How Can Teachers Train Students to Think Like Designers?

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Abstract

This capstone reports the qualitative research study on design thinking meant to promote students to become innovators. According to the Innovation Foundation (2010), United States ranked sixth in innovation competitiveness and 2nd to last out of 39 countries in regards specifically to energy innovation. There is a gap between the number of American students entering innovative fields and the need of innovators to keep the pace with other countries.

The research question was answered through observations, interview of students, pre-tests and post tests, experience in going through the design process, learning from failure, training to switch direction in design when needed, fast prototyping for redesign. Since, according to Obama's State of the Union Address (2010), Bill Gates (2005), the Innovation Foundation (2010), and Charles Leadbeater (2006), a leader in educational reform, innovation is the highest priority in renewing the economy, and design skills should be taught to students so they are not afraid to enter STEM (Science, Techonology, Engineering, and Math) fields.

Overall, the instructional unit proved to be effective as documented in the participants' progress. This can be seen in the confident responses in interviews and surveys, as well as self-awareness of empowerment in the field of designing for innovation.

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CHAPTER 1: INTRODUCTION

Introduction

The topic of this qualitative research study to improvw design thinking in K-12 students to support future innovations. There are several formats of the design process. This qualitative study will be using the Stanford Design School's version because it is flexible enough to be used with 2nd graders to adults. The research will be completed around February of 2012. The literature view focuses on the question, "How can we turn people into innovators?" and "Is it possible to do this without letting them know what it feels like to be an innovator?" The study will test this theory of focusing on the innovators. By giving them the language of innovation through targeted vocabulary, the focus indeed is on the student.

The Innovation Foundation reports, "United States ranked sixth in innovation competitiveness and 2nd to last out of 39 countries in regards to energy innovation" (2010, p. 2). There is a gap between the amount of American students entering innovative fields and the need of innovators to keep the pace with other countries such as China. There is a gap between innovation skills in students and the need of innovation

skills which the economy is so dependent.

Actual targeting of innovation instruction in the classroom is missing. It is expected that the educational system will create innovators which in turn creates jobs that will not be replaced with overseas workers. Design thinking empowers students to give them opportunities to make innovation routine in order to improve the quality of life for all.

Reasoning and Importance

This topic was chosen because**,** with the world population breaking the milestone of 7 billion, there are countless experimental opportunities that this (and future generations) will need to collaborate on by working together. Ending food shortages, war, energy shortages, polluted water, drinking water, ineffective education, and values have consistently been challenges. American students need to be equipped to deal with failures in a positive light. Tenacity and effective training in design thinking will empower them to follow through on such daunting hurdles.

This project is important to learning and technology because science, tech, engineering, and math (STEM) education alone may be not enough to be competitive in global education. Innovation is the key. Taking STEM knowledge and applying it change the world for the better is expected. At Stanford Design School, interdisciplinary training creates innovation by combining separate fields together. Social innovators from

Stanford's Graduate School of Business (GSB) have innovated processes for 2nd grade up for creative and often simple solutions that are overlooked or not considered.

The purpose of this qualitative study is to how training in the design thinking process affects students' abilities. Participants will target empathy and apply it to user centered design. Participants will practice making decisions and ideating with teams. Students will comprehend and apply the vocabulary of rapid prototyping in process, react to and reflect on failure and experience experimenting. Participants will practice testing, redesign, and reflection on a toy and then projects of their choice.

The proposed solution to make innovative thinking abundant is to give students experience in thinking like an innovator. The Stanford Design Process that will be applied provides projects where students design their own toy or redesign a toy such as the Viewmaster. If students have experience in design thinking, they will feel more comfortable taking risks. The Stanford Design Process avoids traps of solving the wrong problem or spending too much time and money into a prototype to switch direction (when needed) , is prevalent in many failed projects and businesses. It also gives students the opportunities to fail and learn from their mistakes instead of not trying because they are afraid to fail. Allowing students to see failure as a learning experience can empower them and give them more confidence. Familiarizing the participants with the language of innovation through structured vocabulary applications and opportunities to apply it can reduce fears of the unknown and give students confidence to innovate.

On February 4, 2011, Obama proposed to improve K-12 education by promoting achievements and making careers in STEM fields. These ideas are linked to

initiatives that will train the next generation of students for the challenges of the 21st century with innovative strategies to build the world's economy. President Obama stresses innovation in STEM (sciences, technology, engineering, and math) aligned with hyper focused tenacity, as the answer to helping the economy (Obama, 2011).

> History should be our guide. The United States led the world's economies in the 20th century because we led the world in innovation. Today, the competition is keener; the challenge is tougher; and that is why innovation is more important than ever. It is the key to good, new jobs for the 21st century. That's how we will ensure a high quality of life for this generation and future generations. With these investments, we're planting the seeds of progress for our country, and good-paying, private-sector jobs for the American people.

Outline of Problems and Possible Causes

There is a scarcity of design thinking and innovative skills in mainstream education. The biggest cause of this problem is pointed out by Kriss Deiglmeier, director of the Center of Social Innovation at Stanford. Deiglmeier announced that although many projects are proposed, those involved are "missing the tenacity for the long haul" (Deiglmeir, 2011).

The Background and Importance of the Problem

The background of the problem originates from too much information and an abundance of opportunities, but a scarcity in follow through. According to the Churchill Club (2011), the problem they are targeting is "mastering change" for the needs of 7

billion people. While other nations are trying to survive, America's basic needs of food, shelter, and clothing are met. Only 3 of the 12 national honorees being recognized for progress in science and innovation were born in the United States.

The comfort and safety of students in America is such a large focus that our students miss out on the other crucial element for innovative thinking which is appropriate risk taking. While it is standard to avoid risk of getting hurt, there is an environment of nurturing for kids' safety who have never been given the opportunity to take risks in the classroom. There may not be enough risk taking opportunity to begin application to experiments, inventions, processes, etc. to come up with innovation. It is human nature to be wary of the unknown. Students need to be trained to deal with risk taking and failure in a positive way. Designers use their mistakes as signals to switch directions in design when needed. Rapid prototyping avoids the trap of keeping the bad design for typical reasons such as too much time and money was invested in the bad design .

Morality needs to be addressed. Steve Jobs was an innovator who has be likened to the Thomas Edison of our time, had recently died and his biography placed in bookstores. In it, Jobs says "good artists copy, great artists steal", referring to his obsession of taking the latest innovations and creating them into another product (Isaacson, 2011). Some opinions would form that using others' work is not ethical. Advancements in technology can be used for evil purposes, including war.

While resiliency is the most important element in innovation to succeed, other factors come into play. David Kelly, a founder of the Stanford Design School claims in

order for students to become innovative, they need experience with design thinking. In order to have confidence in their design abilities toward innovation, they need to know the process of design thinking and innovation. This confidence is a good foundation for the diligence and experience in risk and failure that comes with creative problem solving. This problem affects academics because if the students do not comprehend the process of innovation, the words become roadblocks for comprehension. Students cannot progress to the next level with these gaps in their knowledge (Antonucci, 2010).

Part of the roadblock is simple terminology. It is imperative to know the language of innovation so there is no fear causing limitations in design thinking. If a team is to generate as many ideas as possible they should feel comfortable with words such as empathy, prototype, innovation, tenacity, radical experimentation, application, collaboration, risk, and failure. This allows them to take risks and empowers them with the tenacity needed to succeed. It also prepares them to turn problems into opportunities. But, to reiterate, defining the problem is part of the design thinking process. Many tasks lead to failure if participants are working only on a piece of the problem or the wrong problem altogether. This changes the focus of targeting problem solving to solving the right problem.

Many students cannot use the word innovation in a sentence, let alone execute it to become the next generation to strengthen the economy. It is possible for students do something innovative without knowing the word. However, awareness brings confidence and empowerment to take appropriate risks which is necessary for innovative thinking. A structured approach to teaching innovation may be more effective than expecting students

to independently become design thinkers and innovators.

Giving the students many experiences in the process of innovation and practice in failing is excellent for confidence. Most students want nothing to do with failure. However, “99 percent of success is built on failure.” according to Charles Kettering (1957). Advice from Covey (2004) states one of the Seven Habits of Highly Effective People is resiliency.

In October of 2011, Obama honored 12 Americans in science, technology, and innovation. He mentioned that students turning in science projects that are models of volcanoes with baking soda coming out like lava should be embarrassed. "Apparently, that was not a cutting edge achievement, even though our parents told us it was really terrific" (Associated Press 2011). This implied that some parents are part of the problem by accepting low standards from their children.

These types of science projects can be chosen to avoid true experimentation, which involves risk and can lead to failure.

Obama commented that only 3 honorees out of the 12 were born in the United States and although attracting immigrants to complete their research in America is valuable in keeping competitiveness in innovation, "it won't be enough if we can't grow some here at home" (Associated Press, 2011). Obviously, parents who are involved in their child's education, and have high standards and can support the improvements in innovation from American students. *Battle Hymn of the Tiger Mom* by Chu (2011) had stirred much controversy when the author implied that Asian mothers are superior because culturally they push their children harder and have higher expectations so their

children work harder. Innovation brings change and some people don't like change.

The last cause of the problem addressed is the imbalance of expectations from parents. While some parents have low expectation of their children, others pressure their children so much that mental health comes into play. Evidence of how parents influence learning and the level of innovation in their children could be considered.

Research question:

Will innovation skills and confidence improve after students are trained in the Stanford Design Thinking Process?

CHAPTER 2: LITERATURE REVIEW

The focus of this literature review will be to find ways to train students in design thinking.

According to the Global Innovation Index 2011, the United States has dropped to 7th place on the list for innovation competitiveness (para. 14). The country has also dropped to 7th place on the list for innovation competitiveness in the Information Technology and Innovation Foundation Report (2010). As noted by Traurig and Feller (2008) there has been a significant decline in students entering college in the STEM fields (science, technology, engineering, and math).

The history of design thinking for educators evolved from the mindset of ideas in changing things for the better. From exercise, nutrition to creativity, teachers are expected to change with the culture to meet the needs of the child. Learning styles are changing with technology along with teaching styles.

In summer of 2010, systematic design thinking was introduced for the first time on a large scale to the education community by Hassor Plattner's Institute for Design at Stanford University to address the huge task of changing the mindset of the students to become innovators who can compete and contribute to the local and global economy. Antonucci (2011) reported, "We want to try to develop empathy for people, see what they value as humans and try to use that to come up with big ideas, so we call our method human-centered design. There's a creative act in trying to decide what problem is worth working on in the first place" (p.1) According to Covey in *The* 7 *Habits of Highly*

Effective People, (2004) empathy is one of them because community is built upon this trait.

Targeting design thinking principles can give a systematic training and experience for students so they can take the skills outside the classroom and use them in solving problems (Brown, 2009).

Stanford's Graduate Business School has a Social Innovation Center which supports the need to produce innovators through education. Patell (2010) explained that Stanford's GSB students are invited to use design methods. Students are loosely managed for a more constructivism theory in nurturing creativity. However, the traps where usual projects stumble, are avoided by the basic structure of these designing thinking elements. At Stanford, the roadblocks which prevent the improvement quality of life for the poor are avoided by "meeting extreme poverty with extreme affordability" (p.1). Prototypes are first built with low cost materials such as duct tape and paper. There are simple solutions to big problems. However, defining the problem is part of the design thinking process. Most tasks fail because participates are working only on a piece of the problem or the wrong problem altogether. This changes the focus of targeting problem solving to solving the right problem. Patell (2010) explained that generating many ideas instead of getting stuck on one idea makes design dynamic and flexible enough to deal with today's fast paced culture. Problems can be explored by effective dialogue. Students need to feel comfortable with this innovative thinking by experience. When students have a great deal of experience in this type of processes, intimidating tasks can be considered through reflection, or hand-on problem solving, and interaction.

This new qualitative study to be performed in November of 2011 will give a team of students ranging in age 8 to 13. Spaces and materials are considered. Rapid protyping materials will consist of the following: adhesives such as duct tape, variety of paper like post its, card board, markers, scissors, pipe cleaners, foam core, and photos. Pre-tests and post-tests will be conducted and compared to chart progress, as well as a pre-interview and a post-interview and survey. Students will participate in the entire design thinking process through the following steps: empathy, define, ideate, rapid prototyping, and test. The purpose is to test this theory that training students with design thinking mindsets will empower them to become innovators.

Putting the design thinking process into action can change attitudes from apathy to empathy by creating awareness. Geer reports that discovery is a large part of the design process. Mistakes and failures come with risks but are necessary for thorough exploration of the task. Team work requires sharing what one knows and learning from each other. Flexibility and research, successes and failures, roles of each team member, and feedback are all part of the vocabulary. It is imperative to know the language of innovation so there is no fear causing limitations in design thinking. If a team is to generate as many ideas as possible they should feel comfortable with the vocabulary. This allows them to take risks and empowers them with the tenacity needed to succeed. Geer (2011) reports, "Innovators aren't exceptional as much as they are confident. So says David Kelley, the founder of the venerable Palo Alto, Calif., design firm IDEO" (para. 1).

"How can we make our students confident in their creativity?" Tina Seelig (2009), Stanford Technology Ventures Program's Executive Director, inquired," How can we

have an entrepreneurship week if we don't get people the opportunity to feel what it feels like to be an entrepreneurial?" (p.1). Professor Seelig teaches the class The Art of Teaching Entrepreneurship and Innovation. This class is not about making money, but about changing something of little value into much value which it and of itself is innovative. Seelig currently holds Innovation Tournaments at Stanford to support design thinking.

Innovators create change and disruption. By making innovation routine, it takes the fear out of change. Seelig (2009) advises, "If you are not failing frequently you are not taking enough risks" (para.1.) If a potential innovator fails much, after a while, the emotional stress is neutralized and ultimately the ratio of successes to failures is stable. Of course, this type of failure is in reference to the ability to learn from your mistakes. Wojcicki (2011) names failure and risk as one of the 8 pillars of innovation reported in Google's Think Quarterly. Seelig (2009) advises to fail fast and frequently, positing the fact that the "secret sauce of Silicon Valley is its ratio of successes to failures. This ratio is pretty stable" (para.1). Design thinking is a methodology of generating a large number of ideas in its ideate stage to support the success of these ideas turning into innovations.

Regarding the pilot program introduced to the community surrounding Stanford University in summer of 2011, the vision is to create more centers to spread design thinking. Rich Crandall, former Director of the K-12 Lab, is strongly focused on design thinking. He noted that research is under way, but early indications are that K-12 students exposed to design thinking are more engaged and motivated to learn of the K-12 lab (Geer 2010).

By making innovation routine, an individual can be empowered. Geer (2011) reports that "To Mr. Kelley that is the Holy Grail of design thinking. He says it is behavioral change that enables students to gain innovation confidence, something he believes is as important as gaining literacy skills. 'For me this is a mindset,' he says, 'It's a way of thinking that you can use in every part of your life' " (para. 18).

Glunt (2011) cites "focusing on the innovator, not just the innovation, and one will get both" (p. 1). Charles Leadbeater (2010), a leader in innovation, challenges the educational community to create an informal disruptive educational change in order to give 3rd world children not in school an education. Leadbetter showed, "Sustaining innovation formally is the status quo. Informally, teachers supplement to sustain innovation. In order for formal disruptive innovation, reinvention is needed and informal disruptive innovation, and transformation occurs" (p. 47-49).

In order to meet the challenge of innovating education and to spread quality education, Leadbetter (2006) explained that habits to spread innovation uses the Chinese Restaurant Model (unique to meet the needs of the community) and not the McDonalds model. (duplicates which may not meet the needs of the community). He recommended that to spread innovation a Chinese Restaurant Model plants innovation centers that have subtle changes based on the needs of the community. Based on his research, it is clear that the McDonald's model for innovation centers would scale but not spread. In other words, applying this user based conceptual models to plant more schools, even portable ones on bus, meets the needs of the community. Stanford Design School has planted five

Design Thinking Centers: one in Michigan, one is India, and three in the Bay Area, all which have vastly different communities. There is a need to plant more. Leadbetter (2006) indicated, “The Six C's of innovation are as follows: Combination, Conversation-collaborative, Challenge, Co-evolution, Commitment and Connection” (p. 3). By targeting this language of innovation in an engaging way, students may have more confidence in their design thinking.

As Bill Gates points out, innovation is the key to helping the poor (Memmott, 2010). Design thinking which strengthens innovation is tied directly to creating sustainable solutions for those in poverty. Boudreau (2011) reports, “a recent donation to start the Stanford Institute for Innovation in Developing Economies has been given to GSB (Stanford’s Graduate School of Business) working with Stanford Institute of Design making products and business models for the 3rd world countries. Five companies have sprung from this team that fights extreme poverty with extreme affordability, meaning its products will be affordable to those living on about a dollar a day. ‘One venture to emerge from this work is d.light, a company creating products for people without access to reliable electricity’ “(p. 11).

Together with D.light, which was born from GSB and Stanford Design School sent participants oversees who are trained in the Stanford Design Process of Empathy, Define, Ideate, Prototype, and Test. Boudreau (2011) reports, "I would say, from my vantage point, the results will be changed lives -- those billion people living on $1.25 a day, that their circumstances will be dramatically improved. Not 10 or 100 people; we are talking about millions of people" (p. 18). Boudreau states that Robert King, a larger

donor to the university said, "Stanford is in an absolutely leading position to do that" (para. 5).

This qualitative research study may provide insight to this topic. A disruptive change in education may prove to be appropriate for the needs in education rather than a gradual one, particularly since there is an urgent need to stay competitive in the global community. This may also open awareness and opportunities for under-represented minorities in STEM fields.

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CHAPTER 3: METHODOLOGY

Evaluation Methods and Tools

This qualitative research study uses some aspects of action research methods to conclude practical ways to train students in design thinking. Ten students total worked as a team. Peers tend to learn from each other as well as adults. After preliminary attitude surveys, interviews, and pre-tests of prior knowledge, students were introduced to an overview of design thinking in their first lesson.

Since this was a team of students from three different schools ranging from 3rd through 8th grade, lessons were executed on weekends outside of school at a home in a central location. One student was not available to attend, but observed and participate remotely through Skype throughout the process. The complete study including analyzing post data was conducted from the beginning of November 2011 to the end of Jan. 2012.

At the end of the instructional unit, which was completed in December of 2012, data was collected to study the outcomes of the lessons. This included a post interview,

observations, post test, and a post survey to record any change in attitudes.

After a formative evaluation was applied to the unit for logistical improvements, one teacher, an assistant, and parent coaches implemented the instructional unit. Then, there was a personality conflict that was addressed for the student team to work efficiently. The composition of the team included a wide variety of students such as income level, ethnicity, and home language. It complemented the objective of design thinking because diversity can strengthen creativity and innovation.

The group naturally divided itself into a girl group and a boy group which was typical since the girl group was ages 6^{th} - 8^{th} grade and the boys were 3^{rd} -5^{th} grade. This also helped neutralize any bullying, especially among siblings.

The researcher compiled the completed attitude surveys showing the students' levels of experience in design thinking. Results of this survey indicated level of confidence in participants' abilities was connected to how much design thinking experience they obtained outside of school. When asked if school was the environment where design thinking was formed, the consensus showed that none of the students were exposed to or connected their classroom skills with this type of problem solving.

Participants completed the interview, pre-test and survey at the beginning and end of the six week study, which provided qualitative data used to evaluate the levels of progress achieved by each student. The students' tasks asked them to apply their newly learned vocabulary to project of designing or redesigning a toy. The project consisted of each stage of the design thinking process. The post test, post interview, observations, and post attitude survey provided the researcher with data to compare levels of improvement

in design thinking. As a result of targeted vocabulary, activities were recorded after students were prepared with strategies and methods to ensure the learning experience was providing them with skills to use outside the classroom. The instruction unit comprised of the five stages of design thinking with targeted vocabulary to give students the confidence that is needed. Each participant also completed an MI survey before the instructional unit was taught to find the individual needs of each person. Since empathy, a form of interpersonal intelligence, is the foundation of design thinking, it helped coaches, parents, and teachers determine which student had a strong EQ (emotional intelligence) and which students could be assisted with directions in empathy. EQ for IQ is a 6 second activity and confidence builder, that helped enhance the objective of empowering these students as design thinkers.

Reliability and Validity of Evaluation Methods and Tools

Each participant completed a pre- interview and post-interview, pre-survey and post-survey, and pre-test and post-test to ensure reliability and triangulation were implemented. Validity in the form of methods and tools used in this qualitative research study gave reliability and validity to the data by measuring if the students progressed and improved in their design thinking skills with the test re-test exercises and vocabulary given for them to experience. The survey given to the participants was utilized by the researcher to find attitudes and prior knowledge of the subject. By evaluating the participants' prior knowledge, it gave insight on the baseline being built on.

The pretest given prior to instruction provided data that could be measured regarding the level of comprehension on the language of innovation when compared with

the post test given after instruction. The pre-test and post-test determined the level of improvement along with interviews. These tests measured the participants' knowledge of empathy, skills in identifying the problem, ideating, prototyping, and testing. The tests were given one on one to get answer private answers independent of peer influences. Tests were conducted on paper with one exception. The student with dyslexia was interviewed on her answers to make accommodations for her disability in reading the vocabulary words.

The multiple intelligence survey was given to enable the researcher to provide insight on which participant identified themselves with interpersonal intelligence which is related to empathy. In connection with 6 seconds, the emotional intelligence which determines the persons' ability to make intuitive decisions, the MI survey was recorded (see appendix). The research explained the questions on the standardized MI test how learning styles of individuals. By "testing for understanding", this supported the reliability necessary for the test to be valid, in determining accurate information. It also accommodated the difference in comprehension levels and ages of the participants.

The interview answers provided by the participants gave the researcher reliable and valid tests of students knowledge of the subject and attitudes. It provided the self perception and assumptions made by each student. This was also valuable in creating a team that functions well for the competition.

The various activities gave students the ability to experiment, self reflect, review, and learn from each other which affected the post test which was given at the conclusion. The results of the post test was recorded on paper to confirm accuracy that there was

definite progress made. To iterate, accommodations were make for our student with dyslexia and our student with Aspergers.

Integrity of data

Data collected was protected to ensure integrity by making data confidential and not influenced by outside sources. By maintaining controlling environments, corrupted evidence was left out to provide objectivity. Preventing outside variables was priority.

Research Design and Methods

The type of research was practical action research using qualitative methods to find the answer to the research question. The emphasis on using the language of innovation targeted an application of knowledge. Visual, audio, kinesthetic styles were met through building prototypes. This investigative approach prove successful in providing an in depth analysis.

By collecting data on students' prior knowledge on the subject and process of innovation, the research design supported a thorough study that included attention to students multiple intelligences, self perceptions, and challenges. Data that was compared gave measurable evidence of learning. Possible causes and solutions were considered to find the target areas to provide a learning experience that was engaging and not frustrating. Learning issues were also considered to meet the students’ needs directly. The participants who were volunteer students entering the Monterrey Underwater Robotics

competition shared a common goal of hands on learning and experience through challenges.

The Monterrey Underwater Robotics competition is a STEM program under MATE (Marine Advanced Technology and Education). The mission of the 2012 contest is to create a ROV(remote operated vehicle) take can pick up objects off the floor of a swimming pool in a certain time limit. The participants will be interviewed by judges who will ask them specifics about the design process of their ROV and the reasoning behind it. The team will also design their own mock company with a CEO, R&D, marketing, advertising, and production. There will be over 10 teams competing.

Participants Demographics and Characteristics

Since the team was composed across level and abilities, vocabulary pretests were leveled into 2 groups.

Group 1 grades 3rd, 4th and 5th Group 2 grades 6th, 7th, and 8th

Short conferences provided data needed to decide on groupings. Students stayed in their groups during data collection until the completion of the study. The researcher spent about 10 minutes individual with each student for the interview section. During lessons students continued to learn in their groups. The 2 groups were large enough to provide students with a real team and different activities. Group 1 (younger) was given extra support by coaches and Group 2 (older) and breaks when needed. Within the groups, students were partnered with an appropriate learning partner. Some partners were switched to provide accommodations and social dynamics were considered.

Modifications were made to the instructional unit to include time to practice design thinking from beginning to end 5 times. Each lesson focused on one step of design thinking in depth.

Slight modifications to the study took place throughout the time line. Because of the holiday break, sessions were turned into review sessions to reinforce learning into long term instead of short term. This benefits the student by strengthening skills to be used outside the classroom. One of the participants dropped out to bring the number to 10. Skype was used for students who could not make meeting time. All emails were collected and shared to make communication efficient. Meeting place changed in the middle of the study.

Dec 10 – positions were designated and individual assignments were given as part of the competition which introduced extra vocabulary.

Since, according to Obama's State of the Union Address (201, Bill Gates (2005), the Innovation Foundation innovation (2010), and Charles Leadbeater (2006), a leader in educational innovation, innovation is the highest priority in renewing the economy and keeping pace with other countries, innovation skills should be taught to students so they are not afraid to enter these fields. Peer pressure discourages students from being different. Hormones make students self conscious which may prevent students from reaching their full potential. Students are not trained how to think like innovators.

The first to be considered will be the observations made by researcher, parents, and coaches. Secondly, the MI survey will be considered for students' learning styles.

Next, the pre-test, interview, and attitude survey were implemented before the instructional unit.

Lastly, the data results from the post test, post survey and post interview will be analyzed and compared.

Most of the surveys implied that students' attitudes varied greatly. Pre-test showed students' lack of knowledge in the area of innovation, Instructional unit improved comprehension. After finishing the task of ranking importance (see appendix) it measured the comprehension of the word innovation. On all accounts students gave an incorrect definition of the word citing that it was about making something creatively. The correct definition would be making something that brings about change. The key word is change.

Permissions

Permissions were obtained via permission slip (see appendix).

CHAPTER 4: RESULTS
Data-Driven Summary Statement of the Results

Results from the tools that were used: test/ retest for data collected in the form of pretests and post tests measured comprehension and progress. Performance context, notes and observations on learners were recorded by the researcher showed improved confidence in abilities. Pre-interviews and post interviews were compared, as well as ranking surveys on values and an entry behaviors test which showed change in attitudes. A time line, MI survey, and a KWL chart were also used.

Most tools used were chosen to measure entry level behaviors to be compared with the collected data gather upon completion of the study. Pre-test and post-tests of individuals brought insight to the design thinking methodology used during performance context through tangible evidence. Recording devices such as the cell phone and cameras recorded notes.

The observation's purpose was to study the dynamics of how the students collaborated, focused, and learned through their environment. The MI survey was chosen to chart the learner in the style they were most comfortable. This enabled the researcher to meet the needs of the students.

Visual Aids (see appendix)

Outline of results

Analysis of Each Set of Data

Table F. MI Survey for learning style

Students finished the MI survey (commercially made) indicating their learning style. The researcher used the survey to make sure lessons met the needs of the students. Stanford Design Process connects kinesthetic, visual, auditory, and interpersonal styles.

Type of intelligence	number out of 10 to claim this learning style
1. interpersonal	1/10
2. natural	0/10
3. verbal/linguistic	0/10
4. intrapersonal	1/10
5. musical	2/10
6. kinesthetic	1/10
7. visual/ spatial	2/10
8. math/logical	3/10

Value Survey Ranking 1.

The results will be shown according to the time line and the instruments used to gather information. The priority of data collected is the pre test and post test on

vocabulary comprehension on the language of innovation. The two vocabulary tests are leveled for two age groups (Group A ages 8-10 and Group B ages 11-13). The next priority will be the participants' attitude survey, learning style survey, pre interview and post interview to record any progress or change in attitudes. Pre-tests performed at the beginning of the study and post tests executed at the end of the study will be compared.

Most of the participants who filled out the attitude survey showed that they felt comfortable with appropriate risk. However, in regards to failure, most of the participants indicated that they were not comfortable with it. Four of the ten participants implied they would avoid opportunities that might lead to failure. During the pre-survey, participants rank in order of importance on the 6 C's of innovation condensed to 5.

Table G. Survey Ranking 1 comparison

Pre-survey, most participants ranked	Post-survey, most participants ranked
2. Collaboration/ combination/ conversation	2. Collaboration/ combination/conversation
5. Curiosity	5. Curiosity
1. Creativity	1. Creativity
4. Change- co-evolution	3. Change- co-evolution
3. Courage/ Challenge/ Commitment	4. Courage/ Challenge/ Commitment

Connection (user centered) moved up to number 3 instead of number 5. However, as indicated by design thinking, connection (user centered) or in other words, empathy was the foundation of any design. Participants noted creativity as the most

important, but in order to create for the need empathy is required.

The attitude ranking survey gave insight on values brought to the design team and helped to break the ice so the students became familiar with each other. It became a community builder because results were shared orally. One participant in particular still has an emerging sense of empathy which may be due to her Asbergers. This participant finds understanding how others feel to be a big challenge. With most participants agreeing on the ranking for most words, three participants discussed that connection is more atuned with collaboration, but it was clarified by the researcher that this type of collaboration was about connecting with the innovation team and not the product or experience being designed. Participants did not change rankings.

Table H. Value Survey Rankings 2 comparison

What do you need to work on most?

Pre-survey, most participants ranked	Post-survey, most participants ranked
1. Collaboration/ combination/ conversation	5. Collaboration/ combination/conversation
4. Curiosity	4. Curiosity
5. Creativity	3. Creativity
2. Change- co-evolution	1. Change- co-evolution
3. Courage/ Challenge/ Commitment	2. Courage/ Challenge/ Commitment

During the pre-survey, ranking in order of which area needed to strengthen on the 6 C's of innovation, the participants ranked. What do you need to work on most?

This portion of the ranking survey gave a target for the students and researcher to focus on. Students became aware of weaknesses in themselves which they could strengthen during this experience. It was also used as a values survey on prior knowledge of what the students considered most important.

The vocabulary test was used to chart progress in comprehension.
It was also chosen to meet several objectives at one. One objective was to create awareness of these words to give the students a platform where they could build their new “mindset” on innovation. Another objective was to enable the students to communicate effectively so they could understand each other during collaboration. Still another objective was to measure seemingly non-measurables.

Table I. Vocab test group A comparison

comparison group A- AGES 8-10

Results were similar to group A since level of difficulty was adjusted for age.

Vocab word	# of Students Correct- Pre-test	# of Students Correct- Post-test
Design thinking	0/5	5/5
empathy empathize	2/5	5/5
define	2/5	4/5
ideate	1/5	5/5
prototype	0/10	5/5
test, retest	5/5	5/5
collaborate	2/5	5/5
rapid	2/5	5/5
risk	0/5	5/5
inspire	3/5	5/5

Table J. Vocab test group B comparison

comparison group B- AGES 11-13

Vocab word	# OF student S Who WERE correct Pre-test	# OF student S Who WERE correct post-test
Design thinking	0/5	5/5
empathy empathize	2/5	5/5
entrepreneurship	2/5	4/5
ideate	1/5	5/5
prototype	0/5	5/5
dynamic	3/5	5/5
collaborate	3/5	5/5
empower	3/10	10/10
tenacity	0/10	10/10
social innovation	0/10	10/10

Interview of Attitudes on Risk and Failure comparison

Pre-Attitudes on failure ranged from being fine with it, to avoiding it at all costs.
Pre- Attitudes on risk ranged from enjoying it to being wary of it in order to determine the appropriateness of the risk.

Some participants explained they were slightly uneasy about this project because they have never experience anything like it. These participants were coaxed by their parents to join the study. The closest experience was in school when they were challenged with dropping an egg out of a building without it breaking. Students were divided into teams and were given materials. Group B participants had broken eggs at the end of the challenge and stated it was because the team was fighting with each other. Group A had a similar project with building a model bridge while arguing. This brought the discussion of how important collaboration is and remained number 2 on the rankings which were shown to them as a reminder.

During the pre-interview, 1/3 of the participants had no desire to get into a field where they would have to take on such challenges such as innovation. These participants explained that such careers are too hard. The interview was used to obtain insight on attitudes of failure and risk. It gave the researcher opportunities to explore in depth design thinking and let the participants explain themselves.

An informal discussion began after the interviews on the topic of when to fail. Participants' interpreted experimentation/failure as always being okay, and challenged

that idea. Conclusions of the discussion resulted in the appropriateness of when to fail. Failing during experimentation is acceptable. Experimenting during a math test is not acceptable and the participants agreed.

Interview of Attitudes on Risk, Failure, Prototype post-instructional unit

Structured questions (see appendix) were used to start a discussion on how the prototype works, and to test the participants' comprehension of the working design. It also gave insight on what areas need to be re-designed or explored further for future prototypes.

Post-interview after post tests and completion of instructional unit

Students learned that design is not limited to models or prototypes. Processes can be designed as well. One student brought up designing a more comfortable method of digging out earwax. Another when through the design thinking stages to find ways to keep scissors organized at home because he could never find them when he need them. Some participants chose to first draw their model or flow chart of processes.

The activity of applying the design thinking process to designing a Viewmaster toy gave students their first experience in systematic innovative thinking. Interestingly, between the two groups, the younger team considered the use of all senses including smell and sound, while the older team only focused on sight. Considering there where no parameters, it became clear that a new version of a Viewmaster toy would be greatly enhanced with sound and smell and give the user a more multisensory experience. This activity soon grew into a mini-holodeck (from Star Trek) for the older group that is put over your head like a helmet. While explaining their prototype, both groups were inspired

by empathy (what would you like in a toy is what others would like) and ideating (as many as possible and no idea would be considered stupid). Ultimately, participants felt safe knowing that failure is accepted and were given permission to take risks.

Answers to Research Questions Based on Data Analysis Research question

Will innovation skills and confidence improve after students are trained in the Stanford Design Thinking Process?

Results of the collected data showed that most participants became more comfortable with the design thinking process and indicated that they were empowered to take up a challenge that calls for innovation. Three students said they heard or saw the new words they learned online and in an advertisement. One of the 8th graders saw the word "innovation" in the local newspaper. One student brought the advertisement in to show us. Because they are aware of the word, they are noticing that the words are referenced outside the classroom. Awareness influences mindset and focus.

As time went on, participants and their parents found the word innovation in abundance. Stanford School of Medicine newspaper showcased innovation and failings in its current projects and research, particularly in Neuro-innovation. Parents became aware that Bloomberg magazine and website has a section named innovation, Palo Alto Medical has an Innovation Center with Paul Tang, M.D. in the position of Chief Innovation and Technology Officer. It is important that parents became aware of these instances of the use of the word because they reviewed with their child outside the study which reinforces

mastery.

The word was noticed on the NASA website, and a Zazzle contest, which both drew interest from the participants because of this qualitative study. This NASA activity became a voluntary experience for the participants.

Design a NASA experiment which ISS astronauts will perform in space.

Research Results Overview

Language of innovation improved. Students were observed using the vocabulary words during the process to communicate with team members. This provided a smooth collaboration among them. Confidence in abilities improved. Toward lesson 4 in the instructional unit, students were less reluctant to do the hard work and experiment. Fear was removed because failure was accepted as part of the process. Avoidance was removed because the task was not insurmountable.

Risk awareness improved. Participants claimed they felt more comfortable experimented and risk is expected. Dynamics in problem solving improved because change was accepted as part of the process. Participants who had difficulties making decisions throughout the study began to feel more comfortable towards the end in making decisions.

When determining if the Stanford Design Thinking process was a solution to address the issue of scarcity of innovative ideas, students indicated that this experience

gave them more confidence in their abilities. These assurances empower the students by taking away fear and nurturing curiosity. This study brings insight on how to best prepare our students for challenges they are expected to solve as adults.

This qualitative research study indicated that most participants progressed in their design thinking because they have been trained in a direct, systematic methodology to support their endeavors. It becomes a guide yet is flexible enough to be used with a multitude of problems. Without this methodology, participants indicated the only other training they have been exposed to besides the egg and bridge exercise, was studying past innovators in science biographies like Thomas Edison and Einstein. Research also showed that learning the vocabulary of innovation helped with communication and team building. In order to communicate effectively, the team needs to move forward with the same vocabulary to avoid miscommunication.

Summary of findings

This study gave the participants the opportunity to experience the process of innovation. These results determined the goals were achieved. Innovation skills and confidence improved after students were trained in Design Thinking. Awareness was a large factor in the progression of the participants. Most were familiar with the word innovation but did not know much about it.

Post-Attitudes on failure ranged changed to courage instead of fear because failure is now accepted as part of the process. Post- Attitudes on risk changed to courage because some risks are worth taking and failure is about the process and not them.

During the study, the research found the students interpreted the design thinking as linear, when it is in fact more of a spiral sequence after the first run through. Showing this concept in a concrete manner with the vocabulary cards was helpful in explaining the steps overlap and empathy for the user is constant, keeping the user in mind during the whole process. Because of this fast paced world, the problem it self may change and evolve during the designing. New ideas may come at any stage. Prototyping and test can spiral as well. During the post interview, participants are more interested in innovation now that it is accessible to them. Knowing that this process is used by world class institutions such as Stanford University gives them confidence in themselves that they too can be leaders in change for a better world.

The solution to solving the fear of failure would be to give students permission to fail while experimenting and investigating. Also, having failed and being familiar with the feeling gives one the experience that it is not a life or death situation and one can begin anew the next day. Learning about the failures of other innovators, scientists, explorers, and engineers gives one the background to understand that failure is part of the process that leads up to success if one has the tenacity to not give up.

CHAPTER 5: DISCUSSION
Explanation of How the Results Were Obtained

Results were obtained by comparing pre-test and post-test data. The researcher compiled the completed attitude surveys showing the students' levels of experience in design thinking. Results of this survey indicated level of confidence in

participants' abilities was connected to how much design thinking experience they obtained outside of school. When asked if school was the environment where design thinking was formed, the consensus showed that none of the students were exposed to or connected their classroom skills with this type of problem solving.

Participants completed the interview, pre-test and survey at the beginning and end of the six week study, which provided qualitative data used to evaluate the levels of progress achieved by each student. The students' tasks asked them to apply their newly learned vocabulary to project of designing or redesigning a toy. The project consisted of each stage of the design thinking process. The post test, post interview, observations, and post attitude survey provided the researcher with data to compare levels of improvement in design thinking. As a result of targeted vocabulary, activities were recorded after students were prepared with strategies and methods to ensure the learning experience was providing them with skills to use outside the classroom. The instruction unit comprised of the five stages of design thinking with targeted vocabulary to give students the confidence that is needed. Each participant also completed an MI survey before the instructional unit was taught to find the individual needs of each person. Since empathy, a form of interpersonal intelligence, is the foundation of design thinking, it helped coaches, parents, and teachers determine which student had a strong EQ (emotional intelligence) and which students could be assisted with directions in empathy. EQ for IQ is a 6 second activity and confidence builder, that helped enhance the objective of empowering these students as design thinkers.

Implications and Limitations of the Project

Since the students began the study with a large spectrum of skills and levels, the implications are quite broad. This study was limited to the levels of the students grade 3- 8 because of availability. Awareness is the cornerstone of learning. Students' awareness of words connected to innovation breaks roadblocks. Participants constantly mentioned coming across these words outside of class and this study. Example: Student noticed the word "tenacity" used while watching a movie. This type of awareness is invaluable to empowering students simply because knowledge is power.

This study could not have been executed as a team without email because some participants called in sick. This limits students to parents with email, a digital divide. One team member who did not have email delayed the study until the parent finally conceded and found a way to obtain email. The majority of the team was interested in starting a Facebook group. However, another parent was not cooperative because of the privacy issue. This also delayed the study. One team member was not interested in doing things that are hard and dropped out. Another called in sick often enough to use email, Facebook, and phone as communication to learn what was missed. Motivation is crucial and limitations are connected to lack of motivation. This may be a limitation of the study, or just a limitation that is naturally found in participants.

Strengths, Weaknesses of the Project

There were several strengths in this study. This is an ideal time to explore, experiment, and nurture creativity and train the child in the mindset of design thinking.

Other strengths were the ability to measure seemingly non-measurable skills when

pertaining to innovation. Application of design thinking challenged the students and gave them opportunities to explore new skills than are urgently needed in the workforce. The design of the study was strong because it used the cognitive theory, exploration, and self discovery to enhance creativity.

Most importantly, this study showed improvement in confidence by empowering the participants with skills needed to innovate and awareness of opportunities around them.

The weakness of this study is the small sample of 10. Reliability and validity would have strengthened this area. More participants are needed. Also, the digital divide makes it difficult for students who do not have access to email.

Timing does not coinciding with competition.

Problems with the Project and Factors that May have Skewed Findings.

Because of certain deadlines, the study was completed in February whereas the team and its competition ends in May 2012. It would have been beneficial to see the participants apply new skills throughout the competition. Some students were returning to the competition and some were new to it so some students had more experience than others in experimenting. Non-measurable elements come into play. Also, number of participants should be increased for integrity and validity of data.

Since this was more of a home school group project, the study was limited to who was available and email and phone interviews were used to update absent students. Also, because parents were the drivers it became easier for some to wait during sessions using their smart phones, which may have influenced the participants behaviors.

How the Study Could Be Improved

Recommendation of Areas That Could Be Further Investigated

This project could be enhanced by a follow up of the team to ensure long term memory and skills applied outside the classroom. Investigating how the students use their new skills and how their mindsets have changed would be beneficial. As more design thinking centers are planted on various campuses, more information can be studied.

Explanation of What to Do Differently If Study is Conducted Again in the Future

Because of this qualitative study, students are now joining activities involving design and innovation, perhaps because the peers in this group are doing it. Some students will be entering the FIRST Lego League Robots Tournament held in Fall of 2012. FIRST stands for For Innovation, Research, Science, and Technologies sponsored by play@learning. Others are serious about entering their experiment in the NASA competition. For Future studies, it would be profitable to perform a longitudinal study of how far awareness of innovation effects the future. If this study were to be conducted again, numbers should be increased from 10 to 100.

Justifications of These Differences.

A longitudinal study of how the mindset of innovation effects the future would benefit education because there would be evidence based research to support innovation centers. Important areas such as tenacity, motivation, and confidence would also be supported. A large scale study would increase reliability, validity, and integrity of data.

Critique of WGU Master's Degree Experience

The researcher's experience at WGU provided the best value for opportunities for self-improvement. WGU prides itself in being the "Cheapest and most rigorous of choices". This choice became the most efficient and effective way to achieve the goal. Stanford University offers a Masters in Education -Learning, Design, and Technology (LDT) but the tuition is unattainable for the middle class, whereas WGU offers an affordable Masters in Education-Learning and Technology. Since design is an importance element in creating an instructional unit, it became imperative to focus on the design aspect in education and it inspired the capstone.

Reflection on Master's Degree Experience

Making an impact on education and the need for quality teachers in STEM were both motivations in earning a Masters in Learning and Technology. As a special education teacher, technologies such as the iPad, electronic books, and audio met the need to support the majority of students with learning issues. Except for the populations still not connected to the internet or email, technology has improved learning conditions tremendously. Teachers must always continue to grow and strengthen with the best learning tool and methods to offer their students. Potential of learning with technology is tremendous. Children are watching online classes, like the Khan Academy.

Reflection on How the Experience/Skills Gained Can Apply In Work Environment

In order to continue teaching with purpose, and to contribute to helping the poor, it is imperative to always continue learning which supports innovation.

Since WGU provided an online learning experience, the researcher learned 1st hand the potential available to all who have the motivation, time, and technology. The time saved from driving and waiting was used to spend with family, tutor 2nd grade students with dyslexia as volunteer work, travel to Palestine and Israel to support peace in the Middle East, take advantages of all the open university and online classes offered and connected to Stanford, and strengthen ties and experiences in the robotics community. I was even available to donate time to judge the NorCal First Lego League Robotics Tournament for Robot Design which I learned a great deal and had the opportunity to work with exceptional people. I was also mentioned in the Stanford Daily while taking a class to research for my study. http://www.stanforddaily.com/2011/11/30/micro-finance-ceo-

scofield-discusses-social-entrepreneurship/.

This opportunity with WGU is similar to a career switch. It also gave opportunities to study at the Stanford Design School as research for this capstone. Whenever there is a task to change something, it is an opportunity to design well. For the researcher, it is more important to know what is being taught at Stanford than having the degree. Time was well spent for research at Stanford, it served as the center of 21st century learning experience that can be spread to others. Stanford Design School, even with just an instructional unit, offers most effective methods, more systematic yet pertinent to the 21st century. Presently, the educational system is teaching students for careers that don't exist yet or problems not predicted.

Education that pertains to innovation, is a mindset, and support solutions can help the poor. Design thinking can be used it for every problem from finding scissors at home to helping the homeless who can not eat apples because their teeth are bad. Innovation is a way of life. With design thinking programs on every campus, it could being awareness and change the mindset of students to give them the confidence. What is needed is training, research, and experience.

Motivations are to teach with purpose, help the poor. I am interested in earning a PH. D through online learning to study intrinsic, natural, interpersonal intelligence combined with emotional intelligence. Intuition is another area to explore. One team member was observed using his new skills during play time while building prototypes at home with legos.

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Appendices

Appendix A. Instructional Unit

A. Create an instructional unit. Include the following in your instructional unit:

- Table of contents

Overview of the unit, including the instructional goal and appropriate audience

- Material list(s) for the unit
- Seven lesson plans that include performance objectives and activities.
  - Lesson 1 Introduction of process- vocabulary
  - Lesson 2 empathy
  - Lesson 3 define
  - Lesson 4 ideate
  - Lesson 5 prototype/ test
  - Lesson 6 innovate
  - Lesson 7 Assessment and evaluation method

B. Report on instructional unit - Summary

1. Findings from a needs analysis conducted on the problem
2. Instructional goal statement
3. Reason problem could be addressed with instruction
4. Findings from learner and task analyses

Discussion on instructional unit.

The learning theories used- combination of Cognitive, Constructivism, Behavior

The design process used- Stanford Design process

The instructional strategies used

Explanation how strategies, activities, and assessments address the needs of special populations within the instructional audience.

Discussion of revisions made to instructional unit based on learner feedback initial evaluation

- How feedback was obtained

• Description of learner response to instructional unit

References

Overview of the unit.

The appropriate audience is third through eighth graders so students can understand and execute the Stanford Design Process to awaken creativity.

OVERVIEW

This instructional unit's goal is to create an understanding of the design process to strengthen design thinking. Students will understand the vocabulary in the methodology. Students will explain the process and what they learned

Students will gain skills and objectives

1. Listen, Spiral Sequence, comprehend vocabulary, gain experience in experimentation, creativity, problem solving

6. empathize, define, ideate, prototype, test. Apply and Synthesize info.

• Material list(s**)** for the unit- tiles, word box, word list, computer, head phones optional building materials, Pencils, Vocabulary matching cards – from Lesson 2)

1. Ted talks
2. Poster showing process
3. Youtube recording of "stanford design cup holder"
4. PowerPoint presentation of process, large enough for all students to read
5. Stanford website
6. Vocabulary pictures – large, showing vocabulary words, a simple definition, and an icon to show the meaning of the word.
7. Discuss innovation projects on back table, to be done in free time.

Teacher gives students sequencing strips of the process, Poster visible in room, Youtube recording of "Stanford innovation"
pieces to assembly in the back of the room .

• Seven lesson plans that include performance objectives and activities

1A rigorous and systematic approach would be as follows:

Lesson 1- intro of process- vocabulary

A. Daily Objectives

1. Concept Objectives

a. To create an understanding of the innovation process

b. Practice using vocabulary

c. To create citizens who are able to innovate

2. Content from the CA Curriculum Standards

a. "problem solve

3.Skill Objectives

a. empathize

b. define

c. ideate

d. prototype

e. test

f. Spiral sequence and build on tiles for multisensory strategies

B. Materials

vocabulary sequencing strips

C. Key Vocabulary

1. see list

D. Procedures/Activities

1. jumping jacks to increase oxygen supply to brain.

2. discuss innovation

3. Discuss importance

Stimulate Prior knowledge

4. Introduce empathy. (entry level, pretest of vocabulary)

5. Build vocabulary words on tiles to analyze pre fix, suffix, root.

Apply the word in conversation at school . cog

(students remember the word if they discover the word and use it in a sentence). Con, B

1. WORD STATION **

2. Working alone, fill in each empty star with the word that is defined on the stripe behind it. Turn the paper in to the turn in basket when you are finished. Check this station off of your list. Then you and a friend may play with the vocabulary matching cards until

it is time to leave the station.
(Materials: Vocabulary Smart Paper - Appendix D, Pencils, Vocabulary matching cards – from Lesson 2)

7. Sequencing

8. E. Assessment/Evaluation

1. Teacher observation of learners' prior knowledge of "innovation" (by listening to explanation– procedure #2)

1.Take pre- test on word and then review the next week B

2.. Teacher observation , correcting problems as necessary

3.One month later, engage student in interview using the words, expect application.

4.Post test – words put into long term memory.

5.Word is put in a word box and randomly pulled out by student.

referring back to vocabulary signs from Lesson 1 if needed.

2. Teacher observation for cooperation and students ideas

Break into strips and Spiral sequence back in order.

4.

a. empathize- how does user feel- interview

b. define problem- note problem may change through process

c. ideate- brainstorm ideas

d. prototype – build with low cost materials

e. test

f. Sequencing

Lesson 2 Empathy

A. Daily Objectives

1. Concept Objectives

a. To create an understanding of the history word empathy and empathize

b. dissecting vocabulary words

c. To create citizens who can empathize

emotional response

2. Content from the CA Curriculum Standards

a. "problem solve

Skill Objectives

a. Listening

b. empathizing

c. Sequencing and build on tiles for multisensory strategies

d. Understanding vocabulary

e. synthesizing information

B. Materials

'Stanford design thinking" sequencing strips

C. Key Vocabulary

1. Same as Lesson 1

D. Procedures/Activities

1.jumping jacks

2. review

3.Introduce the word empathy Entry level pre test Nouns,V

1. 4. Vocabulary matching cards -- one card to each learner as they enter room

5. Learners find someone who can empathize with their problem They then sit together in the room to discuss.

6. Partners share their matches with class to check for success (Acknowledge every effort)

7.. Build on tiles to analyze syllables, pre fix, suffix, root. Cog

8. poverty stricken muppet on Sesame Street

Procedures/Activities

1. Teacher tells story,

2. learners empathize and discuss

3. Teacher discusses importance of empathy

4. teacher shows PowerPoint presentation for process

5. Partner talk – learners tell a partner how they felt when they heard it

4. Encode the word one part at a time, 4. Practice spelling the word to bring awareness and review. B

5. Use graphic organizers, color code to dissect and decode words
Sample chart

Big picture process.

E. Assessment/Evaluation
1.Teacher observation of procedure #2, correcting problems as necessary
2. Use words in conversation, p test
3.Post test-. One month later, engage student in interview using the words, expect application. Post test – words put into long term memory.
4. Teacher monitors procedure assisting groups as needed
5 Teacher observation o, noting any blanks in learners' re-telling of history, to be addressed in next lesson if needed.

Fill in the blank finish paragraph

When I heard of kids not getting enough to eat, I felt_____.

Lesson 3 Define (Use words and define problem)

A. Daily Objectives
1. Concept Objectives
a. To create an understanding of the design process
b. To create an understanding of vocabulary , verbs,
c.To create citizens who are able to define the root of the problem
2. Content from the CA Curriculum Standards
a. "problem solve
Skill Objectives
a. review
b. Listening
c. Sequencing and build on tiles for multisensory strategies

d. Understanding vocabulary
e. synthesize information

B. Materials
'Stanford design process" sequencing strips
C. Key Vocabulary

1. Same as Lesson 1

D. Procedures/Activities

jumping jacks to get oxygen to the brain

2.discuss problems

3. what is the cause of the problem?

4.empathize, define problem,

5. Apply the word in conversation at school . Cognitive, Behavior summarize

WORD STATION **

Working alone, fill in each empty star with the word that is defined on the stripe behind it. Turn the paper in to the turn in basket when you are finished. Check this station off of your list. Then you and a friend may play with the vocabulary matching cards until it is time to leave the station.

JOURNAL STATION

Complete the Journal page: "problem" and Me. Show your journal page to a friend when you are finished, and ask your friend to check this station off of your list. Turn in your paper to the turn in basket when you are finished.

(Materials: Pencils, Journal page)

9. Play a game with word like hangman with vocabulary. B

4. E. Assessment/Evaluation

1. Teacher observation of discussion

2. Teacher observation of students as they identify cause of problem

3. Teacher observation as students use vocabulary

4. Teacher observation of students as they orally summarize

5. Teacher observation as students writes complete sentences about the problem

6. Observation, correcting problems as necessary

7. Take test on word and then review the next week, next month. B interview

8. Word is put in a word box and randomly pulled out by student.(students remember the word if they discover the word and use it in a sentence). Con, B

Lesson 4 ideate

A. Daily Objectives
1. Concept Objectives
a. To create an understanding of the ideate and where to draw from
b. art
c. To create citizens who are able to innovate
2. Content from the CA Curriculum Standards
a. "problem solve
Skill Objectives
a. review
b. Listening
c. Sequencing and build for multisensory strategies
d. Understanding vocabulary
e. build prototype

B. Materials
'vocabulary" sequencing strips, Low cost building material
C. Key Vocabulary
Same as Lesson 1
D. Procedures/Activities
jumping jacks
2.review

3.introduce project- redesign old view master toy
4.empathy of user, define problem, ideate. Prototype- 7min
5. Vocabulary – Teacher shows signs of the difficult words from process, showing word, simple definition, simple icon, and teaches a gesture to help explain the word.
6. Teacher and learners add gestures from Appendix A to the remember vocabulary word – teacher may insert more gestures where needed
8. In groups, learners practice vocabulary with gestures
9. Learners retell process as a class, using the pictures from procedure # 1 as prompts
10. Learners give group members "High Fives" to celebrate their learning
☐ ART STATION **
Draw a picture of prototype and ideas, brainstorm
Build prototype, test
(Materials: paper, pencils, crayons/markers, pipe cleaners, cardboard, tape,
Misc objects)
WORD STATION **
Working alone, fill in each empty star with the word that is defined on the stripe behind it. Turn the paper in to the turn in basket when you are finished. Check this station off of

your list. Then you and a friend may play with the vocabulary matching cards until it is time to leave the station.

(Materials: Vocabulary Smart Paper, Pencils, Vocabulary matching cards from Lesson 2)

6. E. Assessment/Evaluation

7.Teacher observation of procedure #2, correcting problems as necessary

8. show art

Lesson 5 -2nd prototype to redesign and test

A. Daily Objectives

1. Concept Objectives

a. To create an understanding of prototyping, cost and time investment

b. To create an understanding of the vocabulary

c. To create citizens who are able to innovate

2. Content from the CA Curriculum Standards

a. "problem solve

3. Skill Objectives

a. review

b. Listening

c. Sequencing and build on tiles for multisensory strategies

d. Understanding vocabulary

e. sign language

B. Materials

1.'vocabulary" sequencing strips, cheap building material, popsicle sticks., post its

C. Key Vocabulary

1. Same as Lesson 1

D. <u>Procedures/Activities</u>

1 Jumping jacks for oxygen

2. Vocabulary – Teacher shows signs of the difficult words from the vocabulary, showing word, simple definition, simple icon, and teaches a gesture to help explain the word. (See Appendix A)

3. Teacher and learners add gestures from Appendix A to the process – students creativity may insert more gestures where needed

4. In groups, learners practice with gestures

5. Learners retell process as a class, using the pictures from procedure # 1 as prompts

6. Learners use vocabulary

7. discuss prototype, switching direction of design when needed, incompletion, failure.

8. E. Assessment/Evaluation

9. 1. Teacher observation of procedure #2, performance of team work, creativity, using all the senses, functionality, redesign, more ideating, prototyping, testing, explanation, use of vocabulary.

Lesson 6 application of innovative ideas

A. Daily Objectives

1. Concept Objectives

a. To create an understanding of the Stanford design process

b. paragraph using vocabulary explaining design process

c. To create citizens who are able to innovate

2. Content from the CA Curriculum Standards

a. "problem solve

Skill Objectives

a. review

b. Listening

c. Sequencing and build on tiles for multisensory strategies

d. Understanding vocabulary

e. apply skills

B. Materials

same

C. Key Vocabulary

1. Same as Lesson 1

D. Procedures/Activities

DI. jumping jacks

2. new ideas, inventions, experiences,

3.Brainstorm paragraph

But -Brainstorm discussion <u>TELL IT STATION</u>

With a friend or two, re-tell their idea invention, draw it

4.Write paragraph to go with art. At least 3 vocabulary words.

<u>WORD STATION</u> ** Working alone, fill in each empty star with the word that is defined on the stripe behind it. Turn the paper in to the turn in basket when you are finished. Check this station off of your list. Then you and a friend may play with the vocabulary matching cards until it is time to leave the station.

4. (Materials: Vocabulary Smart Paper - Appendix D, Pencils, Vocabulary matching cards – from Lesson 2)

responsible-Revise checklist, switch with partner

people. Publish- Put on wall under each art piece

5. older grades- definitions as noun, verbs, adj. Behavior, Cog

Review process with gestures and accompaniment

7.. Vocabulary – Teacher shows signs of the difficult words, showing word, simple definition, simple icon, and teaches a gesture to help explain the word. (See Appendix A)

8. Teacher and learners add gestures from Appendix A– teacher may insert more gestures where needed
9. In groups, learners practice with gestures
10. Learners retell invention as a class, using the pictures from procedure # 1 as prompts

Learners give group members “High Fives” to celebrate their learning

Assessment
1. Teacher observation of procedure , grade writing or explanation, use of vocabulary
Teacher observation design thinking graphic goes here but makes the file too big to email.
Teacher observation as students writes complete sentences
2. older grades, Teacher observation of students as they identify nouns and classify them as common nouns or proper nouns.
3. Teacher observation of students as they identify verbs.
4. challenge students adj
5. Teacher observation of students as they orally summarize their invention and importance

7. E. Assessment/Evaluation

Lesson 7 Assessment

A. Daily Objectives
1. Concept Objectives
a. To create an understanding of the Stanford Design process
b. To create an understanding of the innovation
c. To create citizens who are able to correctly use vocabulary
2. Content from the CA Curriculum Standards
a. “innovation
3.Skill Objectives
a. review
b. Listening
c. Sequencing and build on tiles for multisensory strategies

d. Understanding vocabulary
e. comp
B. Materials
posttest
C. Key Vocabulary
1. Same as Lesson 1

D. Procedures/Activities
1. jumping jacks
2.post test, interview, survey, compare before and after
3. What did you learn?

Assessment interview – Talk to a partner about these two questions: How can you be innovative? When do you switch direction in your design? Again in partners, learners will design an invention or experience

- At least one assessment and evaluation method

interview

After vocabulary is mastered and participants have practiced use of the lexicon, students will complete 3 tasks correctly 100% of the time.

Task 1- student will use a word on the list in conversation and interview

Task 2- student will find examples of objects they
would like to innovated, redesign, create, or experiences they would like to improve.

Task 3- Students will apply new skills outside the study.

Example of conversations.

T: What do you want to innovate?

Recorded data from research.

3rd grade

musical rubix cube, removing earwax at the doctor's office, UV house so the sunlight does not cause damage. UV building material.

4th grade

jacket with heater that can get wet after swimming

(note- some of these ideas have already been done but can be improved.)

5th grade- bone marrow for leukemia

(they know a child that is having trouble finding a match)

6th grade - solar powered submarines, better music stand

7th better ramen recipe that is healthy, easier Christmas lights for tree and house displays

8th ROV, holodeck replicator for food and water during shortages

Key Vocabulary

1. Group work on mind maps will be graded based on rubric:

4		3	2	1
Participation	All participated in the work required.	Most participated in the work required.	Some participated in the work required.	One member did all of the work
Cooperation	All cooperated	Most cooperated and polite.	Some cooperated and polite.	Members not cooperative
Information Items	Had 3 items	Had 2 items	1 item	0 items given
Appropriateness to topic	3 items appropriate	2 items appropriate to topic	1 item appropriate to topic	0 items appropriate to topic

Appendix B

Time line every Sunday for 2.5 to 3 hours.

Nov 6 Sam's house welcome home costume party- introduced project
Nov 13 pre-test, interview, survey in two groups Eva's house with Laurel, Zoe, Charlie, Shawhin, Jenny, Rebecca, Jordan, Babette, Alexandria, Nicolas

Nov 20 lessons intro , empathy 2, define 3, ideate 4 discuss prototyping

Nov 27 missing students for Thanksgiving break review

Dec 3- SAT 2 hour drive to Santa Cruz for field trip (review lessons)

Mission- create a ROV that will pick objects off the floor of the pool.

Ultimately, ROVS need to be created to salvage oil rigs in ship wrecks to save the ocean.

2 hour drive home ideate sessions in car (wire, PVC, shovel, battery, motor, propeller.

Dec- 11 lessons 5-7, prototype 5, test 6, lesson 7 entire process with rapid prototyping

Dec- 18 Post test, change in attitude survey, post interview- end data collection

Dec 25- break, individual research empathy, define, ideate , rapid prototyping

Jan 1 break- email lists -Jordan, Rebecca, Nicholas, David-Skype assign positions

Jan 7 Fitzgerald Marine Reserve

Jan 8- show team, combine ideating, redesign, prototype 1 and 2

Jan 15 – test, retest

Jan 22- modifications, test, and practice until May 21 comp day.

Jan 28- SAT_ Wiring Workshop back up Feb 11

Feb 15- deadline for capstone.

Pool practice days SAT- April 14 and 28
Comp May 12

Appendix C

Demographics and characteristics

Students who are interested in design and creative thinking, becoming social entrepreneurs, participated in this study. Participants are a team of students who will be competing in the Underwater Robotics Competition- scout class. Several of the students went through the competition last year and are returning. Students will be starting on Dec 3, 2011 at UC Santa Cruz and will be designing a remote operated underwater robot. Data collection on pre-assessments will start in November. The competition date is May 12, 2012. There are three adult teachers who will be coaching the team and the researcher will be one of them. Lessons will be executed every Sunday after Dec 3 lasting for 3 hours in Redwood City about 10 minutes from Stanford Campus. This team is comprised of students from two different public schools. About half of their parents rent their homes to live in the area which has a high cost of living.

The team's motivation comes from the interest in robots. Considering the location of the team, which live in Silicon Valley, opportunities such as the Underwater Robotics Competition are available to foster innovation in students. These opportunities support Robinson (2001) theories of "Learning to be Creative" because it gives students the chance to create outside of school.

Student #	New or returning to competition	Sex	Age/ grade	Ethnic group	School/City	Facts1
1	returning	F	11 5th grade	Filipino	NSA/ Redwood City CA	Robotics club
2	new	F	11 6th grade	Chinese	NSA/ Redwood City CA	dyslexic
3	new	F	11 6th grade	Jewish	NSA/ Redwood City CA	Parents divorced
4	returning	M	8 3rd grade	Filipino	NSA/ Redwood City CA	sibling
5	returning	M	12 7th grade	Indian	Cupertino Middle School	
6	returning	F	11 7th grade	Caucasian	Boulder Creek Middle School	
7	new	F	11 6th grade	Caucasian	NSA/ Redwood City CA	Asperger's (has an AID)
8	new	M	8 3rd grade	Iranian	NSA/ Redwood City CA	
9	returning	F	12 7th grade	Taiwanese	Cupertino Middle School	
10	new	M	9 4th grade	Chinese/ Belgium	St. Lady of the Angels/ Burlingame	Parents divorced
11	new	M	9 4th grade	?	St. Lady of the Angels/ Burlingame	

Appendix D. Permission slip

Western Governors University Learning and Technology K-12

Capstone Project- Design Thinking @Stanford Design School by Mira Gillet

Your student is invited to participate in a research project conducted by

Mrs. Gillet that will study the most effective ways to improve a student's ability to create, design, and innovate. Mrs. Gillet teaches 2nd grade at Clifford School in Redwood City is currently finishing her Masters in Learning and Technology through WG University.

Description of Project:

The purpose of this research is to evaluate various strategies that equip students with design thinking which is necessary for innovation. Students will participate with other students in a variety of activities 3 hours each Sunday for the duration of month to study to evaluate which methods help to improve creativity and problem solving. Students participating in this study will do so with the consent of their teacher and will maintain current levels of classroom activities. Participants will be required to complete a short survey at the beginning and end of the study, complete one project and interview, and fully participate in the assigned activities with their group.

Benefits and Risks of this study:

Students participating in this study will benefit from the experience in Stanford Design School strategies which promote systematic design thinking. These strategies provide a solid foundation necessary for the development of innovation and leadership skills, particularly in Silicon Valley. The educational community will benefit from researching

which methods presently available are most effective to equip students with these crucial skills. No risk will come to students during this study.

Confidentiality:

All data collected throughout the duration of this study will be kept confidential and will be cumulative in nature. Your student's coach and Mrs. Gillet will be the only individuals to see the results of tests, surveys and interviews included as part of this project. Any data included in Mrs. Gillet's thesis will not include student names.

Voluntary participation and withdrawal:

Participation in this research project is completely voluntary and parents have the option to withdraw their student from this study at any time. Parents have the option to request that their student's results be excluded from the final report. Students will be expected to participate in the activity with the partner chosen for them to promote team building.

Questions, Rights, and Complaints:

Mrs. Gillet can be reached at teacher@mrsgillet.com or 650 646 8833 if parents have any questions or concerns during this study. Parents can request a copy of their student's results as well as a copy of the final report.

Consent Statement:

By signing below, legal guardians agree to allow their student to participate in the study as described.

_____	_____
signature of participants	signature of parent
_____	_____
type/printed name	type/ printed name

_____ _____

date date

Appendix E. Chosen tools and instruments

Test data collected
pretests, post tests,
Anecdotes on learners, performance context.
interviews
Questionnaires
Time line
Multiple Intelligence Survey- Emotional Intelligence, Interpersonal Skills
Materials for building
Ranking Survey on Values- entry behaviors test
Word Meaning
KWL chart

Appendix F. MI survey for learning styles

Type of intelligence	number out of 10 to claim this learning style
1. interpersonal	1/10
2. natural	0/10
3. verbal/linguistic	0/10
4. intrapersonal	1/10
5. musical	2/10
6. kinesthetic	1/10
7. visual/ spatial	2/10
8. math/logical	3/10

Appendix G. Survey Ranking 1.

During the pre-survey, ranking in order of importance on the 6 C's of innovation, the partcipants ranked

Table G. Survey Ranking 1 comparison

Pre-survey, most participants ranked	Post-survey, most participants ranked
2. Collaboration/ combination/ conversation	2. Collaboration/ combination/conversation
5. Curiosity	5. Curiosity
1. Creativity	1. Creativity
4. Change- co-evolution	3. Change- co-evolution
3. Courage/ Challenge/ Commitment	4. Courage/ Challenge/ Commitment

Appendix H. Survey Rankings 2.

Table H. Value Survey Rankings 2 comparison

What do you need to work on most?

Pre-survey, most participants ranked	Post-survey, most participants ranked

1. Collaboration/ combination/ conversation	5. Collaboration/ combination/conversation
4. Curiosity	4. Curiosity
5. Creativity	3. Creativity
2. Change- co-evolution	1. Change- co-evolution
3. Courage/ Challenge/ Commitment	2. Courage/ Challenge/ Commitment

Appendix I. Vocabulary test group A

Table I. Vocab test group A comparison

comparison group A AGES 8-10

Vocab word	# OF student S Who WERE correct Pre-test	# OF student S Who WERE correct post-test
Design thinking	0/5	5/5
empathy empathize	2/5	5/5
define	2/5	4/5
ideate	1/5	5/5
prototype	0/10	5/5

test, retest	5/5	5/5
collaborate	2/5	5/5
rapid	2/5	5/5
risk	0/5	5/5
inspire	3/5	5/5

Appendix J. Vocabulary test group B

Table J. Vocabulary test group B comparison

comparison group B AGES 11-13

Vocab word	# OF student S Who WERE correct Pre-test	# OF student S Who WERE correct post-test
Design thinking	0/5	5/5
empathy empathize	2/5	5/5
entrepreneurship	2/5	4/5

ideate	1/5	5/5
prototype	0/5	5/5
dynamic	3/5	5/5
collaborate	3/5	5/5
empower	3/10	10/10
tenacity	0/10	10/10
social innovation	0/10	10/10

Appendix K. Interview

Attitudes on Risk and Failure comparison

Pre-Attitudes on failure ranged from being accepting of it, to avoiding it at all costs.
Pre- Attitudes on risk ranged from enjoying it to being wary of it in order to determine the appropriateness of the risk.
Post-Attitudes ranged with acceptability with not winning the competition (considering that many of the teams are 4^{th} or 5^{th} year returning.

Appendix L. Interview

Questions on Attitudes on Risk and Failure comparison Prototype

The following questions were used to start a discuss on how the prototype works, and to Test the participants comprehension of the working design. It also gave insight on what areas need to be re-designed or explored further for future prototypes.

Possible Questions about prototype if applicable

- How does it work?
- Is it stable?
- How often does it fall apart?
- How can you make it durable?
- How did you get it to stay together?
- What happens and have you through about ways to fix this?

Mechanical efficiency
Would it be possible to use fewer pieces or components and still accomplish the same task?

Mechanization
Tell us about how your prototype uses attachment or other mechanisms to complete task.
Describe how it moves from place to place, overcomes, obstacles, balances speed, power.

automation/navigation
Would you explain how it turns or travels a specific distance, or goes from base to a specific destination?
How satisfied are you with this?
As it moves around, was there one area that was more difficult to navigate than another?
If so what did your team do to overcome this challenge?
Would you explain which sensors you used, and how and why you used them?
Would you explain how it knows when it is on the field?

"We tried a lot of different things and this one was the best."

What is your strategy to complete the task?
How did you make decisions to support that strategy when designing your prototype?
How many versions have you gone through?
What did you learn?

Design Process
strategy innovation
Mission strategy
How did you team decide which task to tackle?

How many of the missions has this robot completed successfully in a single match?
(Includes a tournament match, tournament practice, home practice)

We want to consider the overall strategies behnind your robot design.
Tell us about your robot. attachments, sensors, missions the robot attempts
so that we understand your team's design strategy

Innovation
What part of your design, program or strategy do you think is unique to your team?
How did you come up with the idea?
What will you do differently next time?

Look for
Usual strategy, programming or design
Propulsion or steering methods
or functional aspects that no one else has or you are surprised someone would try.

Is it able to efficiently perform the same task over and over?
Parts or functional aspects that make something difficult look easy?
Parts or mechanisms that perform several functions
Propulsion, steering methods or functional aspects that work
Can you describe what the robot will do base on the program?
Noteworthy observations about FLL

Efficient
Capable of mission
Well researched
Mechanical design

Programming trick if applicable
Excel across mechanical design
What was the greatest design or programming difficulty you encountered?
How did you solve the problem?

Appendix M. NASA activity- extra

Interview on inspiration and motivation of starting this activity

Design a NASA experiment which ISS astronauts will perform in space.
http://www.nasa.gov/mission_pages/station/research/nlab/experimentchallenge.html