Opening a Design Education Pipeline from University to K-12 and Back

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Abstract
To prepare students to imagine desirable futures amidst current planetary level challenges, design educators must think and act in new ways. In this paper, we describe a pilot study that illustrates how educators might teach K-12 students and university design students to situate their making within transitional times in a volatile and exponentially changing world. We describe how to best situate students to align design thinking and learning with future foresight. Here we present a pilot test and evaluate how a university-level Dexign Futures course content, approach, and scaffolded instructional materials – can be adapted for use in K-12 Design Learning Challenges. We describe the K-12 design-based learning challenges/experiences developed and implemented by the Design Learning Network (DLN). The *Dexign Futures* course we describe in this paper is a required course for third year undergraduate students in the School of Design at Carnegie Mellon University. The "x" signifies a different type of design that aligns short-term action with long-term goals. The course integrates design thinking and learning with long-horizon future scenario foresight. Broadly speaking, we ask how might portions of a design course be taught and experienced by teachers and students of two different demographics: within the university (Design Undergraduates) and in K-12 (via DLN). This pilot study is descriptive in nature; in future work, we seek to assess learning outcomes across university and K-12 courses. We believe the approach described is relevant for lifelong learners (e.g., post-graduate-level, career development, transitional adult education).

Keywords: DEXIGN | Futures | Foresight | Scenarios | Design-Based-Learning | Flipped-learning

In a world of accelerated change, faculty and students are required to adapt and master new knowledge to address larger scale problems such as planetary sustainability. Design educators are challenged to teach to design for short-term and long-term timescales. Fortunately, Future Studies researchers already describe how to teach students greater agency within long-term timescale horizons (Hicks & Slaughter, 1998; Slaughter, 2008). Teaching Futures Studies methods in a design school or K-12 school poses pedagogical and logistical challenges to teaching practices. We ask:

How might we best prepare our students?

How might we make learning more efficient and "sticky"?

To explore these overarching questions, we discuss two cases: one at the university-level and at the K-12 level. First, we studied third year undergraduate design students enrolled in a required Futures course. By the end of the course, students were expected to be able to align short-term design action with long-term vision horizons. We used a flipped-class learning pedagogy to introduce students to new concepts outside of class in preparation to apply those concepts in class. Second, we collaborated with the Design Learning Network (DLN) operating in the K-12 setting to address the question of how might we best prepare college bound students to overcome constraints and afford building robust educational pipelines. The goal within the K-12 context was to engage students and educators in creative problem solving through inquiry-based learning, design challenges, and reflective practice. We investigated these questions:

How might quality design learning be opened to a broader spectrum of students with varying academic levels (K-12-university-lifelong) and disciplinary backgrounds? And, how might we more effectively teach new design content and methods?

Recognizing barriers and opening access

In the United States, an increasing number of K-12 students have limited access to the arts. According to the 2016 National Center for Educational Statistics Report on State Education Reform 27 states define the arts as a core or academic study. While all 50 states adopted some level of elementary and/or secondary arts education standards, only about half require arts education as a graduation requirement. Yet, only a handful of states require an arts-based assessment, and/or district-level accreditation to teach the subject. Decreased access to creative and applied arts classes is linked to limited K-12 arts education budgets.

Limited access to creative and applied arts classes further challenges high school students to prepare a visual portfolio needed to apply to design schools. Unfortunately, most student portfolios show arts related content (e.g., art drawings, paintings) but do not include design projects. Drawing, while highly valued, is only one skill required for problem-based design challenges. This leads to college admissions decisions determining an applicant's design potential weighing heavily on a narrow subset of skills exhibited in the individual's portfolio.

This meritocratic practice favors students that have had more opportunities to develop the best portfolio. Thus, budget cuts to arts education in K-12 further skews the university-level admissions pool of students toward those with higher socioeconomic status (SES). We seek to relieve some of these pressures, enhance student learning, and open opportunities by providing K-12 students access to quality design education in areas like futures design and exposure to and practice with design thinking and learning, a highly applicable and transferrable skill.

Recognizing design as a pathway to learning

There is movement afoot, albeit slow, to integrate design thinking into learning. The draft 2017 Department of Education in South Carolina, College- and Career-Ready Standards for Design Proficiency offers K-12 design-thinking standards (pp. 98-135). In addition, private, philanthropic, and public initiatives emerged to offer K-12 students' opportunities to focus on

creative problem-based studies alongside academics. Design schools actively engage pre-college students in summer programs, K-12 educators in professional development, and executive education innovation programs (Appendix A).

Opening the pipeline to persistent design learning and thinking

We aim to increase opportunities for students from all SES to consider design as a career path as well as to support teachers as they integrate design-centered instructional strategies into their teaching, thereby developing otherwise untapped design talent and leveraging diverse perspectives for solving societal-level challenges through design. We are interested in attracting better-prepared design school applicants, who are motivated by complex design challenges.

In the face of unprecedented global challenges, design is a frontline tool to transition towards long-term survival (Irwin, Tonkinwise, & Kossoff, 2013). Our approach increases access to futures thinking. For the individual student, design thinking and learning coupled with futures thinking gives tools to imagine their own futures and more fully explore potential learning pathways – it opens the space of possibility.

CASE 1: Dexign Futures University-Level Required Course

Typically, design is taught with studio-based courses: 15-20 students who meet over the course of 15 weeks, two times a week for 3 hours a day. The studio pedagogy allows students to receive rich feedback on projects from instructors and peers. The desk critique allows deep discussions with students individually during class. Traditional studio pedagogy has desirable features for learning, but there are limitations to the number of student this model can reach. We identified three student challenges from teaching prior versions of *Dexign Futures* courses with traditional studio pedagogy (Scupelli, & Wasserman, 2014; Scupelli, Wasserman, & Brooks, 2016[a]):

1) limited critical engagement with futures thinking.
2) superficial interpretations of futures signs, forces of change, and benchmark goals for desirable futures.
3) limited application of futures methodologies within design projects.

Since the futures course is a new required course for 50+ third year undergraduate design students, we wanted to make sure to a) leverage what works from studio pedagogy (e.g., plenty of practice with guidance and feedback); b) manage exposure to content so students could engage more meaningfully with futures thinking and design; c) help students to apply the new concepts and methodologies to their design projects.

Here, we provide highlights of the course via four examples of the instructional activities connected to student learning experiences and outcomes: hopeful and fearful futures; alternative futures; connecting futures to real-world events; and experiential futures.

Hopeful and fearful futures

The preparatory course materials and in-class activities for "hopeful and fearful futures" were designed to a) connect students' prior knowledge and experience to futures thinking; b) expose students to their own pre-conceptions about futures; c) contrast their personal views with those of

leaders in the Futures Studies field.

Elaborative Interrogation: Students were asked to explicitly link new concepts presented in the course to their own past experiences. For example, students were asked to list their hopes and fears through a series of sequenced activities (Figure 1). First, students considered their hopes and fears as two separate lists. Second, students considered their hopes and fears through two-time scales: short-term and long-term (Figure 2). Third, students were asked to consider their short- and long-term fears through the lens of STEEP forces (i.e., social, technological, economic, environmental, political). By connecting short-term personal hopes and fears to long-term STEEP forces, students could more easily identify larger societal issues.

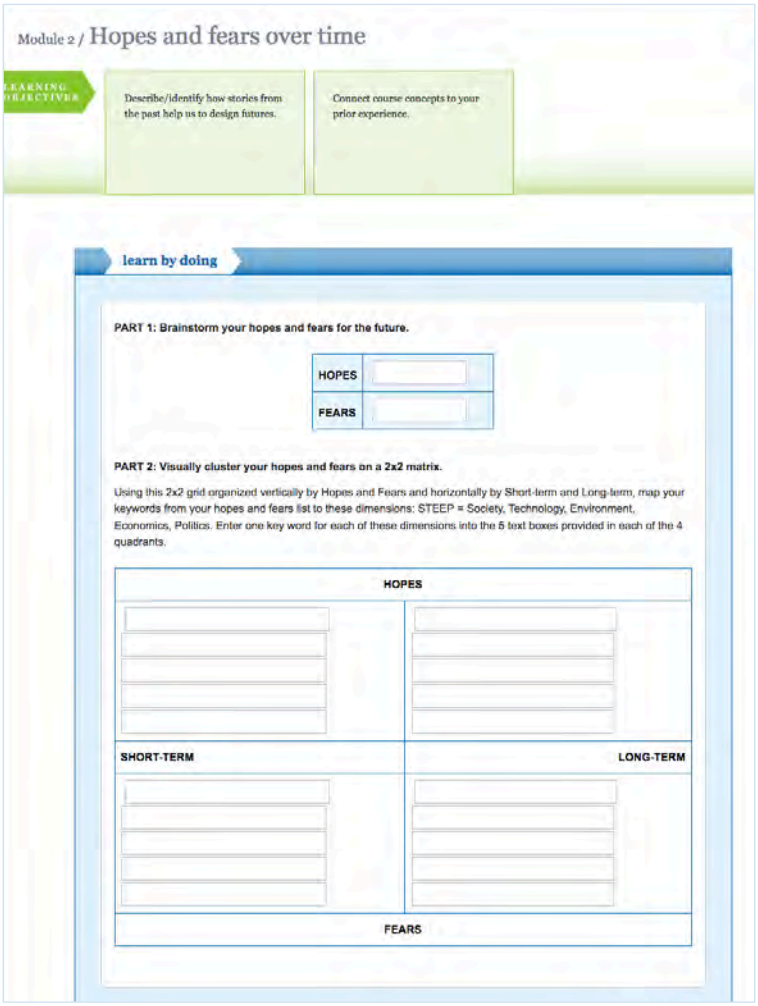

Figure 1. Online module, pre-class work: "hopes and fears" sequenced activities to 1) list hopes and fears, 2) plot them on a short- and long-time horizon, 3) connect them to STEEP forces.

Self-Explanation: To promote discussion and self-explanation with peers, students aggregated the individual hopes and fears into word clouds and presented in class (Figure 3). As students explained their hopes and fears reasoning to each other, they identied and connected common themes, while also surfacing differences or diverging worldviews.

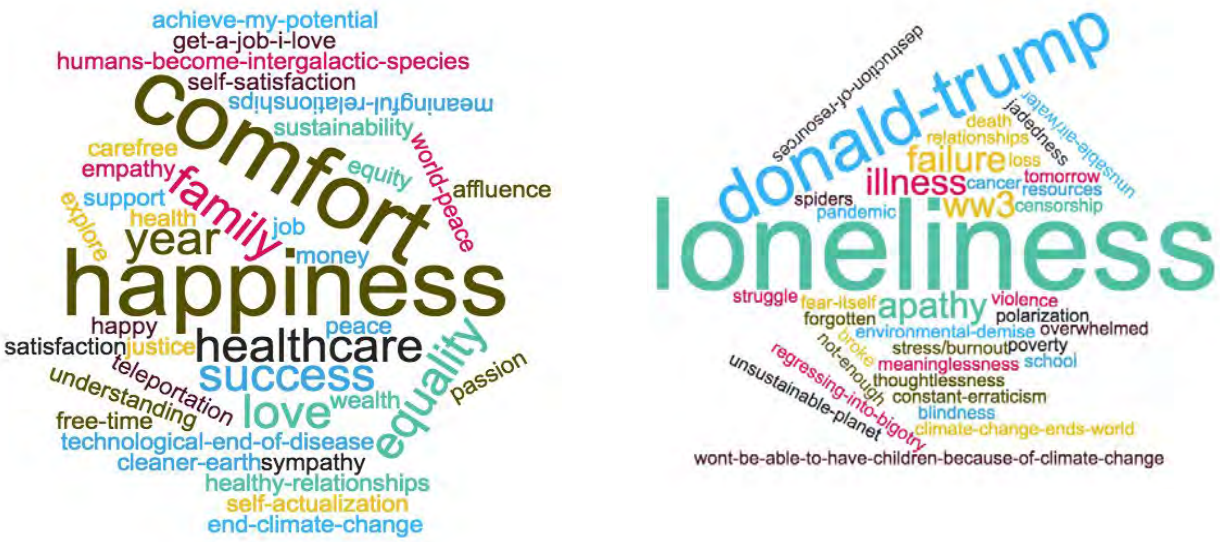

Figure 2. Word clouds displaying students' hopes (left) and fears (right) for the future.

Figure 3. Word clouds displaying students' hopes and fears categorized into short- vs long-time horizons.

Distributed Practice: The sequence of weekly modules was designed to provide students with multiple exposures to new concepts and expert perspectives with distributed practice overtime. For example, on the topic of "Foresight" students noticed how futurist Alvin Toffler explored both the positive and negative aspects of futures. In the class discussion, we

compared the students' word clouds (Figure 2) with the word cloud that students generated to represent Toffler's perspectives presented in his 1999 "Big Thinkers" program for ZDTV[1] (Figure 4). In contrast to the students' focus on the future through their individual hopes/fears, Toffler focused on societal-level futures more holistically (e.g., social change, future shock). The distributed practice overtime gave students a foundation to compare their own thinking with the expert futurists and to better identify a broader spaces to explore.

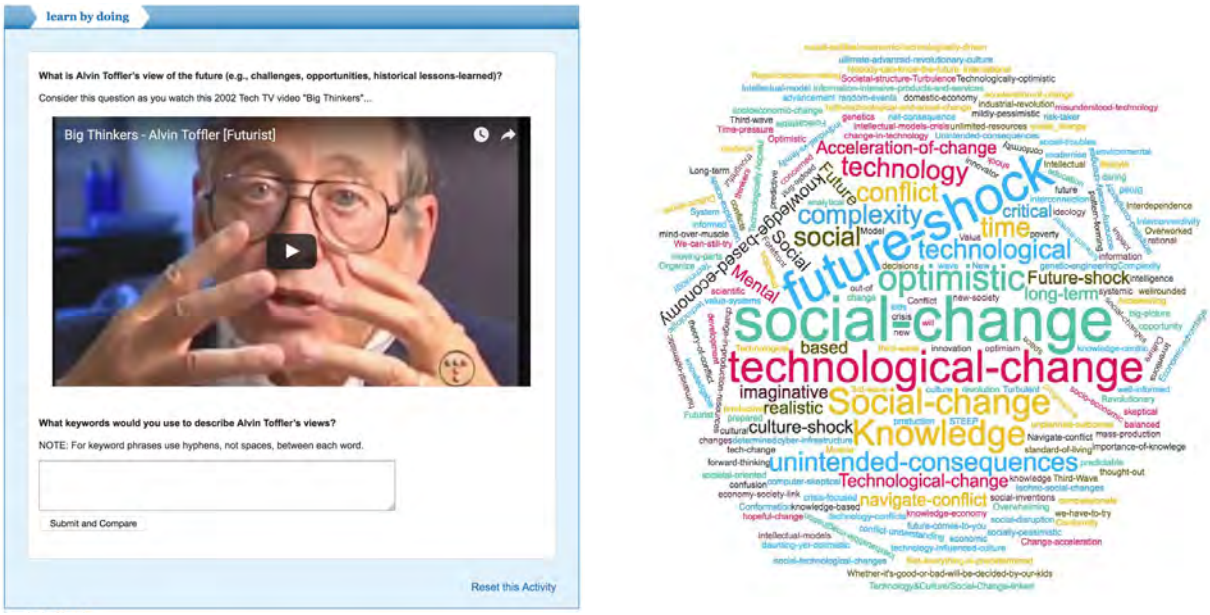

Figure 4. Online module pre-class work: Alvin Toffler's ZDTV "Big Thinkers" episode (left). Collective word cloud resulting from DF student key words extracted from the episode.

Next students summarized the main points, from the *Futurestorming Series* for the 2016 World Futures Society conference, where prominent industry and academic futurists discuss these questions: a) What excites you most about the future? b) What can we do to address our anxiety about the future? By providing distributed practice (e.g., compare and contrast Alvin Toffler's words in 1999 with a much younger generation of futurists in 2016), students would need to recall past content/concepts and connect that information with new concepts, thus helping with retention and further building of new knowledge (Figure 5).

Interleaved Practice: Rather than focus on a single method at a time, with interleaved practice, students were exposed to multiple futurists' perspectives on foresight in the same work session. Foresight is a deliberate process of expanding awareness and understanding through futures scanning and the clarification of emerging situations. In these terms, it is evident that foresight expands the boundaries of perception forward in several ways. Foresight helps us to: (a) Assess possible consequences of our decisions and actions; (b) Anticipate problems before they occur; (c) Consider the present implications of future events; and, (d) Envision desired aspects of future societies. (Slaughter 1995). To help students distinguish the defining characteristics of foresight, they were asked to view and then compare and contrast the features of foresight discussed by

[1] http://www.virtuosochannel.com/2013/12/zdtv-big-thinkers-episode-2-alvin.html
[2] One student asked "what is the point of future studies and trying to shape desirable futures, when your personal nightmare becomes true?"

five futurists: Richard Slaughter, Jim Dator, Sohail Inayatullah, John Sweney, and Stuart Candy.

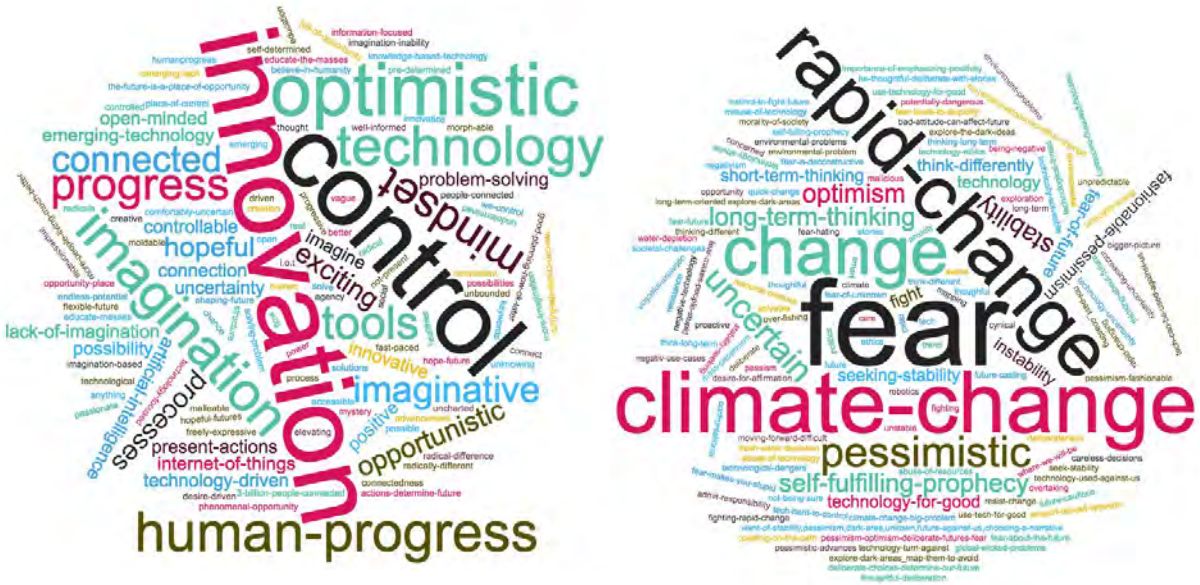

Figure 5. Left, Wordcloud made during class with words the students extracted from the video *Futurestorming Series*: *What excites you most about the future*. Right, Wordcloud made during class with words that the students extracted from the video *Futurestorming Series*: *What can we do to address our anxiety about the future?*

The activity of comparing and contrasting different definitions of foresight helped students identify common themes and differences, revealing how the field of futures studies has expanded and changed over time. In-class discussion provided a deeper dive into the foresight concept as students began to explain idiosyncrasies particular to each futurist. Students benefitted from the focused activity of finding distinguishing features across futurists.

Alternative Futures

One key lesson from the field of Future Studies, is that there is no singular future – there are multiple futures. To engage students experientially with the notion of multiple possible futures, we leveraged distributed practice and interleaving to help students critically engage with three different types of alternative futures scenarios: Royal Dutch Shell (Wack, 1985; Kahane, 2012), life@oneplanet (Luebkman, 2009), and four generic futures (Dator, 2009). In class, students described multiple possible majors and possible future careers within Dator's four generic alternative worlds (i.e., continued growth, collapse, disciplined society, transformative society). By making the alternative pathways visible, tangible, and comparable, students were able to evaluate possible consequences of "difficult choices."

Practice Testing: We embedded frequent low-stakes practice into the online course modules. After completing each pre-class online practice, students submitted open questions. At the beginning of each class period, we discussed students' questions and misconceptions as needed.

In-class activities were designed for applying futures design concepts and for practicing with the new approaches/methods. For example, students were asked to develop and iteratively refine

scenarios for a three-generation persona family. As students were exposed to futurists work, over time they developed a critical eye toward their own personas – explaining why their own were "flat," lacking the depth they found in the futurists' perspectives. Thereby, students were motivated to receive and use feedback from peers and guidance from the instructor to iterate and refine their work.

Linking the real world to the classroom

On the first day of class, many students expressed fear at the prospect of a Trump presidency (Figure 2). The unlikely 2016 election of Donald Trump caught many university students off guard. The days following the election, some students questioned the validity of futures design methods being taught.[2] The US presidential election provided a rich context to meaningfully engage with the course concepts and fueled a series of rich in-class discussions: What futures signs did we miss that might have signaled the election outcomes? What were the STEEP forces at work? How might we choose to address new challenges?

Experiential futures: bringing it all together

The final project for the class, "Experiential futures[3]" (Candy, 2013) had multiple deliverables: First, provide an audience with a first-hand experience of life in a possible future. Second, create experiential futures with four levels: (a) setting: the kind of future world; (b) scenario: a specific future history or state; (c) situation: one-to-one scale visible representation of time and place; and (d) stuff: artifacts or instantiations. These four levels go from abstract to concrete (Candy & Dunagan, 2016). Typically, design students were more comfortable within the realm of the concrete and struggled to connect abstract ideas with concrete instances. Third, the final learning objective was to connect the abstract level of futures scenarios with concrete artifacts and tangible everyday experiences. In the assignment, students used: scenario writing, storyboarding, designing artifacts and environments from plausible futures.

Students read an example of a professionally written futures scenario LEARN 2050! (Wasserman, 2014). One limitation of written scenarios is that given the level of abstraction, the audience usually struggles to imagine how it might feel like to live in such a future. In the final project, students enacted a scene from an education future scenario set in year 2050. Students created a five-minute skit to act out in the classroom so that the rest of the class could experience what it might feel like to live in that specific future. Students used Dator's second law of futures. "Any successful statement about the future should at first appear to be ridiculous" but must be balanced to remain plausible to the viewers. Student teams were to assume that parts of the LEARN 2050 scenario had come to pass. They then asked: What problems disappeared or significantly decreased? What new problems emerged or worsened? What surprising things ceased to exist? Students explored artifacts, products, environments, or communications from the future to help the audience experience the future scenario. Students embedded future artifacts in a five-minute performance (Figure 6).

[2] One student asked "what is the point of future studies and trying to shape desirable futures, when your personal nightmare becomes true?"

[3] The experiential futures assignment was adapted from Stuart Candy's "Time Machine / Reverse Archeology" assignment. https://www.researchgate.net/publication/305333152_Time_Machine_Reverse_Archaeology

Figure 6. A team of four students enacts the future of education in 2050. Their props included an augmented reality headset, costumes, and the projectors to create a futuristic learning experience.

Dexign Futures: Measures of student learning

In a post-course survey (n=43), to the open-ended question "What activities in the Dexign Futures course do you feel contributed the most to your learning?" On average, students listed 2.47 (SD 1.07) activities contributed most to their learning. The following percent of students selected these activities as contributing most: online course modules (61%), in-class discussions (41%), weekly reflections (29%), and group activities (22%).

Students were also asked: "What, are concrete examples of how you applied what you learned in Dexign Futures class to projects you worked on outside of class (e.g., studio projects, independent projects, own life)?" We interpret student responses to mean they experienced the design futures toolkit most powerfully in their own lives[4] and when exploring big design spaces.[5]

Connecting futures to real-world events: Student reflections submitted during the week of the presidential election point to students' learning and motivational challenges. In class, many students expressed a negative response to the Trump presidential election expressing loss of agency to influence their world and disillusionment with design futures. The instructor used the real-world event as context to connect to relevant course concepts (e.g., plight of the working class, income inequality). The just-in-time adaptation of the course addressed student motivational needs, provided a pathway for students to regain a sense of perspective and agency. Some students expressed appreciation for the opportunity to engage with current events.[6]

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[4] *"I definitely used this class to think about my own future quite a bit. For example, when we mapped out different ways our careers could go, and how they might play out in different societies, I thought about what would happen if I studied art or design, or if I worked for a firm or on my own practice. I realized in this class that I want to go to grad school to study textiles while making my futures wheel."*

[5] *"The most important thing I think one must do is think of multiple future scenarios - this formula of attacking a problem from different angles allows one to find the most appropriate solution to the problem."*

[6] *"I just wanted to write you a quick note to say that I really appreciated your sincerity and candor in class today. It's really obvious that you care about us and you want us to do good. Thank you for stopping to let us have these really important conversations, and for urging us to think more deeply, even when it isn't comfortable. One of my biggest fears is complacency--*

Experiential futures: Student experiential assignment performances are a measure of student learning; and students' self-reports are a qualitative measure of their learning experience. The instructor's evaluation of the experiential futures projects revealed that students significantly iterated on previously written scenarios and storyboards to include much greater detail and depth to their final presentations. Students identified early in the course that their scenarios were "flat" and lacked depth as compared to experts' scenarios. Over one fifth of students said that experiential futures project contributed most to their learning.[7]

CASE 2: K-12 Pedagogy | Jobs in the Year 2050

The primary purpose of the Design Learning Network (DLN) is to engage students and educators from all over the world in creative problem solving. The design learning process empowers creative problem-solvers with clear intentions via inquiry-guided design learning challenges. Students gather information, define problems, build new understandings, and show evidence of learning progress, while reflecting and assessing throughout (Figure 7). As educators, learners, creatives, decision-makers, and often community members – together we design experiences using high impact learning strategies. We learn how to learn, wonder why things are as they are, ask tough questions to figure out how to figure out, and make sense of an ever-changing 21st century world. Our challenges have explored a wide range of topics (e.g., looking into the future, the redesign of high school, and the plight of the honeybee).

We began opening the pipeline from K-12 to higher education in January 2014 with approximately one hundred students from Kansas City area schools. Inspired by the Dexign Futures course, DLN facilitated an international future-foresight design learning challenge entitled, "Jobs in the Year 2050". The Kansas City lead-teachers and students were guided by following critical question:

Imagine the year 2050, how might the study of careers today, future, and past impact high school students as they prepare for college and jobs in the near future?

Learners investigated future career opportunities by making sense of interconnections and interrelationships between job postings in the year 2014 to future job opportunities in the year 2050. The students investigated the learning needs of next generation creative problem-solvers as well as their own. Students proposed innovative job scenarios aimed at transforming current adverse environmental practices into balanced ecosystems by the year 2050 (Figure 8).

I think we all need to be challenged more."

"This week in Futures made a big difference in my life, helping me understand the election results, my classmates, and more. The philosophical ideas are comforting and enjoyable to think about. More than all that, though, I want to thank you for the talk you began with on Friday about self-improvement. Living deliberately is something I realize I should spend more time on, and your speech helped me to that realization."

[7] *"I think doing the skits in the last class helped me understand better because we had a chance to really talk with peers about future topics and got to share parts we don't understand and parts we do. It was also helpful to learn what other people thought of a topic verses your ideas. The hands-on skit activity also was really fun and helped me experience what the future would be like."*

"I think that the final presentation helped me a lot in that I could really get a sense of what is going on rather than just doing OLIs and read text."

"I enjoyed learning more about education in 2050; I wish we had done more skits / bodystorming because it brought my understanding of futures to life. There was a wide spectrum of possible futures - it would be interesting if we could explore each unit through bodystorming / experiential futures."

Gather Information	Define Problem	Build Understanding	Show Understanding	Reflect and Assess
Step 1) EXPLORE Learners gather new information and become familiar with the problem set	Step 2) DESCRIBE Learners define problem, collect data, and make sense of findings	Step 3) EXPLAIN Learners build new understandings by investigating the problem set from multiple perspectives	Step 4) DEMONSTRATE Learners show evidence of new understandings by designing and presenting a plan of action	Step 5) EVALUATE Learners reflect and assess level of impact the learning process is having by evaluating in an iterative fashion

Figure 7. Overview of the Design Learning Process.

Figure 8. Jobs in Year 2050 | Design Learning International Challenge, Kansas City Art Institute -- March 2014.

The Kansas City students collaborated with students from a middle school in Illinois, a high school in Massachusetts, as well the United Kingdom. DLN traveled to the University of Lincoln School of Art and Design where approximately 500 U.K. primary school students experienced the challenge firsthand at the School of Art and Design. Children ages 7-8 shared hands-on brainstorming sessions with a diverse group (e.g., high school and college students, faculty, professionals). Students shared real-time conversations via Skype with challenge participants back in the United States as well as universities in Nanjing, Beijing, Guangzhou, and Shanghai, China; and Girona, Spain; feedback was offered from a global perspective. The culminating event took place in Kansas City on March 1, 2014 (Figure 9).

Figure 9. Jobs in Year 2050 | Design Learning International Challenge, University of Lincoln, UK - February 2014.

Participants of this design learning challenge included a range of ages, alongside a widely diverse set of mindsets, some from a high-end school district, others from an inner-city district, some from completely different parts of the country – the lead-teacher sums it up nicely[8].

[8] *Watching the design mentors work with students, the teachers learning alongside, and the students working quickly and brilliantly (and in some cases with completely new group members) to come up with even better solutions than they had brought to the table, not one person was concerned with the growing winter storm outside. As I have experienced repeatedly with the Design Learning Process, we witnessed total engagement and excitement from every participant. The final presentations gave each student the chance to be heard, develop confidence, and prove to themselves and the entire*

Integrated aspects of learning science:
Elaborative Interrogation: to make meaning, learners first studied the type of jobs available in 2014 – before defining what future jobs might require in the year 2050.

Self-Explanation: for greater comprehension, learners explored their own learning needs as young creative problem-solvers – alongside likely requirements of the next generation.

Distributed Practice: for longer retention to take place, challenge participants grew their understanding of the problem set over 2-months' time – with multiple opportunities to check-in with their teammates as well as lead-teachers and creatives.

Interleaved Practice: for deeper understanding of new concepts, learners developed their solutions by practicing visualizations, creation of mockups, etc. during the culminating event.

Practice Testing: for long-term memory retrieval, learners engaged in iterative formative assessments to check for understanding prior to generating their plan of action.

In summary, creating effective learning pathways between primary and secondary students with university design schools on a global scale is a compelling concept. Lessons learned: we now know primary students are able visualize their ideas and could have benefited from showing their new understandings in 3-dimensional form similar to the secondary students.

Case 2: K-12 Pedagogy | Insightful Experiences, Monumental Understandings

The second test of adapting our university-level design materials within the K-12 context took place in December 2016 with over 150 low socioeconomic status (SES) high school students. The Insightful Experiences, Monumental Understandings Design Learning Challenge invited learners to become aware of the powerful concept of Habits of Mind – which habits they carried out with confidence, which required more practice (Figure 10). At the conclusion, students explored their hopes and fears in respect to their personal goals and related Habits of Mind, a slightly modified version of the university-level Dexign Futures course (Figure 1).

Garfield Gini-Newman and Roland Case of the Critical Thinking Consortium describe students who practice Habits of Mind as "motivated thinkers are inquisitive, consultative, open-minded, fair-minded, tolerant of ambiguity, self-reflective, and attentive to detail. An individual's attitudes – or habits of mind – are key constituents of good thinking. People who are closed to new ideas or inflexible in their thinking are seriously impaired in their ability to arrive at justifiable resolutions of issues. Open-mindedness is but one of an array of habits of mind needed by thinkers. Some individuals tend to leap rashly to conclusions. Here underlies another crucial mental habit of a good thinker, the inclination to deliberate – to think before acting. Successful thinking is significantly (but by no means exclusively) a matter of attitude."

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audience that their ideas were important. As I watched the final presentations, and then listened to the design mentors validate each group's strengths before the whole audience, I realized that all of us had crossed many bridges (and even an ocean) to make this experience possible. It was a truly amazing experience, and I look forward to building even more bridges towards KC2015. – KC2014 Lead-Teacher.

Figure 10. Insightful Experiences, Monumental Understandings | Design Learning Challenge, Boston December, 2016.

Participants began the challenge by identifying a monumental person in their life, someone who had served as a significant source of inspiration. Students then selected an insightful experience, an interaction shared with their inspirational person that had monumental impact on their own Habits of Mind. Students mapped their reflection using the following prompts: What is your person saying? What is your person doing? What is your person thinking? What is your person feeling?

Prior to the Monumental Understandings Gallery Walk, students empathized with their viewers by previewing what they might say, do, think, and feel. In addition, students created sketches and representational mockups of their Insightful Experience (Figure 11). Similar to the *Dexign Futures* students' experiences, these high school students concluded with a personal reflection regarding their short-term and long-term Hopes and Fears. Note, the word clouds in Figure 12 indicate these low SES high school students were able to clearly articulate what they felt in their hearts; knew in their mind – not dissimilar to high SES students. Post-challenge comments by the lead-teachers suggest future-learning explorations of this kind would be of high value.[9]

Integrated Aspects of Learning Science

Elaborative Interrogation: to make meaning, learners first recognized what they knew about themselves and their monumental person – before immersing into the unknown, what viewers might say, do, think, or feel.

Self-Explanation: for greater comprehension, learners built on the empathy mapping exercise to select which insightful experience to share – prior to representing the interaction in sketch and 3-dimensional forms.

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[9] *I have never seen this level of engagement and focus from my students in such a short period of time. Today's experience has caused me to rethink my entire approach to teaching.* – High School English Teacher.
I was taken aback today, watching my special needs students – it was like they were a different person, showing initiative, collaborating with others, and far more articulate than they normally are. One student in particular stands out; she rarely speaks in class much less directly with me. Throughout the session, she was on task and jumping in like the rest! – High School Art Teacher.

Interleaved Practice: as evidence of deeper understandings, learners used the Hopes and Fears exercise to shift their focus to their own Habits of Mind – to articulate short- and long-term actions, ways in which to accomplish their goals, as well as insights into potential barriers.

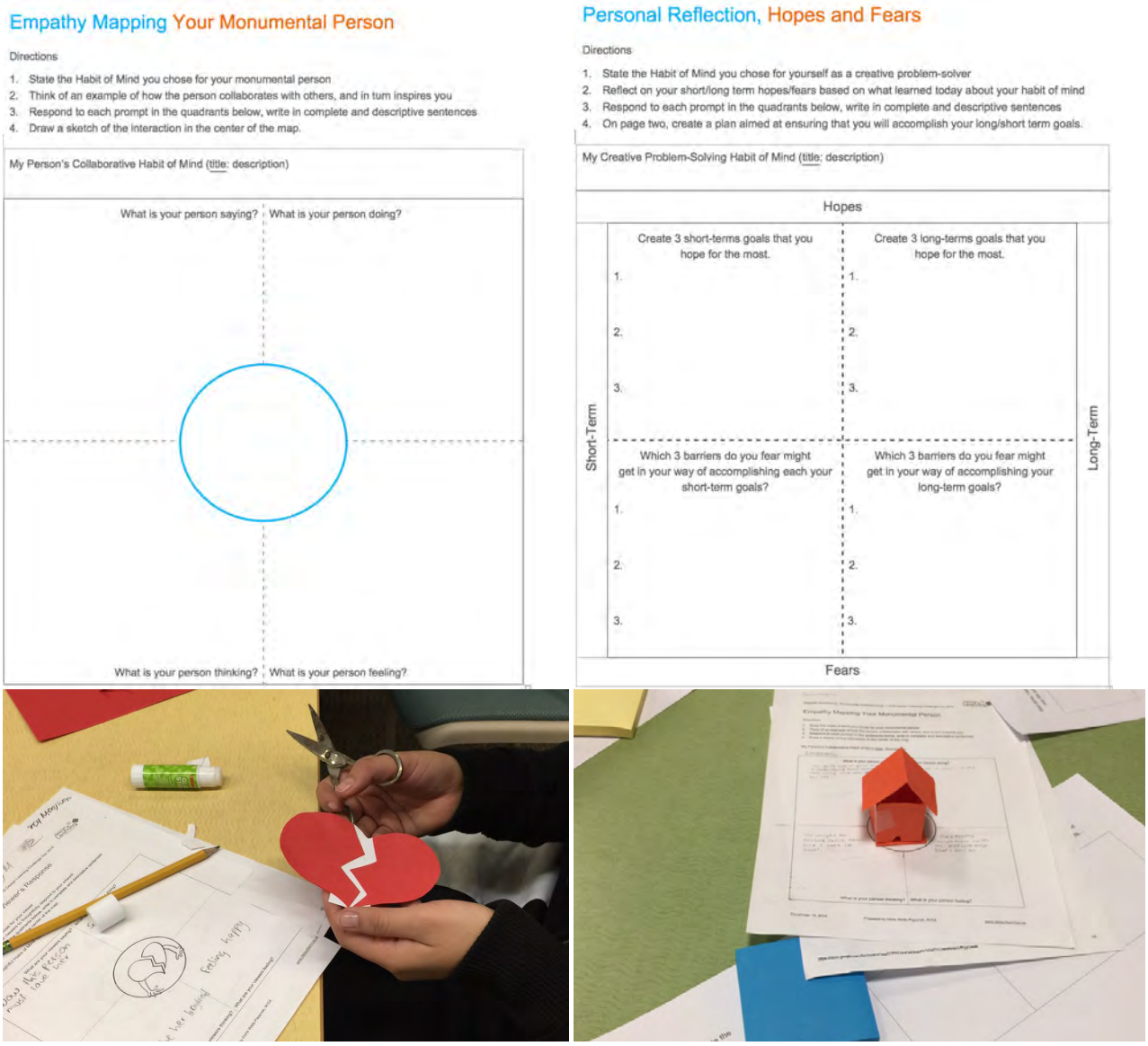

Figure 11. (top) Empathy Mapping ThinkSheet, Hopes and Fears Reflection. (bottom) Student worksheets for Hopes and Fears reflection | Design Learning Challenge, Boston – Dec 2016

In summary, the shifts in perspectives embedded in this learning experience challenged learners to get outside themselves and dig deep into levels of awareness, the craft of creating representations, and gaining insights by sharing with others. Lessons learned: however rarely spoken or heard, we cannot underestimate learners' need to articulate what they are thinking and feeling. We need to: (a) support our learners in productive articulation; (b) promote active listening, and (c) nurture the learner's capacity to learn, think, and articulate.

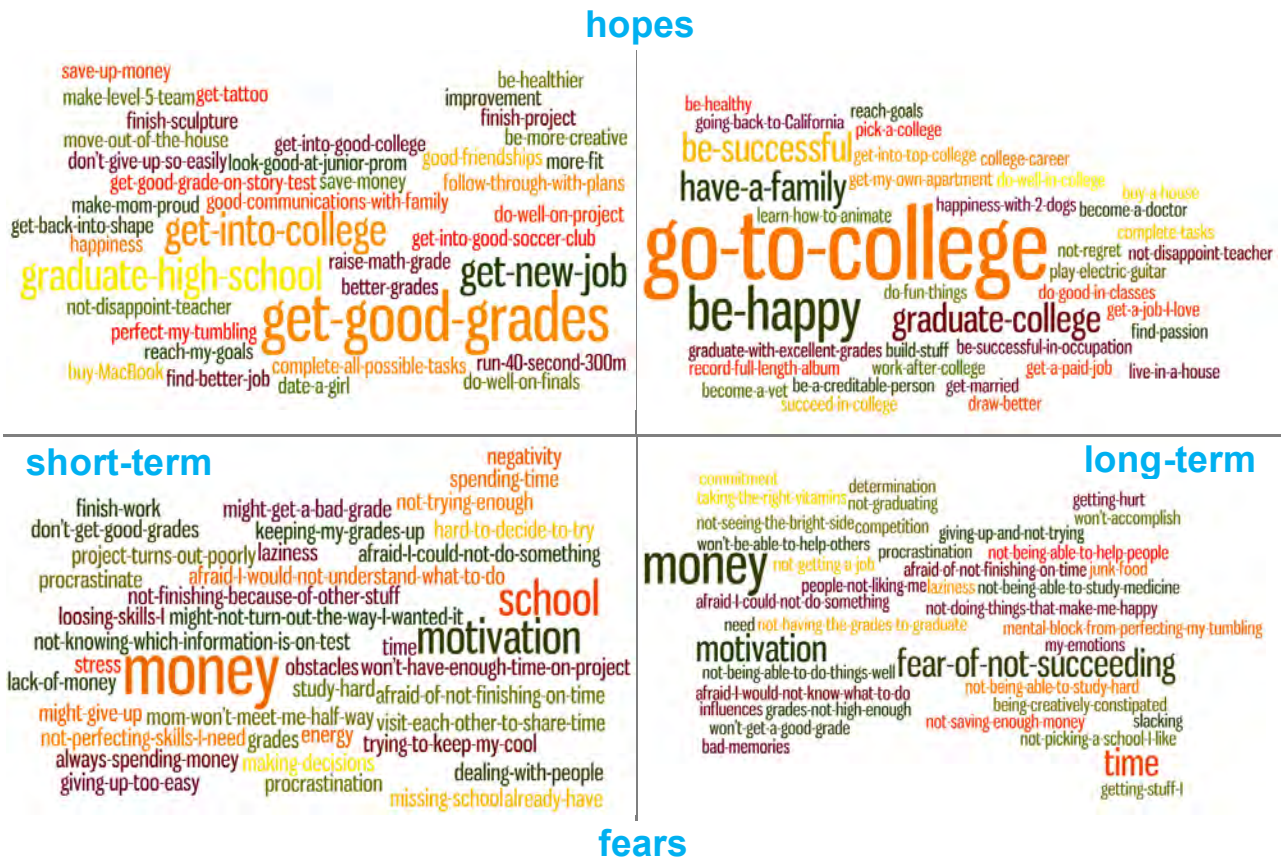

Figure 12. Hopes and Fears wordcloud mapped according to short-term and long-term timescales | Design Learning Challenge, Boston – December 2016.

Discussion and future work

The *Dexign Futures* course sought to address three challenges observed in previous courses where students aimed to combine futures thinking with design thinking (Wasserman & Scupelli, 2013; Scupelli, 2014; Scupelli & Wasserman, 2014; Wasserman, Scupelli, & Brooks 2015[ab] ; Scupelli, Wasserman & Brooks, 2016[ab]). First, an advanced studio course that requires a completely new type of design method overwhelms students. Second, in traditional studio and seminar courses students struggled to manage the breadth of information necessary to critically engage with futures thinking. Students focused on a single future scenario superficially and were unable to go beyond personal experiences and biases. Third, students were unable to interpret futures signs, forces of change, and benchmark goals for desirable futures. To help overcome these challenges, we created the *Dexign Futures* course as a flipped learning and active classroom experience to connect to and scale studio pedagogy from fifteen students to fifty.

We found that the flipped classroom pedagogy and in particular the use of the online homework with immediate feedback and the opportunity to discuss open questions in class supported student learning at scale. While the online modules worked to expose students to concepts, students were still not quite ready to apply those in class as the next step. Additional mini lectures were inserted when students needed to see an expert link the concepts to an application. With this adjustment, students also benefitted from the resulting group-level discussions. The additional in-class lectures and class discussion helped students bridge the chasm between online

homework and in-class activities but reduced class time to complete in-class activities. As such, students finished the in-class activities as homework. For next year, we are redesigning the in-class activities to fit into shorter timeslots.

We implemented weekly reflection questions to help students consider how they might apply *Dexign Futures* methods into their studio projects. We are exploring with other faculty how to help students apply these futures thinking methods in their design courses. To empower faculty in other courses to help students apply new methods, we are discussing how such methods might fit into their courses. Likewise, the high-school teachers commented on how engaged some of their lower performing students seemed to be in the workshop, but wondered how they might implement such pedagogy in their own classrooms.

The word clouds for the hopes and fears exercise done by the DF course students (Case 1 Figure 3) and the DLN challenge participants cover similar topics concerning short-term and long-term futures (Case 2 Figure 12). Future work for DLN includes adding exercises to help the K-12 students broaden their perspective on shaping their futures by transferring newly acquired understandings into other contexts.

In the Habits of Mind challenge, the Monumental Person exercise had high-school students reflecting on positive influences in their lives. The goal of the activity was for the students to reflect on the habits of mind that helped such people respond to difficult situations. In future work, we would like to embed the Monumental Person exercise into the university DF course to scaffold the connection between habits of mind, personal character, and role models.

The students in the Jobs in the Year 2050 Design Challenge proposed innovative job scenarios to explore the connections between current job postings and future jobs. Similarly, the DF university students explored personal alternative careers in four alternative worlds (i.e., continued growth, collapse, disciplined society, transformative society). We posit that one desirable outcome of both exercises was that some students began to envision their own future career in a more optimistic way, feeling agency and hope to achieve desirable futures.

Encouraged by this first pilot study between the DF course authors and the DLN in K-12, we pursue three main areas for future work: Improve the DF course modules; Explore alternative timescales for DF and DLN activities; and Develop common assessment measures to study student learning. First, we plan to implement three changes to the DF course modules: implement adaptive feedback, add more expert worked examples to support students in how to apply future thinking to design type problems, and revise the in-class activities to bridge the gap between thinking and doing in the classroom (Figure 13).

To allow for more interactive in-class activities, the course is now taught in a flat design classroom with large whiteboards and furniture on wheels. Second, the course duration differences between a semester long course and shorter K-12 Design Challenges encourage us to explore shorter modules. Third, we would like to develop common measures to assess learning in the K-12 and university settings. We seek to study student learning and retention over time.


Figure 13. The lecture-style classroom discouraged students from hands-on active learning group based learning activities.

Acknowledgements

We would like to thank for the support of the: Neirenberg Family for Arnold Wasserman's endowed visiting professorship in 2013; the Wimmer Family Foundation for Peter Scupelli's 2013 Wimmer Faculty Fellowship; and the Carnegie Mellon University Eberly Center for Teaching Excellence and Innovation for continued encouragement and support. We would like to thank the Revere Public Schools for their generous support of the Design Learning Network.

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Appendix A: Design Thinking and Learning Pipeline Examples

Baltimore Design School teaches grades 6-12 students to see design as a way of living an ethical, productive, and rewarding life to become prepared for admission to colleges and careers in a variety of design fields.	Drew Charter School Engineering Design offers K-12 students real-world experiences through project-based learning and creative problem solving utilizing a multi-disciplinary approach to STEAM.
Carnegie Mellon University offers a 6-week summer Pre-College Design Program to build strong foundation of skills and a clear idea of what to expect from a college-level accredited program in Design.	Henry Ford Academy is a college prep high school preparing students for the future through strong academics, a college-going culture, career exploration, and real-world experiences that focus on innovation and creativity.
Charter High School for Architecture and Design Is founded on two principles: to provide a safe, academically sound, and stimulating high school for urban minority students and to prepare them for collegiate study and training in architecture and design.	INDEX: Learning to Improve Life is implemented across pre-college schools in Denmark and Sweden and includes a teacher accreditation component. Design to Improve Life Education gives teachers the opportunity to create varied and goal-oriented frameworks.
Da Vinci Design School uses hands-on, project-based learning to prepare students for college and 21st century careers in architecture, graphic design, and jobs that call for related skills in art, design, science and technology.	New Design High School uses the concept of design to assist in meeting the holistic needs of adolescents; believes that design and design processes help students to engage in a more experiential form of inquiry-based learning.
Design Architecture Senior High is a public magnet school offering art and design curriculum complemented by academics.	New Orleans Center for Creative Arts is a pre-professional arts center that offers students culinary arts, dance, media arts: filmmaking & audio production, music, theatre arts, visual arts, and creative writing, along with academics.
Design for America is an idea incubator, a motivated community, and a way of approaching life's complicated challenges. DFA is a university-based student network addressing social challenges through design.	Rhode Island School of Design Offers a 6-week summer program to strengthen student's ability to observe, conceptualize, analyze and create. Offers studio classes focused on experimentation and creative problem-solving.
Design-Lab Schools offers a range of services to K-12 public, charter, parochial and independent schools and districts led by educational and business leaders working to transform education.	Stanford Design School Offers K12 Lab Network professional development to K-12 educators; Design Thinking Bootcamps to corporate executives; and week-long Design the Future classes to high school students.
Design Learning Network empowers creative problem-solvers as they investigate the unknown, engage in deeper learning, share insightful feedback, and reflect via purposeful assessments. Offers professional development, student-centered design learning, and strategic curriculum development.	Studio H offers in-school design/build class for 6-12 grade students who apply their core subject learning to design and build transformative projects; and provides professional development for teachers.