated" (Guba & Lincoln, 1989, p. 13). The careful use of source material is thus imperative, and the perspective of the outsider researcher is balanced with the views of the participants – teachers, students and school leader – so that the truth is more likely to emerge when all these perspectives are synthesized.

Data sources included field notes, audio and video recordings of the lessons and interviews. The interviews were transcribed verbatim, data-coded and analyzed using the comparative procedure of open coding (Glaser and Strauss, 1967), where every sentence in the field notes and transcripts was labeled with terms that best captured what the main idea and concept was about. An initial set of codes was developed and then applied to the remaining data. Codes that shared more abstract qualities were amalgamated into broader pattern codes (Tables 2.1 and 2.2 in Appendix 2 capture the codes developed for the observation field notes and interview transcripts respectively). The data was analyzed at three levels: the individual case studies of teachers, a comparison across the case studies and a generic inductive qualitative analysis to consider the data in the wider schooling context. Finally, the data was triangulated among the participants' responses as categories emerged.

During the development of codes and categories, memos were also written to interpret the material, especially in light of how design thinking was being used to intersect with the teaching and learning of academic content. As the key concepts and themes emerged more distinctly, I also looked up relevant literature to further clarify and integrate with the analysis that has developed. This proved important in ensuring that the assumptions made were not solely the result of interpretation, but also grounded by actual data and literature to demonstrate that the analysis is grounded in lived experience (Charmaz, 2006).

Findings

Design Thinking at New Horizons: Motivation, Appropriation and Manifestation

> "When I hire people, I say to them that I don't think this is a school for everybody. You have to have a special set of talents. You have to be good enough to understand the curriculum. You have to be wise enough to understand that the students are coming from situations that are bereft of all kinds of support. I can't just have everybody here. You have to be dedicated to changing the world (laughs)."

Dr. Alice's words may conjure images of unruly students, rowdy classes and dirty school compounds. But the smiles that greeted me were warm, the environment visibly clean and I did not sense the tensions and sharp divisions of power that often accompany student-teacher relationships in middle school. Sure, the buildings look a little old but many of the classes are well furnished and some are equipped with smart boards. As we took a whirlwind tour of the school, Dr. Alice pointed to chewing gum stains on the ground and said as if with disappointment: "Those, we could never remove." Yet, these faint marks bear proud testament to the school's success in purging the "mayhem", "riot mentality" and "messy sloppy environment" that once plagued New Horizons.

Under Dr. Alice's leadership, the school has seen an evolutionary change. The fighting got under control, the ugly behavior was gradually displaced, and New Horizons also became a STEM school in 2008. Teachers now have their personal laptops, and students enjoy the comfort of learning spaces equipped with updated technological equipment to facilitate learning. The hardware has changed. However, Dr. Alice and the teachers in this study reminded me that the student profile still presents a challenge. Helping the students experience success continues to be top priority at New Horizons. As Miss Jacqueline explained, "Our group of kids is a little different and I think for them it's important to have a safe place to come to, to feel comfortable at school and to feel like they can succeed." Dr. Alice described the majority group of students at New Horizons as the "Teflon group": They come from families with middling or modest incomes, and face many learning challenges.

> "It's very high academic work. Nothing sticks unless you do things in a particular fashion over and over again so that whatever construction of knowledge that hasn't been put into place firmly in the frame, in the schema for those kids, it is there after they are here in school. We get kids who've been through seven years of schooling already, and some of them can't read past third grade level. They can't do math past third grade, and they are supposed to finish algebra by the time they are done with eighth. And now you have the psychological issue that these students feel like failures as learners. So that whole group and whatever that's about – that the students come in either from impoverished households in terms of not language-rich, not syntactically-rich, not ideas-rich, not dialogue-rich families so those kids come to school and that's why they are at a disadvantage. And whether or not the school is able to build up that a psychological infrastructure for the kids so that they could survive in school is a really good question."

Motivation One: Feeling of Success

Dr. Alice envisions New Horizons to be the school where learning gaps could be bridged, a place where learning experiences orient students to succeed instead of merely helping them to avoid the negative consequences of failing. In short, it is a place where students will find greater motivation to learn. She emphasized that some students – the "school-proof" ones whose parents make sure they read, who are exposed to rich ideas and go to museums — are intrinsically motivated to learn, but other students need and expect their teachers to inspire and stimulate them. Indeed whatever level of motivation students bring to the classroom will be transformed, for better or worse, by what happens in the

classroom. Although there is no single magical formula for motivating students, Dr. Alice is hopeful that design thinking is the "antidote":

> "For most of what we have done in education is 'Is it really okay to fail?' Doesn't design thinking do that? Whatever my users tell me, the technical part of design thinking makes the students more central and powerful and teaches the students to prototype, test it and to examine the process. What is it building in the student's mind and psyche? A relational learning toolkit!"

The three teachers of this study, despite the challenges compounded by problems characteristic of middle school and the challenging student profile at New Horizons, do not feel paralyzed for lack of means. At times, they expressed a guarded optimism but their strong sense of devotion to help their students experience success – and through design thinking – was often articulated.

> "Design thinking helps with motivation. It really does encourage them to realize that they can succeed, and if they can succeed then why not try. So design thinking is a way. And also by giving them projects that they are interested in as opposed to just throwing down a piece of paper and saying 'here's what we are going to do' – that helps."
>
> (21 April 2011, Interview with Miss Jacqueline, Interview Transcript)

> "Design thinking's definitely useful. Actually the kids are so into it that they built things that are beyond my imagination. And they are so proud of their ideas."
>
> (22 April 2011, Interview with Miss Estella, Interview Transcript)

> "Let them feel successful. Let them feel accomplished. Get something done that they can have in front of them and say, 'I did this. I'm proud of this. I learned something from this.'"
>
> (20 April 2011, Interview with Mr. Lawrence, Interview Transcript)

These teachers speak of a common belief about student motivation – that it emerges with the students' expectation that they can be successful in their work. The much-expressed aim was therefore to use design thinking to foster the student's perception that the tasks associated with learning could be accomplishable.

Motivation Two: "Light Bulb" and "A-ha" moments

In our discussion about using design thinking in core content instruction, the teachers identified interest in the subject matter and perception of its usefulness as their central concerns. Indeed traditional curriculum tends to provoke the perennial student question, "Why do I have to learn this?" Motivation in learning, the teachers emphasized, was thus dependent on the students understanding what they were learning. In fact, there were clear and recognizable moments – Miss Estella called them "A-ha" moments and Miss Jacqueline described "light bulbs going off"— when students, after grappling with key concepts taught in class, finally arrived at the destination of more thoughtful engagement with what was taught. As these "light bulb" and "a-ha" moments were endearingly recalled, the teachers were also describing them as one key factor that influences the pedagogical decisions they make on a daily basis.

Whenever the students encountered a topic with which there was little familiarity or concepts where the level of abstraction was high, it became the teachers' goal to lead them

towards a broader understanding of the concepts' relevance to every day life. To Miss Estella, this goal is at the heart of teaching math because students not headed in technical directions often do not appreciate the practical use of mathematical concepts – in fact, giving up is the easy and natural path if they do not recognize math concepts as practical and relevant.

> "That's what we teach for. That's what students should experience. They should understand the relevance of every concept that is being delivered in class so that in the future they can apply it. For example, one of my students would say why would I bother with square roots? I would do gardening in the future. I want to be a housewife or I just want to do carpentry and all these…"

Showing students how math relates to real life thus dominates Miss Estella's daily lesson agenda. She works on cultivating mental habits of connection making by linking abstract concepts to everyday examples. Having taught for seventeen years, she is adept at creating such "a-ha" moments and frequently reaches beyond the conventional boundaries of the topic. In a lesson I observed, she built a case for learning parabolic graphing with its practical applications in the building of suspension bridges like the Golden Gate Bridge. The boys in the class were especially interested, and there was a higher level of alertness as the students seemed more invested in understanding the concepts. In the case of Social Studies, a subject new to students in sixth grade, Miss Jacqueline described a similar challenge: Helping the students experiencing Social Studies as a living subject, one that is relevant to their world.

> "It's very foreign to students. They are kind of like 'Who cares about what happens to people from across the world thousands of years ago'? That's the most challenging subject for them because it's about ancient civilizations. So that whole idea of understanding, points of view, and other cultures, and other societies, and why things occur is really important… We don't look at memorizing dates and, you know, people's names and time periods because all of these are irrelevant to the kids."

From Miss Jacqueline's perspective, the "light bulb" moments, when they emerge, are indicative of "something has clicked" – a connection has been made and the students have transcended the learning of isolated facts which otherwise would hold little significance in stored memory. These are the moments that these teachers seek to create on a daily basis. They expressed a common desire to go beyond traditional methods of memorization and recall and develop creative strategies that help students connect abstract concepts to their own ideas, experiences, feelings and motivations, therefore maximizing their chances of experiencing success.

Appropriation: My Own Version of Design Thinking

In the lessons where elements of design thinking were present, I observed students generating and developing ideas – and these were often solutions to problems for which answers did not exist or were not readily apparent. From conversations with the teachers in this study, it was also apparent that the "light bulb" moments often came on when the students were pursuing and developing original ideas – especially through the prototyping phase of the design thinking process. Yet just two years ago, despite its transformative promise for learning, design thinking was very new to everyone at New Horizons, and incorporating it in classroom learning was nothing short of challenging.

> "You can ask any language arts or social studies teacher here. It was a big undertaking. There weren't any real concrete examples for our type of kids, our

> grade level, anything like that so we kind of had to make it up and we kind of took a lot of projects that we were already doing and tweaked them to sort of make it more design thinking and allowing the kids to have more input and that kind of thing. And from there you know once it starts to connect for the teacher, then all of a sudden you get the "Oh, we could try this. We could try this! It's absolutely working". It's my own version of design thinking, maybe. I don't know."

"My own version of design thinking" – indeed it was clear from the lesson observations and interviews that design thinking as a new approach for learning had undergone "appropriation" by the teachers to align with the desired outcomes of their subject, perceived needs of students, and their pedagogical objectives, skills and experience. Though the teachers of this study are similarly committed to their students, they bring different values and personal experiences into the school. Most importantly, they are probably the most insightful knowers of their classrooms, who reflect upon, justify, and critique what goes on there, and whose understanding of themselves and of their students will have an effect on how design thinking is appropriated to achieve different sets of objectives and priorities.

Wertsch (1998) defined appropriation as the process of "taking something that belongs to others and making it one's own" (Wertsch, 1998, pp. 53). More specifically, at New Horizons, appropriation appears to be an active and iterative process where the teachers demonstrated that they were not passive recipients of a new pedagogical tool. To enable the adoption of design thinking, they adapted and used it in multiple unique ways – to encourage student motivation, and to suit other different purposes, different learning contexts and, more importantly, different subjects. In fact, Dr. Alice acknowledged that design thinking should be used as tool to intersect with the existing classroom learning culture and routines and emphasized, "Design thinking doesn't belong to every time, every moment… Design thinking has a place at its time."

At New Horizons, every teacher is expected to incorporate design thinking in at least one subject unit. The school administrators recognized that in the absence of precedents and exemplars such efforts would take a leap of faith and a lot of courage. Teachers also needed to invest time and energy to understand the conceptual underpinnings of design thinking as a flexible and divergent learning approach, which necessitated a process of re-formulating their pedagogical instruction. However, Dr. Alice emphasized that the teachers were granted creative license to experiment and explore.

> "We manage the school differently. It's partly the teachers we have here. They wouldn't stay here if we want the things to stay the same for thirty years. And also there's some hope in prototyping. Ok, didn't work so let's fix it. We are not going to stay with the same thing. Remember you have top-down and bottom-up. I have a choice to decide whether I want to do it again. That's the grassroots. You don't have one entry point in good policy management. You have it everywhere."

Although constraints and personal values will shape the way teachers use this tool for learning, Dr. Alice believes that design thinking should be "appropriately utilized to help inform practices, to help people see things in a way that they have empathy for every group they are working with". The journey was not easy, but she let on that she had encouraged the teachers with the assurance of "Don't worry about it, get there when you can", "It doesn't have to be right", and "It's already part of what we do". However, she expressed deep faith in her teachers who "walk on water", are "incredible" and "that's why they are here".

Manifestation One: Design Thinking Is Not New

Although there is no whole-school approach for incorporating design thinking in

classroom learning, one dominant view is that a lot of what teachers have been doing is already design thinking. Dr. Alice explained:

> "Think about the brainstorming. Think about this idea that you generate as many ideas as you can about a particular topic. Think about searching out what the question is. Well, to me, it's not like you are bringing in a distant cousin that nobody recognizes. It's something that we all recognize."

When Miss Estella was attending the design thinking workshop held at Stanford University's d.school two years ago, it dawned upon her that she had already been incorporating elements of design thinking in her math lessons, "When you think about strategies and how to solve problems, for me, I think you are actually doing design thinking there. I've been doing these projects in my class." She described one such project: the spaghetti bridge challenge. Every year, she gets her students in algebra class to build small-scale model bridges out of spaghetti and test them with twelve textbooks placed on top of them. Students explored the relationship between the amount of weight that could be supported by their model and the thickness of the bridge. Such tasks aimed to bring deeper learning into the classroom through project-based learning, which she started introducing to her students in Virginia after attending a conference when she was still teaching in a high school there. She described her personal "a-ha" moment, which illuminated the importance of "building something and proving it":

> "I was like, yah, instead of you explaining parallel lines, why don't you build ladders and see of it works? And see if one of the steps is twisted, then will that work?"

From this view, design thinking is thus not new because it focuses on getting the students to encounter the central concepts and principles of math hands-on while exploring a real-world problem – like project-based learning. Therefore, Miss Estella was of the firm belief that design thinking was already a part of her classroom routines: "It's just that right now we are into becoming a design thinking school so we need to define a process and have the strands of design thinking embedded. But I've been doing these activities actually but we don't really name it design thinking."

The first manifestation of design thinking at New Horizons also takes the form of familiar classroom practices taking on new labels associated with design thinking. Osvaldo, an eighth grader shared that his teachers routinely called the drafts of essays and reports "prototypes" so that the students would work towards making improvements:

> "In class, when we were working on a project and they were referring to like a rough draft, like a report, that rough draft of report is a prototype. And when you make more changes and improvements, then you are going to make the actual thing – the final submission."

In fact, Miss Jacqueline makes it a conscious effort to give her students a broader understanding of prototyping, making sure that they "do not think that prototyping means physically building something but creating an essay or an answer to a problem – that's a prototype too." In one of her language arts lessons, I observed students critiquing each other's essay drafts. She started the lesson with the following instructions:

> "We are going to look at our samples, the class-editing portion, where you are going to take your draft, or a portion of your draft, your prototype and test it in the class. And get some feedback. See how people think you are doing. And getting your one idea of what you are doing well and what you should improve on."

She then invited students to volunteer and present parts of their draft while assuring them "it is only a prototype", that they were testing for user feedback, the users being the classmates. This was a familiar scene of students presenting their work for class critique – some were nervous, some more confident, but the activity was not new. In this manifestation, using "design thinking" lingo to describe familiar classroom practices appears to stem from the intent to provide more positive frames of reference – and according to Dr. Alice, this may not be just a renaming exercise:

> "If I say prototype, you say prototype. You make meaning, you generate meaning, and you are not doing it to brainwash. It's like reading a book; you are reading a book because it's interesting. You are not reading a book to read a book."

Manifestation Two: You Don't Have to Do All the Parts

In exploring the application of the design thinking process, the teachers were deeply concerned about how the approach and its different steps could be used to support and dovetail with the objectives of their discipline. During one of the staff discussions about how design thinking could be instantiated in their own subject curriculum and teaching, an "amazing insight" emerged – one that has been instrumental in helping teachers at New Horizons make the leap of faith to use design thinking in classroom learning. Dr. Alice explained the implications of this discovery:

> "You don't have to do all the parts of design thinking. They can teach parts of it in different places of the school. They (the teachers) were like 'Thank God! I get it.' The takeaway was you don't have to do all the parts. So that informs the history teacher, the language arts teacher. Because when you are reading a novel, you just want to build empathy around the character. Maybe you are going to ideate… Maybe you are going to write in a history class. And we have a foundations class in sixth grade that teaches them the process. And in Math class, in Estella's class, she does lots of projects where the students are thinking of prototypes."

Indeed Miss Estella is not only adept at using real-life examples to anchor students' understanding of abstract concepts. Her sensitivity to creating the teaching moment potentially explains why she uses prototyping whenever "it seems right". She is of the opinion that design thinking should be used "spontaneously" and not enacted like "it's scripted". Her belief is "if you just do it spontaneously as part of your curriculum, then over time you just do it as part of your system." Coincidentally, Miss Estella's personal beliefs appeared to coincide with Dr. Alice's description of what a good Math teacher should do:

> "The moment you are going to make an analogy in the class and a great teacher will know – this is a design thinking moment. It is now appropriate for us to prototype something versus 'No, you have to learn how to solve this equation today.'"

In fact, in a lesson on functions and relationships, students moved from practicing examples and reviewing answers to working on prototypes. The transition appeared seamless but according to Miss Estella the activity was not planned. The prototyping idea emerged because she realized it would be a good way of recycling some old and unused color paper in her cabinet, and that also presented an opportunity for students to "play". About fifteen minutes before the end of the lesson, she called the class to attention and issued the instruction: "Now your goal is in 15 minutes create something that you think has a function. Everything that you do has a function." Then she went on to share about how a group of graduate students from Stanford developed "d.Light" to bring affordable, clean and efficient LED light to households in a rural village in Myanmar. The example demonstrated that ideas often have a function to serve the needs of other people. She then reminded the students that

they were working on a "prototype" and "it doesn't need to be perfect" – a statement that drew a query from a curious student.

Student: It doesn't have to be perfect?

Miss Estella: It doesn't have to be perfect. The prototyping idea is the idea of having the idea. You can modify it and make it perfect when you have proof. At this stage, we are only coming up with the idea for the functions we are studying.

The students then swarmed towards her teacher's table, picking up pieces of paper and tape, and as chatter filled the room the students quickly developed unique creations with the limited resources and limited time that they had. Although this exercise was borne out of a spontaneous decision, it seemed pedagogically strategic because students were empowered to "interact with new knowledge" they had acquired. Miss Estella embraces the divergence and creation of the students through prototyping because the outcomes represent the students' interest, ability, and self-confidence to extend learning. In fact, she was rather pleased with the outcomes (although whether the activity helped to anchor the students' deeper understanding of conceptual knowledge was not clear).

> "To my surprise, their thinking of what a thing can do is beyond my expectations. Like one student put squares on his piece of paper and said, 'This is like a pad for when you do play and your hands get wet, so all you have to do is put your fingers on it so that it dries quickly, because it sucks the sweat and then you can play again.' Because he is into sport and he said he doesn't like to put a towel and so why don't we just a put a pad here and just place the fingers there and you are good to go – as quickly as possible. It's like seconds. That's a nice idea, and they built lots and lots of things that are not even in the context of my lesson, my imagination. So actually the kids are into that area, they build things that are beyond my imagination."

For Miss Estella, the idea of "You Don't Have to Do All the Parts" fitted nicely with her teaching paradigm – a "teach, learn and apply" sequence, which I observed to be the standard of her lessons. Her lessons typically begin with her going through or reviewing basic concepts with practice examples (sometimes she brings in real world examples to establish conceptual relevance). She scaffolds the whole-class learning by drawing on different students' input and demonstrating the procedures and skills needed to solve problems related to the concept. Then the students practice either individually or in groups where direct instruction takes place – she provides students a high level of support and guidance by moving around the classroom and helping them with the practice. Design thinking or hands-on tasks, if they do take place at all, usually happen after these routines. For Miss Jacqueline, this linear sequence also made sense because "of the fact that there are concepts (in Language Arts and Social Studies) that just need to be directly taught" before engaging the students in hands-on activities:

> "What I learned just by experience is that when we are doing the design thinking activity it does have to come after some of the background knowledge. If we threw those kinds of projects a little too early then they get a little off-task or they sway away from what my end goal was. I thought that has kind of been our learning curve here. By making sure that when we do these projects once they have got a little bit of the background and knowledge formed, then they take it a step further in the design thinking process."

That is why in her classes, design thinking projects are often culminating tasks "to make sure that they (the students) are exploring the concepts". Situating design thinking activities near the end of the curriculum was apt, but identifying the step of the design

thinking process that best served the objectives of the Social Studies subject was a challenge for her.

> "I would be totally honest. Since our school has gone into design thinking, it was a challenge for all of us in language arts and social studies. And I think, for both myself and my partner teacher next door, we've really tried to work it out and say, 'What does this really look like and say what does this look like in social studies?' Because it makes sense when you have experiments and things to build. It was challenging, but we have tried to see it as more of an approach to learning, and a hands-on type of learning. The empathy piece plays a huge role especially in our social studies curriculum, so we look at each and every ancient civilization and we try to have each of the students feel what it was like for each of those people. So the lessons on design thinking are designed around becoming one of those roles. And really engaging."

In the social studies unit on ancient China, Miss Jacqueline used the perspective taking approach to help students understand the thoughts, feelings, and motivations of different occupations from the ancient Chinese civilization. Stepping into new roles, the students each took on board the perspective of the emperor, aristocrat, scholar, or peasant, and developed empathy for their concerns. The students' key task was to develop a flood control proposal that best served the needs of their occupation. During the lesson, the students shared and built on each other's ideas in their occupation group, before returning to their home groups to present the improved proposal.

> "The whole concept of becoming an occupation is powerful, and realizing what are your concerns like, for example, if you are an emperor you are going to have different concerns than if you are a peasant. And the view of having different kids take on that character is that they own it. Then they become a part of that character, then bring them all together as a group, then seeing the differences and that really opens their eyes on their roles, and that was kind of like a lesson within a lesson but doing it that way instead of spending a day lecturing on here's what the different roles do, it's a much more memorable experience for them."

In fact, Miss Jacqueline emphasized that this approach had worked especially well for her "academically lower" students, who reported having better understanding through the empathy building activity. As mentioned, the key challenge she faces with teaching social studies is creating balance between facts and making learning active and fun. Miss Jacqueline is not against the conventional way of passing and sharing knowledge through lecturing, but she believes the way to help her students see the subject's significance in their lives is through perspective-taking and empathy-building – and these approaches pave the way for students to feel successful for being able to accomplish a task independently.

> "By just saying that you know you, you are important, you get to become the emperor. Now what? And all of a sudden it's kind of like 'Wow. Now I can be in charge of people. I need to make sure that things go well and if there's a flood it's my fault.' You know by taking on that role and having that empathy they are engaged and by being engaged they do their work and they feel success. And then when the test comes around they see their scores improving. They are like 'Wait a minute. I can do this, and I will be successful at it.'"

Manifestation Three: A Multidisciplinary Model

The third manifestation of design thinking at New Horizons takes the form of a multi-disciplinary model in the STEM-design thinking foundation class. According to Dr. Alice, this introductory program aims to offer every student that enters New Horizons a "design

thinking primer" – it is intended to be a unique educational experience that immerses the student in the application of knowledge and authentic expression of their views and skills. The "danger", she acknowledged, is that "it is not hard enough, not structured enough, a series of activities that is too loose." Therefore this foundation course may not have the academic rigor and high expectations traditionally associated with core content subjects. Indeed, as the teacher for all sixth-grade STEM-design thinking classes, Mr. Lawrence identified student "apathy" as a key challenge.

> "One thing I'm struggling with and it's something that I keep running into is, there's a lot of apathy. The kids are like 'why are we doing this? Is this going to be on the…' It's this whole thing on 'Is this going to be on the test? Is this going to be on the big test that we have to take?' Like the big thing of the future. Uh. And it's supposed to be an elective. It's supposed to be fun so there's this element of it. So I try to make it fun, not just me talking at the moment time, but I keep running into the apathy."

Aiming at enticing student engagement through fun and play therefore would not suffice – what was needed was the molding of dispositions to invest in the learning that took place during STEM-design thinking lessons. Mr. Lawrence shared that he had addressed the challenge – though not always with success – by making connections to key concepts and skills in core content subjects. With his wide array of experiences that extended beyond teaching, he was also interested to structure his lessons to show students how knowledge and skills from different disciplines can connect to the development of original insights and ideas. Therefore, instead of simply showing real-world examples (I had observed him to possess an impressive supply of ready examples and anecdotes, probably because of his varied work experiences), he adopted as strategy the integration of knowledge and skills that the students had learned in their core content classes.

> "Those connections are made, and nothing's isolated like a vacuum. They all tie in together so… The test scores of the school, they are on the low end so we do need to raise their test scores. And there's all the funding. I mean it's for the kids. It's the kids first and foremost that you are trying to do a master of education. So, yes, they are going to learn to brainstorm, they are going to tape sticks together with tape and glue, but they are also going to learn math, they are also going to learn science. So if there's something to reinforce in this class that makes it clearer when they are doing the Pythagorean theorem, and if they do not understand tectonic plate, then this (class) helps clarify because they are getting it twice. That is a good thing for me rather than just doing random stuff and why are we doing this?"

In a class project to develop disaster-proof houses, his students revisited measurement conversion and explored how geography affected the susceptibility of certain U.S. regions to natural disasters while simultaneously engaging in the design thinking process to generate original solutions. The students developed blueprints of their houses and built cardboard prototypes, which were put to the "water and sand" tests that simulated malevolent tsunamis and earthquakes of high magnitudes. This experience was especially memorable for Jake, a GATE student in sixth grade.

> "That was fun because we got to find out what we should have put in it (prototype of the disaster-proof house), like materials – water-proof or fireproof or wood, or like steel inside to keep it from breaking during earthquakes. And the design, for example, the triangle keeps the building most secure. My teacher shook the table really hard (the water test) and our house did not survive, but at least we know what we can improve on the next time."

Mr. Lawrence likened this process to the scientific inquiry process, but with lower stakes.

> "I like that they are able to stop and go, 'Okay. We are brainstorming here and then we are going to use this to build our prototype. And then we are going to test our prototype. If something doesn't work then we can go back to this (pointing to the steps of design thinking poster on the wall).'"

Besides the STEM-design thinking foundation class, all sixth graders also experienced the integration of design thinking with STEM and other core content subjects in the "Cultural Awareness Project". In September 2010, the students each chose a culture to focus on in this year-long multidisciplinary project where a research report was first put together in language arts class before prototypes were developed in STEM-design thinking class. These prototypes would be tested at New Horizon's Open House later in the school year. At the point of this study, when data collection was still taking place, the students had just completed the first part of this project. In the process of producing and finishing the report, the students had invested themselves deeply in their work. Miss Jacqueline explained that the Language Arts team decided to focus on "the empathy piece" of design thinking and let the process driven by the student's interest:

> "We went through a cultural awareness kind of lens and basically the language arts teachers took on the actual research and the actual report portion. So each student picked a culture. It could be their own culture or just one that that they were interested in. We wanted it to be their project and let them research an invention or a creation from that particular culture."

The team's belief was that the students would be motivated to learn what they wanted to know and would assume more responsibility for the direction and quality of their own learning. Miss Jacqueline explained:

> "There is freedom for the student and in a sense they are more free. We always give them guidelines but when it comes to the design thinking project, we basically just give them a prompt and let it go. And they can really take it a thousand different directions. Because when they are wanting to do something and that they can take it their own way, it's a completely different story."

Indeed the students seemed to enjoy the process, which stimulated and challenged their motivation to explore things they did not learn in class. To Asher, another GATE student from Miss Jacqueline's class, this project provided him an opportunity to learn deeply about a topic that was intimately linked to his heritage. He developed a deeper appreciation for his Israeli heritage after researching on the Pillcam, a very small camera that is placed in a swallowable pill to allow surgeons to see the organs of patients without putting pipelines in the throat. This invention was created by an Israeli company.

> "I got to learn more than any other project. I got to learn things about my own culture and this invention that I never knew before. I started finding out even more once I did the research and wrote the report. Many of the other design thinking projects were about coming up with something yourself, but I really liked finding out the facts for this project. And it was kind of like free so you could do almost anything you want."

Perhaps more importantly, for Asher, who confessed that he was not a "big fan" of writing, putting together the report turned out to be "really fun":

> "It is really fun when I can take one of my not-most-favorite subjects (language arts) and be able to do something I like and connect that subject with STEM, and I find that really nice."

In fact, he was so motivated to find out more that he approached his science teacher to advise him on opportunities for further research. He ended up discovering more about the digestive system and explored new ways to extend the use of the Pillcam beyond surgical purpose. In this multi-disciplinary manifestation of design thinking, the curriculum is therefore connected within and across subject matters in a way that allows students to draw on concepts of STEM, research and report writing skills, both equipping and empowering them to lead in their own learning. Indeed design thinking is inherently interdisciplinary and combines concepts and thinking skills found across subjects; it also concerns itself with social, cultural and physical contexts, and teachers do not need to make forced connections across incongruous topics to meet curriculum mandates (Davis et al, 1997).

Discussion

The introduction of design thinking into classroom learning at New Horizons has not been without its challenges. Unlike efforts aimed at changing structural and working conditions, this innovative approach of learning required deep reflection and challenged the teachers' conceptions of teaching and learning. Today design thinking has rooted firmly in the school culture, and this study has made the following observations:

(i) Teachers utilize design thinking as a strategy to maximize student motivation – to help students feel successful and experience "lightbulb" and "a-ha" moments where they gain both understanding and confidence in learning.

(ii) To ensure certainty of desired outcomes, design thinking is appropriated in different ways and in varying degrees.

(iii) As a result, design thinking as a conceptual tool has manifested as:

- A familiar classroom activity with a design thinking label
- A task for application of learning, where only a step of the entire design thinking process is adopted
- A multidisciplinary project that takes place in STEM-design thinking class and as a grade-level project

The use of design thinking in classroom learning is an ongoing enterprise at New Horizons. How it changes and evolves will be shaped by assumptions that underlie the teachers' perception of what matters in learning, what motivates students to learn what is deemed important, and the role of design thinking in delivering that learning.

Revisiting Motivation: What Outcomes do Students Value?

Teachers, especially those from academic disciplines, are continually perplexed and discouraged by their students' limited efforts and lackadaisical attitudes in the classroom. "Why are students not motivated to learn? What can we do to cause these students to want to know more?" The efforts at New Horizons appear to be addressing this problem, emphasizing higher order thinking skills of problem solving and making connections to the world beyond the classroom – through design thinking. In order to enhance student motivation to learn in the classroom, it is useful to draw on expectancy theory, which views people as purposeful beings who behave in accordance with their expectations that their efforts will result in outcomes they value (Hancock, 1995). When applied to students, it suggests that the amount of effort a student will exert ultimately depends on three perceptual relationships: "expectancy", which refers to the student's subjective estimation of the likelihood of successfully performing a particular behavior; "instrumentality", which refers to his subjective estimation that this behavior will result in certain outcomes; and "valence",

which refers to the positive or negative value that the student attaches to these outcomes.

Our teachers at New Horizons are of the firm belief that design thinking can provide students the opportunity to experience success. With expectancy theory as reference, we can see that it has been used as a strategy to increase students' "expectancy" and "instrumentality" that the desired outcomes of learning are not out of reach and are achievable through their engagement in design thinking tasks. However, the study has shown that the teachers' desired outcomes for the students are still ultimately linked to the learning of academic course content. Therefore at the "valence" level, whether students attach positive or negative meaning to such outcomes does not emerge as a key consideration. Yet if teachers want their students to demonstrate higher levels of motivation, they must be certain that the outcomes are valued – or even viewed as rewards – from the students' perspective. In fact, students may see little value in the outcome of a good grade in math or language arts and thus may not invest efforts for the sole purpose of an excellent evaluation in the project. However, if learning is tied to broader outcomes and proficiency in *both* core subject knowledge and 21st century skills like creativity and problem-solving, then the likelihood of students being more motivated to invest efforts in their work will increase.

Students often value the generation of ideas that relate to their interest and allow them to go beyond the narrow confines of their subjects – design thinking encourages that. In fact, when students are personally invested in the activity, they will overcome challenges and constraints that arise in the process. Miss Estella recalled a design thinking challenge in an elective class she conducted, where students were tasked to create solutions for environmental problems. Despite the lack of resources for prototyping their ideas, her students proactively sought out alternatives – and were deeply committed to the work.

> "One of the students said, 'Why don't we use empty bottles or cans?' So we tried collecting for a week. And then everyday they created something – they created a trashcan that is also a robot, a waste collector. You just throw the trash in there and the garbage will be disintegrated. And that robot can separate the biodegradable and the non-biodegradable. It was funny – I enjoyed the class."

Here, we see constructive learning behaviors taking place. Although Miss Estella did not share how students were evaluated and assessed, there is clearly great potential of spurring the students toward higher levels of motivation if feedback were provided on non-academic areas of assessment like creativity, practicality and human-centeredness of the solution – and not just about how effectively math concepts were applied in the solution. It is in this light that the role of design thinking in classroom should be reconceived. School and teachers should move beyond the immediate goal of developing conceptual understanding and emphasize problem-solving, critical thinking, creativity, and entrepreneurship – competencies and skills that students need for the 21st century world – by assessing students on these non-academic and non-examinable domains.

Revisiting Appropriation: Beyond Academic Objectives

According to Grossman, Smagorinsky, and Valencia (1999), grasping and appropriating a tool and using it do not necessarily co-occur – and this is especially relevant to design thinking. First, its adoption required openness to the idea or, more accurately, a willingness to seek an alternative to what the teacher is currently doing. Second, design thinking is at its infancy stage of adoption by schools and there are currently no exemplars for teachers. Third, because design thinking is still a relatively new concept in K12 education, there is no statistically significant research showing its effects on academic outcomes. Finally, change takes time and where no precedent is available for emulation,

change takes even longer to figure out.

Given these reasons, teachers in general have a vested interest in maintaining the status quo. Every teacher has a set of tried-and-tested methods, routines that satisfy their need for certainty, control and simplicity. Therefore, one may understand the conceptual underpinnings of design thinking but reject the premises that support it (Grossman et al, 1999). In addition, adopting any innovation can mean discontinuing the use of familiar and time-efficient practice. Design thinking activities take up more time and might conflict with the number of topics that have to be covered – a perennial problem with which Miss Estella continues to grapple:

> "So that's the challenge. How to do design thinking without the tension on my standards? So you have these 25 standards in math, put projects in between – that's going to take time. It's challenging for me to include all 25 standards and design thinking projects at the same time. That's very ideal. I don't know how this is going to work. It's still a big question for me."

Increasingly, teachers are confronted with the challenge to provide sufficient coverage. On the one hand, there is an increasing volume of content to cover, and on the other, there is a call to cover the curriculum in more depth. Against the backdrop of high-stakes testing and teacher accountability, using design thinking in the classroom may require a greater leap of faith. During my second interview with Miss Estella, I noticed that she looked visibly worn down. She expressed deep worry for her students in eighth grade, many of whom she felt were not ready for the statewide examination happening in less than two weeks. Traditionally, test scores are a utilitarian means to measure and rank both student and school success. Although there have been much effort calling for the de-emphasis of testing, until that happens test scores are still a legitimate – and perceived as important – proxy for student ability. In Miss Jacqueline's case, even as she devotes time and energy to maximizing engagement and understanding, central to her teaching and lesson design is raising student confidence for statewide examinations.

> "Do the STAR test scores matter? Of course they do. That's part of it. Do we have to hit all the standards? Of course we do. That's mandated and that's what we have to do. So to me that's the technical stuff and it's gonna happen, and it will and it is a measure. And the test scores, even minor test scores, report cards, that kind of thing, it does matter."

Therefore, if noble ideals and everyday realities were placed on opposite ends of a continuum, the teacher is tempted to position herself in the middle and seek refuge in old-and-trusted methods with an occasional sprinkle of design thinking activities or familiar practices that are given new, refreshing design thinking labels. However, the teachers in this study acknowledged – perhaps a result of the research process which had made them reflect more critically on their pedagogical choices and ask themselves questions they rarely confronted in their everyday experience of teaching – that they were still on the road to mastering design thinking and more had to be done to realize its potential in teaching and learning. At the beginning of this study, Miss Estella was adamant that "design thinking is not new". In our last interview she rated herself as "60 to 75 per cent" successful and acknowledged that more opportunity must be provided for students to test their prototypes beyond school and reiterate their ideas.

> "I know I'm not quite there yet but I am just learning every day. Every year is new for me. The population is different, the generation is changing, and technology is already part of your curriculum. The classroom is changing to a flat classroom where you want to use conferencing and all these. And your teaching becomes a web something. So yah, challenges are there and I need more exposure to design thinking kind of curriculum."

As mentioned before, the teachers still saw student outcomes as primarily determined by academic course content. However, they also spoke of the need to develop other non-academic skills and dispositions that will prepare their charges for the future. Mr. Lawrence's vision for his students is that they would become more intellectually alert, that their minds would become alive, and he believes this could be achieved by helping them feel more confident to try and express their ideas through design thinking. In fact, creativity is highly valued by Mr. Lawrence, who shared that students seemed to struggle with "independent thought".

> "You know it sounds really weird to say this about a kid because you think they are creative, you know… But sometimes I could just say, 'You have got twenty minutes', and they just don't know what to do. 'What do you want me to do? What steps do I need to go play?' Well, so creativity, the free thinking, the free speech someone is used to in a classroom culture where your ideas are valued is really important."

To Miss Estella and Miss Jacqueline, design thinking also provides a gateway to the generation of solutions for the compelling problems the world continues to face. In fact, Miss Estella cited the rapid rise of gas prices as an example that justified the need for challenging students to think and "let them explore ways to come up with something that would benefit the society".

> "Gasoline is soaring up high, $4.25 everywhere in the country and Obama was saying we need scientists and mathematicians to solve this. If students are exposed to that kind of education thinking and resolving and problem-solving in the future, I think we are in a better place. So design thinking is important at this time given there are so many issues that are coming up."

The cultivation of a broader set of skills and dispositions for the 21st century is critical, and they merit the investment of more time and resources. More importantly, their continued nurturance will be dependent on their place in the present curriculum. The teachers of this study acknowledged that design thinking had a greater role in classroom learning, and they should start by challenging the conventional assumptions of student outcomes to include non-academic domains. That being said, it must be recognized that these teachers are already pushing boundaries and moving beyond established frames for instruction. In fact, in its different and still-evolving manifestations, design thinking is permeating within and beyond classroom walls, bringing New Horizons closer to realizing Dr. Alice's vision:

> "It's (design thinking) everywhere. Students would feel it in the way they are learning. It would be used in a way that the walls are malleable. The things aren't so fixed and staid. That if it didn't work we should fix it, that we should talk about it."

Where schools are known to be plagued by piecemeal innovations that come and go as ad-hoc initiatives, New Horizons seems to have experienced the reverse with design thinking. In fact, if this were the first phase of implementation, the seeds of curricular revolution had already been sown, and as Dr. Alice said, "If there is water here and there, it grows."

Manifestation 2.0: Design Thinking as a Way of Being

The standard practice in schools often follows a teaching paradigm of "teachers teach, students learn". Design thinking, however, refocuses teaching practices on a learning paradigm where the student assumes ownership of the situation. In fact, Dr. Alice described

design thinking as a process where "the driver is the student", and is akin to reading:

> "Maybe design thinking is like learning to read. It's like a way to go about something. I can't make sense of this without reading. I can't make sense of a problem without design thinking. It's not knowledge; it's a process; it's a way of being."

This analogy is an apt one because reading, as a process, is not automatic. Children must develop skills of phonemic awareness, fluency, vocabulary and reading comprehension to read with ease, confidence and understanding (NRP, 2000). Therefore, if we want students to experience design thinking as a "way of being", then they must be equipped with the skills of brainstorming, observing and interviewing to develop empathy, collaboration, prototyping and testing. However, design thinking is less complex. According to David Kelley (2010), design thinking is more experimental and less step-by-step, and "you can build confidence in it if you do it over and over again". Indeed it is a dynamic, generative and creative process. Yet it must be noted that the generation of ideas does not "just happen" and one cannot just wait for the "flash of insight". Duckworth (2006) tells us that research has shown that creativity is not accidental, that it is much more likely when both teachers and students set up the conditions needed to increase the chance of creative outcomes. This means teacher need to provide instructions in process skills, focusing student attention on how to carry out the skills of design thinking confidently.

At New Horizons, a curricular infrastructure is already in place to facilitate the teaching of design thinking skills. First, design thinking in its different appropriated forms is already a part of core content classes and is the key framework for the STEM-design thinking foundation program. At the grade level, students also work on a multidisciplinary design thinking project of their own interest. Second, the teachers are using the same design thinking vocabulary across subjects and classes so that the steps of the design thinking process are easily identifiable for the students. In fact, Miss Jacqueline explained that such efforts "give some uniformity to the teaching" and also communicate the more important message that design thinking is not limited to the STEM-design thinking class.

> "At the beginning, they were using design thinking in their STEM class before we had a grasp of how we could use it in core subjects. So now that we got it all figured out, we really wanted to break away from that and make it a bayside idea in any classroom you go to. I think by using the technical lingo and we try to put it up in all the classes, we show the students that they are all the same throughout. We do interchange the words with different ones also but we are just trying to make sure that they see it everywhere, so that they know it's happening everywhere."

Through its different manifestations and a common set of vocabulary, design thinking as a school innovation has rooted in New Horizons as a signature practice. Moving forward, teachers can work on helping students to develop a set of skills and habits of mind for more self-directed learning. Granted, the problems posed by the coverage of standards and statewide examinations will not go away. The real challenge, however, lies in how teachers can re-conceptualize the curriculum to achieve synergistic outcomes: teaching design thinking to improve student learning and understanding. David Ackerman and David Perkins (1989) conceived the curriculum on two levels: the curriculum that is composed of substantive concepts and content of discipline-based fields, and the meta-curriculum that is a set of skills and strategies selected to help students acquire the curriculum content, and to develop the capacity to think and learn independently (Ackerman and Perkins, 1989, pp. 80-81, as cited in Davis et al, 1997). Design thinking could be conceived as this meta-

curriculum. Its basic premise revolves around empathy, being understanding of what other people need, and how the world is put together from a social and emotional point of view. These are important dispositions that align closely with 21st century skills, and move students toward deeper levels of engagement and understanding. In fact, Kelley (2010) explained that its prototyping focus feeds motivation and drives learning:

> "We have plenty of examples of schools where we see that because students are doing what we call 'build to think' work—doing things with their hands, doing projects—it becomes a great context to communicate basic skills. If you are working on a solar car project and you need to learn some kind of math to calculate something that you really need on the solar car, then you are willing to learn that math. So we think of design thinking as a way to enable and help at least some kids be motivated through real-world application."

In the teaching of design thinking skills, a mind-shift is necessary. When much of the buzz in the teaching literature was still centered on thinking skills a decade back, Costa (2001) said that we must treat the process as the content. Today, this is still very relevant. It means changing one's mind from simply valuing content acquisition to knowledge production as an outcome. In developing the students' critical thinking, empathy, and creativity, teachers thus need to consider these attributes and focus the curriculum on achieving them. According to Sternberg (2001), the teacher can teach process skills as a separate course or infuse the teaching into the pre-existing curriculum. Given that time is a luxury that teachers cannot afford, the second strategy appears to be a better option. In fact, it could be more strategic because students learn that design thinking skills are part of their regular course work and they also use what they learn directly to integrate with the course content they are learning. One problem, admittedly, is the lack of professional development courses and reference materials on design thinking in education – which the teachers of this study explained could provide useful models for developing their own curriculum.

> "I would like to see more examples distributed and shared a little bit more, because you can tweak it and make it work for you. Especially at the beginning, examples are key."

Miss Jacqueline recognizes that such resources are scarce, and until that happens, she believes that among the resources that teachers need is a network of other teachers who are using design thinking in their classroom.

> "They are the best sounding boards. People with the same class, same subject same grade, the same kids. Just being able to sit down and bounce off ideas, in all honesty, that's the most helpful to talk with people in the same boat. Just getting the time to just collaborate and talk is the most important."

One interesting thing to note is, the teachers in this study are keenly aware that there are other schools that are also using design thinking in teaching – but they have little or no idea where they are. Miss Estella, who desires to integrate the full process of design thinking to achieve more synergistic outcomes in her lessons, suggested that best practices be highlighted and shared not just within a school, but also across schools.

> "If there is a school that embraces design thinking, then we can see how it is used in the different subjects, even PE, music or whatever curriculum there is that is using design thinking. Especially if you see success, I think that would be an eye opener."

Indeed teachers and schools attempting to integrate innovative methods into the curriculum are often isolated from one another and from researchers, curriculum developers, and other advocates of the innovation. This is very much the case for design thinking. The

goal therefore is to highlight and share promising practices in K-12 education, to seed collaborations among educators, and to inspire further research on how design thinking can be further instantiated in teaching and learning. As Davis, Hawley, McMullan and Spilka (1997) already highlighted in "Design as a Catalyst for Learning" more than a decade ago, "Surely there is a critical mass of developing interest which – if supported by strategic investments in networking, pre-service training, resource dissemination, and further research – will lead to a quantum leap in the integration of design methods across the spectrum of U.S. education". It is timely to revisit this statement and make it happen.

Conclusion

Enacting change is complex. Under the charge of Dr. Alice, New Horizons had seen radical transformation. However, the job of orchestrating this change was shared and owned by everyone in the school community – the administrators, teachers, staff, students and their parents. The school as a credible institution of learning had begun to emerge, and the attention to the holistic development and growth of the students also ushered the adoption of design thinking as a new pedagogical tool. I remember marveling at the teachers' open-door policy, which appeared to be deeply entrenched in the school culture. As Dr. Alice whizzed me in and out of different classrooms during an orientation tour around the campus, I noticed that the teachers continued teaching as they normally would. They were clearly accustomed to her presence in their classroom, and the students also did not look alarmed. On another occasion, I ran into a discussion between Mr. Lawrence and his colleague, which centered on teaching and quickly ended (I had scheduled an interview with Mr. Lawrence) with a confirmation of date and time to observe each other's lessons. At New Horizons a culture of professional sharing and collaboration seems to be firmly in place. In fact, Miss Estella shared that the school administrators encourage the teachers to observe one another's lessons so that ideas for teaching and learning can cross-pollinate.

It is important to note that New Horizons may not be characteristic of other middle schools that remain trapped in a vicious cycle of decline with a lack of clear vision, uncommitted teachers and little success with change. Besides, teaching is inherently isolationist – unlike the teachers at New Horizons, many still close the classroom door and do what they want to do in their protected space. Teaching has also been described as a kind of artistry that "requires sensibility, imagination, technique, and the ability to make judgments about the feel and significance of the particular" (Eisner, 2005). However, such traits and skills do not come easily to the teacher who has to simultaneously engage with content, classroom management, and ongoing monitoring of student progress. In adopting design thinking, schools therefore need to help these educators re-learn and even unlearn old habits – and school leaders must remove the fear of failure as a barrier to trying. It is in fact just as necessary as for teachers as for children to feel confidence in their own work and ideas, a point which Dr. Alice emphasized:

> "I tell them it doesn't have to be right. Who knows what that is? You try it in the classroom. That's what a really good teacher does. In the teaching moment, if it didn't work, you switch it up. Don't keep doing it. That's a design thinking approach right there."

Dr. Alice believes that there is a design thinker in everyone and encourages her teachers to indulge in "appropriate playfulness in the classroom". It is essential to accommodate the teachers' realities and pressures presented by state standards, examinations and challenging students, but she places a greater importance on engaging her teachers as design thinkers who "look at things differently", "try to make things work" and "they dare each other to do things".

> "When's the right time to use it (design thinking)? Isn't that what a good teacher does? I can't go in and tell the teacher, 'Wow, you missed that moment.'"

In the process, her teachers have been empowered as curriculum designers who plan their lessons to bring about the change and deep learning the school desires for the students. Indeed it is perhaps inherent in teaching that professionalism is inextricably linked to curriculum development. It is the teacher who has specialist knowledge of their students'

needs – and it is crucial for success that those who are involved in the implementation of curriculum design should play an active role starting from the planning stage to the evaluation aspect. Indeed the role of the teacher as a curriculum designer or "curriculum maker" (Clandinin and Connelly, 19992) is a compelling one. For Miss Jacqueline, this role is also one that brings much fulfillment and accomplishment.

> "Once you grasp the idea of design thinking, it sounds interesting so you kind of want to make it work. And once you have one successful lesson and all of a sudden you see all the light bulbs go off and it makes sense and the kids enjoy it and get a lot of academic out of it so you just want to continue. And it's a different way of teaching; it's not so dry and boring and clear-cut as a lot of teaching methods are. It's fun for us you know and it's interesting for the kids so I keep trying."

It is also important to remember that teachers come to the profession on the basis of their subject interests and commitments. For many of them, incorporating design thinking in classroom learning would require a similar commitment to constrain their impulse to erect walls around the teaching of academic content. In fact, this study emphasizes the need to promote 21st century skills as similarly important student outcomes. Further research should thus explore how teachers and schools can use design thinking to deliver both sets of objectives. The experience of New Horizons also speaks of the importance of school leadership, which is instrumental in the instigation and adoption of design thinking to transform curriculum and instruction. Research in other schools can further elaborate how school leaders develop a shared vision and foster conducive environments for the adoption of design thinking to take place. It must also be noted that the students interviewed were mainly drawn from the GATE program and may not be representative of the general student population. According to Davis (1997), design-based experiences appear to reach a wider variety of learners than traditional methods of instruction, which favor the student who perceives information abstractly and processes it reflectively. Therefore analysis between different ability groups is an important direction for future research.

Finally, strong convictions are rooted in strong sources. Teachers' convictions are forged within the crucible of personal beliefs, prior knowledge of teaching and learning, and beliefs about the value and worth of investing in change. The challenge is to develop design thinking as a tool that inspires teachers to use it in their classrooms. Just as the curriculum evolves to include new knowledge and skills that students need for the 21st century, professional development for educators become critical to equip them as designers of exciting learning experiences. Our teacher preparation and professional development programs would require continual innovation to develop a generation of teachers who can actualize this vision.

Note

All names of individuals and the name of the school discussed here are pseudonyms.

References

Aronowitz, S. (2008). *Against schooling: Toward an education that matters*. Boulder: Paradigm Publishers.

Barseghian, T. (2009). Design Thinking: Creative Ways to Solve Problems. In *Edutopia*. Retrieved April 11, 2011, from http://www.edutopia.org/classroom-design-k12-laboratory.

Berg, B. (2004). *Qualitative research methods for the social sciences* (5th ed.). Boston: Pearson Education.

Carroll, M., Goldman, S., Britos, L., Koh, J., Royalty, A., & Hornstein, M. (2010). Destination, Imagination and the Fires Within: Design Thinking in a Middle School Classroom. *International Journal of Art & Design Education, 29(1)*, 37-53.

Charmaz, K. (2006). *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. Thousand Oaks, CA: Sage Publications.

Chen, M. (2010). *Education Nation: Six Leading Edges of Innovation in our Schools.* San Francisco, CA: Jossey-Bass.

Clandinin, D. J., & Connelly, F. M. (1992). Teacher as curriculum maker. In Jackson, P. (Ed.), Handbook of research on curriculum. New York: Macmillan, pp. 363–401.

Cohen, L., Manion, L. and Morrison, K. (2001). *Research Methods in Education. 5th Edition,* Routledge Falmer: London.

Costa, A.L. (2001). *Developing minds: A resource book for teaching thinking.* Alexandria, VA: Association for Supervision and Curriculum Development.

Davis, M., Hawley, P., McMullan, B., & Spilka, G. (1997). *Design as a catalyst for learning*. Alexandria, VA: ASCD.

Dewey, J. (1938). *Experience and Education*. New York: Collier Books, pp. 25-50.

Drake, S. M. (2007). Creating standards-based integrated curriculum Second Edition: Aligning curriculum content, assessment and instruction. Thousand Oaks, CA: Corwin Press.

Duckworth, E. (1996): *The Having of Wonderful Ideas and Other Essays on Teaching and Learning.* New York, Teachers College Press.

Dweck C. S. (2006). *Mindset: The New Psychology of Success.* New York: Random House.

Eisner, E. (1992). Educational reform and the ecology of schooling. *Teachers College Record, 93 (4)*, pp. 610-627.

Eisner, E. (2006). *Reimagining schools: The selected works of Elliott Eisner*. New York,

NY: Routledge.

Freire, P. (1995). *Pedagogy of the Oppressed*. New York: Continuum. pp. 52-67.

Friesen, S. & Jardine, D. (2010). 21st Century Learning and Learners. In *Government of Alberta*. Retrieved April 12, 2011, from education.alberta.ca/.../wncp%2021st%20cent%20learning%20(2).pdf .

Fullan, M. (2002). Principals as leaders in a culture of change. *Educational Leadership*. 59(8), 16-21.

Gardner, H. (2010). Five Minds for the Future. In Bellanca, J., & Brandt, R. (Eds.), *21st century skills: Rethinking how students learn*. Bloomington, IN: Solution Tree.

Gee, J. P. (2008). *What video games have to teach us about learning and literacy*, *revised and updated*. Basingstoke: Palgrave Macmillan.

Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine Publishing Company.

Green, R. L. (2010). *The four dimensions of principal leadership: A framework for leading 21st century schools.* Boston, MA: Allyn & Bacon.

Grossman, P. L., Smagorinsky, P., & Valencia, S. (1999). Appropriating tools for teaching English: A theoretical framework for research on learning to teach. *American Journal of*
Education, 108(1), 1-29.

Guba, E. G. & Lincoln, Y. S. (1989). *Fourth generation evaluation.* Newbury Park, CA: Sage.

Hancock, D.R. (1995). What Teachers May Do to Influence Student Motivation: An Application of Expectancy Theory. *The Journal of General Education*, *Fall 1995*, pp. 171–179.

Hardiman, M. (2010). The Creative-artistic Brain. In Souza, D. (Ed.), *Mind, Brain, and Education: Neuroscience Implications for the Classroom*. Bloomington, IN: Solution Tree.

Hayes Jacobs, H. (2010). *Curriculum 21: Essential Education for a Changing World.* Alexandria, VA: ASCD.

Herman, J. (2004). The effects of testing on instruction. In Fuhrman, S., & Elmore, R. (Eds.), *Redesigning accountability systems for education.* Amsterdam Avenue, NY: Teachers College Press.

Jardine, D. & Friesen, S. (2011). *Guiding Principles for WNCP Curriculum Framework.* Mahwah, NJ: Lawrence Erlbaum and Associates.

Kay, K. (2010). 21st century skills: Why they matter, what they are, and how we get there. In

Bellanca, J., & Brandt, R. (Eds.), *21st century skills: Rethinking how students learn*. Bloomington, IN: Solution Tree.

Kelly, F. S., McCain, T., & Jukes, I. (2009). *Teaching the digital generation: No more cookie-cutter high schools*. Thousand Oaks, CA: Corwin Press.

McWilliam, E. (2009). Teaching for Creativity: From Sage to Guide to Meddler. *Asia Pacific Journal of Education*, 29:(3), 281 – 293.

Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education*. San Francisco: Jossey-Bass.

National Institute of Child Health and Human Development. (2000). *Report of the National Reading Panel. Teaching children to read: an evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*.

Pink, D. H. (2005). *A Whole New Mind: Why right-brainers will rule the future.* New York: Riverhead.

Prensky, M. (2010). *Teaching Digital Natives: Partnering for Real Learning.* Thousand Oaks: CA: Corwin Press.

Rauth, I., Köppen, E., & Meinel, C. (2010). Design Thinking: An Educational Model towards Creative Confidence. Proceedings of the 1st International Conference on Design Creativity ICDC 2010 (to appear).

Reeves, D. B. (2004). *Accountability for Learning: How Teachers and School Leaders Can Take Charge*. Alexandria, VA: Association for Supervision and Curriculum Development.

Steinberg, A. (1998). *Real learning, real work*. New York: Routledge.

Sternberg, R.J. (2001). Teaching Problem-solving as a Way of Life. In A.L. Costa (Ed.), *Developing minds: A resource book for teaching thinking.* Alexandria, VA: Association for Supervision and Curriculum Development.

Vasquez Heilig, J. & Darling-Hammond, L. (2008). Accountability Texas-style: The progress and learning of urban minority students in a high-stakes testing context. *Educational Evaluation and Policy Analysis. 30*(2), 75-110.

Wertsch, J.V. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard University Press.

Zhao, Y. (2009). *Catching Up or Leading the Way.* Alexandria, VA: ASCD.

Zastrow, C. (2010). New Designs for Learning: A Conversation with IDEO Founder David Kelley. In *Learning First Alliance*. Retrieved May 21, 2011, from http://www.learningfirst.org/visionaries/DavidKelley

Appendix1: Interview Protocols

Table 1.1. Interview Protocols for School Leader

ICEBREAKER

- How long have you been involved in education?
- Tell me what you love about education.

GENERAL

Values and educational philosophy

- What do you value most in education? Can you tell me about a time when what you value was present and center for you?
- How do you view your role as an educational leader?

TEACHING & LEARNING

Curriculum Leadership

- Describe what a good lesson looks like.
- How have you shaped teaching and learning in the school? Provide examples of how you have done that.

Curriculum development and pedagogy

- What is good teaching to you?
- Describe an example of a good lesson you have observed.

Outcomes

- What are some student outcomes that you are concerned with as an educational leader? How about your teachers – what are some student outcomes they are concerned with?

DESIGN THINKING

Attitude towards design thinking

- How do you feel about design thinking?
- What is design thinking to you?

Design thinking in teaching and learning

- How would you describe the Bayside STEM approach of using design thinking in classroom learning?
- How do you feel about design thinking as a way of learning? Are there challenges?

Design thinking and Effects

- In what ways has design thinking changed your teachers? How about your students?

Design thinking and Training

- How does the school administration or department support them in using design thinking?

Table 1.2. Interview Protocols for Teachers

ICEBREAKER

- How long have you been teaching?
- Tell me what you love about teaching.

GENERAL

Values and educational philosophy

- What do you value most in teaching and learning? Can you tell me about a time when what you value was present and center for you?
- What do you find challenging about teaching?

Teaching (curriculum development and pedagogy)

- Describe what a good lesson looks like.
- How would you describe your teaching style?
- What are your key considerations when preparing for lessons?
- What are your key considerations when carrying out your lessons?
- What do you think is your best teaching quality?
- How do you know when a student is engaged? How do you know that he or she understands?

Students

- How would you describe the students in your class? What are their strengths? Weaknesses?
- Given their profile, how do you address their learning styles and needs?
- Given your experiences, what do you think are key in helping students learn better?

Outcomes (accountability)

- What are some student outcomes that you are concerned with as a teacher?
- Which is most important to you? Why?

DESIGN THINKING

Attitude towards design thinking

- How do you feel about design thinking?
- What is design thinking to you?

Design thinking in teaching and learning

- How do you describe the Bayside STEM approach of using design thinking in classroom learning?
- How do you feel about design thinking as a way of learning?
- How do students respond to design thinking?
- How often do you incorporate design thinking into your teaching? Tell me about a time that you have, describing it in as much detail as you can remember.
- Was there a time you did design thinking work that was a negative experience? Can you tell me about that experience?

- What are some challenges with using design thinking in the classroom? How have you dealt with them?

Design thinking and student outcomes

- In what ways has design thinking changed your students? How have they benefitted?

Design thinking and Training

- How does the school administration or department support you in using design thinking?
- Is there a time you can tell me about when the topic of design thinking came up in the faculty? What did you talk about?
- What areas of training or support do you wish for in design thinking?

Table1.3. Interview Protocols for Students

ICEBREAKER

- How has your day been?
- Can you tell me about your school? What is Bayside STEM Academy like?

GENERAL

Lessons

- What do you like about your school? What do you not like about your school?
- What subjects do you like? Why?
- Describe how the lessons for these subjects are like. What did the teacher do? What were some of the activities that took place?
- Was there a lesson that was especially memorable? What happened? What did you learn?
- How are lessons here different from elementary school?

Teachers

- How are your teachers like?
- Who is your favorite? Why?
- How is he/she like in the classroom?
- Does he/she help you learn better? What does he/she do?
- What do you hope your teachers can do more of?
- What do you hope your teachers can less more of?

DESIGN THINKING

Knowledge about design thinking

- Do you know design thinking?
- What do you know about design thinking?

Design thinking in teaching and learning

- Describe a lesson that you had which used design thinking. What was it like?
- How is it different from normal lessons?
- What do you learn in a class that uses design thinking?
- How often do you have design thinking lessons? In which subjects?
- What do you like about design thinking lessons? What do you not like about design thinking lessons?
- Do you want to have more lessons that use design thinking?

Appendix 2: Coding Schemes

Table 2.1: Coding of Observation Field Notes

Code	Explanation
Student activity (seatwork)	Students engaged in routine tasks of practicing examples or writing tasks.
Student activity (hands-on task)	Students engaged in learning-by-doing activities.
Teacher Activity (Direct Instruction)	The teacher delivered the lesson via a lecture mode.
Teacher Activity (Guiding / helping)	The teacher facilitated group or individual work.
Design thinking language	The teacher called a project a design thinking project or used any of the labels / names that describe the steps of the design thinking process.
Real-world examples	The teacher uses examples from everyday life to explain concepts.
Integration	The teacher uses ideas or concepts from other subjects.
On-task behavior	Students are paying attention and/or engaged.
Off-task behavior	Students are distracted and not fully engaged.
Positive Reinforcement	The teacher used praise or encouragement.
Negative Reinforcement	The teacher used methods of reprimanding or withheld certain privileges.

Table 2.2: Coding of Interview Transcripts

Code	Explanation
Student learning (Understanding)	The interviewee described concerns / strategies / activities that help student gain understanding of concepts.
Student learning (Motivation)	The interviewee described concerns / strategies / activities that develop student interest and willingness to invest in an activity or learning.
Student learning (Creativity)	The interviewee described concerns / strategies / activities that develop student creativity / innovation.
Student's experiences	The interviewee described engaging students' prior knowledge, skills or experiences
Strategy (Making Connections)	The interviewee described strategies to help students make connections and establish relevance.
Strategy (Integration)	The interviewee described strategies to integrate ideas and concepts from other subjects.
Strategy (design thinking)	The interviewee described the use of design thinking in developing student learning.
Strategy (prototyping)	The interviewee described the specific use of prototyping in student activity.
Challenge (Time)	The interviewee described time as a challenge to teaching / using design thinking.
Challenge (no exemplars)	The interviewee described lack of examples or references for using design thinking.
Teacher Confidence (+)	The interviewee described confidence in teaching / using design thinking / interaction with students / classroom management.
Teacher Confidence (-)	The interviewee described or suggested a lack of confidence in teaching / using design thinking / interaction with students / classroom management.

Acknowledgements

This thesis would not have been possible without the strong help and support of many people, and I am especially indebted to the following few. First, I would like to thank my advisor, Shelley Goldman, who has provided me incredible support and feedback. Her constant encouragement has spurred me on throughout my course at Stanford. Her passion for design thinking and K12 education has inspired me to engage in this research – and I am grateful to have had the opportunity of learning so much with her guidance. Her thoughtful and meticulous reading of this paper has helped me to push further in understanding more deeply the complex work that teachers engage in.

Next, I need to thank my colleagues in the REDlab team – Maureen, Leticia, Adam, Zaza, and Jain – who, together with Shelley, continue to explore the promise of design thinking in K12 education. I cherish the opportunity of working and learning with them, and especially the friendship that we have forged over the last nine months. It is a dream to work with such talented individuals who work hard and play just as hard. I am so lucky to be a part of this team.

The process of working on this study, from data collection to writing, has evoked fond memories of my own teaching days. To the principal and teachers at the site where this research was conducted I am especially grateful – for their generosity and openness has made this study possible. Their commitment to helping their students experience daily victories in their learning is deeply inspiring; I salute them and wish them the very best in their new endeavors with design thinking.

Words are not enough to express my love and gratitude to my wife, Shuhui, and son, Kieran, whose company I have missed immensely throughout the last five months. Not having them with me was difficult, but I was as a result able to fully commit myself to the rigorous work at Stanford. I am ever grateful of my family's belief in me.

Finally, I came to Stanford in search of answers to the questions that have arisen out of my teaching experiences. With the end of this course, I am excited to return to Singapore and share my new knowledge with my fellow educators, and contribute to the development of more rewarding learning experiences for our students.