AC 2011-802: GRADE 3-8 TEACHERS' INITIAL IDEAS ABOUT 21ST CENTURY SKILLS IN THE CONTEXT OF A SCIENCE AND ENGINEERING PROFESSIONAL DEVELOPMENT PROGRAM

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Grade 3-8 Teachers' Initial Ideas about 21st Century Skills in the Context of a Science and Engineering Professional Development Program

Introduction

In today's changing economy and global workforce, several published policy documents advocate an increase in science, technology, engineering, and mathematics in K-12 education.[1] Science and engineering education are seen as promising vehicles to promote 21st century skills in the classroom because they (science and engineering) are not only a body of accepted knowledge, but they also involve processes that lead to knowledge.[4,2] For instance, in the engineering design process (EDP), students are able to ask questions, propose possible solutions, construct and test prototypes, and present final products that promote creativity, innovation, critical thinking, problem solving, communication, and collaboration.[3] In the US, employers demand skill sets from recently hired workers, such as the ability to effectively communicate, collaborate, problem solve, and think critically. However, these work-related skills were found to be lacking in many high school and college graduates.[4] Little is known about effective teacher professional development models to cultivate 21st century skills in K-12 science and engineering content and classroom activities.[5] Specifically, it is not clear what teachers know about these skills or if they know how to foster them, particularly in elementary classrooms.[6]

In this study, 48, third to eighth grade science teachers from seven school districts throughout New Jersey, are participating in a professional development program that uses science inquiry and EDP to foster the acquisition of specific 21st century skills in students. During the 2010-2012 school years, teachers in the program pursue 15-credit hours of graduate content courses in physical and Earth sciences, four professional development workshops, and monthly classroom support visits. One of the goals of this program, the *Partnership to Improve Students Achievement in Physical Science: Integrating STEM Approaches (PISA^2)*, is to enhance teachers' ability to design learning environments that foster students' 21st century skills. In this paper, we will report on the teachers' initial conceptions and pedagogical approaches to foster 21st century skills in their science classrooms, based on semi-structured interviews and teaching philosophy papers, conducted and collected during the first month of the program. Knowing the teachers' conceptions of 21st century skills and their thoughts about classroom pedagogy that fosters these skills can inform professional development programs with similar or related goals.

Background

Economic growth in the United States in the1950s was attributed to the scientific and technological advances during that decade. In 2005, a survey was conducted by the National Association of Manufacturers and the Deloitte Consulting Company to gain an understanding of the demands associated with the economic reality and employability of the US manufacturing workforce in the current decade. Results indicated that manufacturing companies would look to hire workers with proficient reading, writing, and communication skills, the ability to work in a team, strong technology-related skills, the ability to translate drawings, diagrams or flowcharts, strong math skills and innovation/ creativity skills.[7] Top growing service occupations in the US require active listening, critical thinking, decision making, reading comprehension, and writing

as skills needed by fast food workers, janitors and cleaners, and home health service workers to do their jobs effectively.[8] Finally, a survey conducted in 2006 with over 400 employers across the US describes the skill sets that new entrants or recently hired graduates (high school and college) need to succeed in the workplace. Results indicated that the majority of employers mentioned critical thinking/problem solving, information technology applications, teamwork/collaboration, creativity/innovation, and oral communications as some of the basic knowledge and applied skills that new entrants need to compete with the global workforce.[4]

To address these challenges, the Partnership for 21st Century Skills was established to provide tools and resources to help the US education system promote an array of skills, including, but not limited to: critical thinking and problem solving, communication, collaboration, and creativity and innovation in the classroom.[9] The Partnership for 21st Century Skills acknowledges the crucial role teachers, who are directly involved in educating and preparing the new generation of students, play in the classroom. According to Shulman,[10] "a teacher knows something not understood by others, presumably the students. Moreover, the teacher can transform understanding, performance skills or desired attitudes or values into pedagogical representations and actions (p.7)." Teachers' disciplinary content knowledge can have an influence on instructional practice.[11,12] Several research studies have shown that teachers were able to use science and engineering education as vehicles to promote certain 21st century skills.[13,14] For instance, a study conducted by Kolodner et al.[15] showed that students in classes that used problem-based learning lessons performed better than those in traditional settings with respect to collaboration, meta-cognition, and science process skills.

In this paper, we will describe what teachers participating in our survey know about 21st century skills and how they foster these skills in their classrooms, in the context of a science and engineering research project. Teachers' conceptions about 21st century skills will be compared to the skills sets defined in a framework developed by the Partnership for 21st Century Skills (see Table 1)

LEARNING AND INNOVATION SKILLS	
1	Creativity and Innovation
2	Critical Thinking and Problem Solving
3	Communication
4	Collaboration
INFORMATION, MEDIA AND TECHNOLOGY SKILLS	
1	Information Literacy
2	Media Literacy
3	Information, Communications, and Technology Literacy
LIFE AND CAREER SKILLS	
1	Flexibility and Adaptability
2	Initiative and self-direction
3	Social and Cross-Cultural Skills
4	Productivity and Accountability
5	Leadership and Responsibility

Table 1. Essential 21st Century Skills

Methods

Participants

A qualitative approach was used to understand the teachers' initial conceptions of 21st century skills and their classroom pedagogy to foster these skills. Forty-eight teachers (15 female and 33 male) from seven school districts throughout New Jersey were selected to establish a baseline at the start of the program. Within this group, 31 are teaching students in grades 3-5 and 17 are teaching students in grade 6-8. Thirty-nine teachers have at least six years of experience.

Instruments

During the first month of the program, we conducted individual, semi-structured phone interviews, lasting about 15 minutes. Our interview protocol consisted of the following two questions:

1. Educators often consider both knowledge and skills that are important for their students to learn; focusing on skills, what skills do you think your students need to prepare them to become productive citizens of the 21st century?
2. How do you promote these skills in the classroom or in your lessons?

Interviews were audio-recorded, transcribed, and then analyzed.

We also asked our teachers to write a teaching philosophy paper during the first month of the program. Teachers were asked to respond to the following two questions:

1. What do you think are the goals of science education?
2. What do you think are the best ways to learn and teach science in the 21st century and how do you know this?

Data Analysis

Separate data analysis was performed on each prompt. The development of our coding schemes proceeded through an iterative process of application to the data set, expansion of codes and refinement of codes to capture relevant emerging themes in the data.[16]

Data analysis began with the identification of 21st century skills by teachers who also provided a description of these skills. The following main themes emerged from what teachers identified as important skills for their students to become productive citizens in the 21st century: (1) information technology, (2) communication, (3) critical thinking and problem solving, and (4) comprehensive reading and listening.

For the second prompt, our first coding pass gave us the different pedagogy (e.g. science lab work, problem solving in groups, Internet-based research, etc.) that teachers use in their classrooms to promote the skills mentioned above. In order to make sense of the data collected,

three categories were created based on interactions: (1) student-teacher, (2) student-student, and (3) student-technology. For instance, students working in groups to solve a problem were included in student-student interaction, while students using the internet to write emails and do web-quest research were categorized as student-technology interactions.

Separate data analysis was performed for each of the two questions teachers responded to in the teaching philosophy papers. Responses were collected from 47 teachers (one teacher withdrew from the program). Data analysis on question number one (What do you think are the goals of science education?) led us to group the teachers' responses into two main categories: (1) content knowledge and skills and (2) attitudes toward science and technology. This analysis was used to provide additional information regarding the teachers' conception of 21st century skills and the roles of science and technology in education.

Analysis of the second question (What do you think are the best ways to learn and teach science in the 21st century and how do you know this?) revealed the teaching strategies and pedagogical approaches utilized in their classrooms. These included: (1) adaptive instruction, (2) problem-based learning, (3) KWL (what I Know, what I Want to know, and what I Learned). We will describe all themes and categories including example responses in the next section.

Findings

What are the teachers' notions of 21st century skills?

To answer this question, we began by looking at the interview transcripts. Based on our data analysis, 20 teachers mentioned critical thinking and problem solving as important skills for their students to learn. Teachers defined these skills as the ability to apply prior knowledge to a new situation, organize concepts, resolve disagreements, generate new ideas, engage in inquiry process and synthesize information. For instance, Evelyn described how she fosters problem solving in her classroom: *"One of the traits of people who have been very successful in their lives... they have been able to problem solve and look at situations from different angles and try different solutions. And in the classroom, one of the things that I try to get the students to do is, when they find themselves stuck to the point where they don't know how to proceed or they don't see that they can go any further…, getting them to reflect on steps – you know, what do I know so far, what is it that we are trying to accomplish, are there any other ways of achieving that?"* Evelyn defined problem solving as the ability to look at situations from multiple ways and finding different solutions to a problem. Helping students to review the steps in solving a problem, its goal, and brainstorming other possible solutions are her pedagogical strategies to foster problem solving in her classroom.

In addition, Linda defined critical thinking as the ability to apply knowledge to another context: *"I think for me [critical thinking] means to go beyond the one word answer, beyond the answer that is, you know, the definition from the textbook…that they actually apply their background knowledge, apply their current learning, that they are able to make a hypothesis, and being able to pull all those things together to come up with their ideas and not just look for the easy way out."*

Twenty-four teachers identified oral, written, and mathematical forms of communication as important skills for students to learn. For instance John mentioned that students need to learn how to express themselves, which included the mathematics of telling time, *"…they need to be able to express themselves, they need to be able to get across with what they are trying to express to people…I still see nowadays that they have a hard time in sixth grade and although watches are digital they are still having a hard time telling time, so I think math skills are very important."*

Twenty-nine teachers mentioned the use of information technology/literacy as an important skill in the 21st century. More specifically, teachers identified conducting online research, acquiring basic computer skills, using an iPod or smartphone, participating in social media networks, and accessing Google products (email, documents, maps).

As an example, Daniel mentioned that technology helps students visualize what they are learning which allows them to learn more concepts: *"Basic computing skills just to interact with…to have certain technology. It could be a computer, eBooks, iPad, it could be from their phone…I believe that technology is a big proponent for students in the 21st century…when I was taught, we couldn't do interactive lessons and with the internet, with all these different things at our fingertips now it helps the kids to visualize and perceive differently and learn a lot more."*

In addition to using technology for learning in the classroom, students should learn how to use technology effectively as a form of communication: *"They need to know a lot of technology, nowadays we do communicate mostly through different forms of the internet whether is beyond Facebook, which is group sites, or whether the use of email…if they have applied for their college or a job, if they have to make a videotape, be able to express themselves."* Kirk mentioned that technology could be used by students for future purposes, such as getting into college or being hired to work.

Seventeen teachers mentioned comprehensive reading and listening as relevant skills students need to succeed in the 21st century. Comprehensive reading and listening is defined as the ability of students to analyze, interpret, and synthesize information based on what they are reading or hearing. Gina mentioned these skills were important so that students can apply them to another context, *"…being able to analyze information, analyzing questions, analyze the answers so they can use that and apply it to something else."* In addition, Julia thinks that students need to be educated to listen and take time to process information so that they don't miss important instructions or lessons: *"They need to…really read what is being asked or listen to what is being asked because sometimes they have the knowledge but they act so quick that they don't even know if they're answering the wrong question or they're doing the wrong thing."*

Cross-cultural sense and social skills were mentioned by ten teachers. These skills were defined as the students' ability to listen to others, respectfully express one's thoughts, and interact with peers and authorities. For instance, Evelyn mentioned respect for differences in language and culture as an important skill for her students to learn: *"For social skills, it would be active listening, how to express your thoughts respectfully, how to disagree respectfully, how to make sure everyone participates, those are what I meant by social skills. I do believe that the skills of respect for differences, and whether it be differences in language, differences in culture, we live*

in a society where everything is global, so I don't think students today are prepared necessarily to deal with other languages, other cultures, so I believe that's another skill necessary to be a learner in this century."

Ten teachers identified collaboration or teamwork as important skills for students to learn. Mercedes said that students need to learn to work in groups *"…share with their peers the group effort, team effort are essential skills that actually need to be learned."*

Finally, only one teacher mentioned creativity and one teacher mentioned leadership as important skills. Linda defined creativity as the ability to come up with something new – a new idea, a new way of thinking or expressing themselves artistically: *"I think that students need to… be creative… generate their own ideas, come up with their own way to cast things, their own way to maybe demonstrate what they have learned, maybe they don't have to write it as a paragraph answer… maybe they can use technology and make some sort of a presentation, maybe they could construct something if they have artistic abilities… to really allow them to work with whatever they are learning."*

Maggie defined leadership skills as the ability to be independent and the ability to tend to tasks alone, *"…leadership skills, show them how to be independent, I think that's also important."*

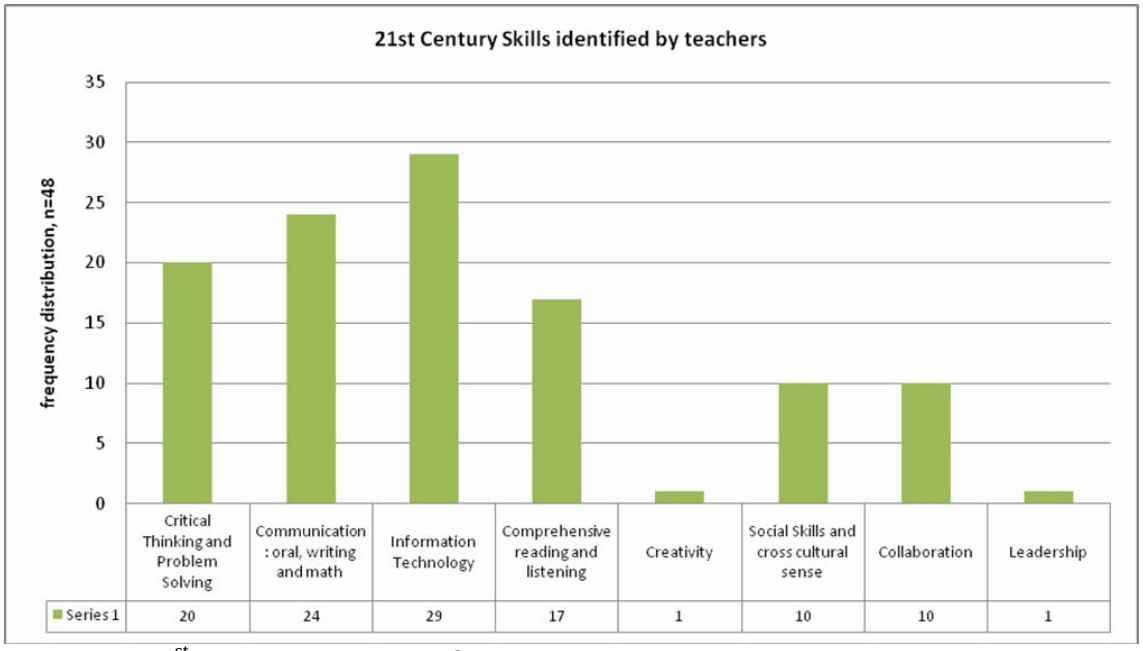

Table 2. 21st century skills identified by teachers in the semi-structured interviews

Awareness Level of 21st Century Skills

Through the relative frequency distribution of 21st century skills identified by teachers, we were able to rank results according to a level of awareness within the whole group. Relative frequencies are calculated dividing each corresponding frequency (count) by the population size (total count).

Awareness Level Ranking	
RF(x) range (relative freq)	Awareness Level
0.02 – 0.20	low
0.21 – 0.40	medium-low
0.41 – 0.60	medium
0.61 – 0.80	medium-high
0.81 – 1.00	high

Table 3. Awareness level ranking

Awareness level of 21st Century Skills identified by teachers		
21st Century Skill	RF(x)	Awareness Level
Critical Thinking and Problem Solving	0.42	medium
Communication Skills	0.50	medium
Information Technology Skills	0.60	medium
Comprehensive reading and listening	0.35	medium-low
Social skills and cross cultural sense	0.21	medium-low
Collaboration	0.21	medium-low
Creativity	0.02	low
Leadership	0.02	low

Table 4. Relative frequency of 21st century skills identified by teachers

This analysis helped us recognize the level of teachers' awareness of essential 21st century skills. Specifically, most teachers recognized critical thinking and problem solving, communication, and information technology as important skills. Few teachers mentioned reading and listening, social skills and cross cultural sense. Only one teacher mentioned creativity and one mentioned leadership.

The teaching philosophy papers provided additional descriptions of the teachers' notions of 21st century skills. Although the first philosophy paper question did not explicitly ask about 21st century skills, embedded in the teachers' descriptions of the goals of science education, 27 teachers mentioned the ability of applying science to our own lives, the development of higher-

level thinking, and the development of problem solving/decision making as goals of science education. Amanda said that students must be able to not only understand science content but be able to apply it into real life situations, *"…the goal of teaching science should be to develop critical thinking and problem solving skills so that children have the tools necessary to not only understand science content, but also to apply it to real life situations. Science must be meaningful to a child's life; and by teaching a child how to think through situations using science content rather than memorizing content, the learning becomes authentic. We should encourage children to ask the questions why and how rather than what.*"

Thirty-five teachers identified the development of scientific processes or practices as an important goal for science education. These included using the scientific method in solving problems and developing inquiry skills in order to better understand ourselves and the world around us. For instance, Paulina said that inquiry skills would be used by students not only in the classroom but also in their lives: *"In elementary school it is also important to provide the students with the knowledge of how to develop inquiries and the process used to answer their questions. This is a life skill that they can carry through their lives, and through science is one of the best ways to show students these skills."* Ashley added that these inquiry skills would help students systematically analyze and explain nature: *"The science class should build children's desire to discover how the world works, and foster children's abilities to systematically analyze and explain the interdependency of nature."*

Three teachers mentioned the development of creativity/innovation skills as an important goal of science education. Henry said, *"…the goals of science education should be to encourage students…as well as to become innovators in this ever changing world. They need to feel as if they can be pioneers for new creative medical and technological advances."*

Finally, 31 teachers mentioned learning science content as one of the goals of science education. Science content was identified as curricular subjects such as physical, Earth, and life/biological sciences. Brenda stated, *"The goals of science education are [to enhance] science content knowledge…all areas of science, life, earth and physical content should be taught at the elementary school level, starting in pre-k, as long as information is provided at the right developmental level"*

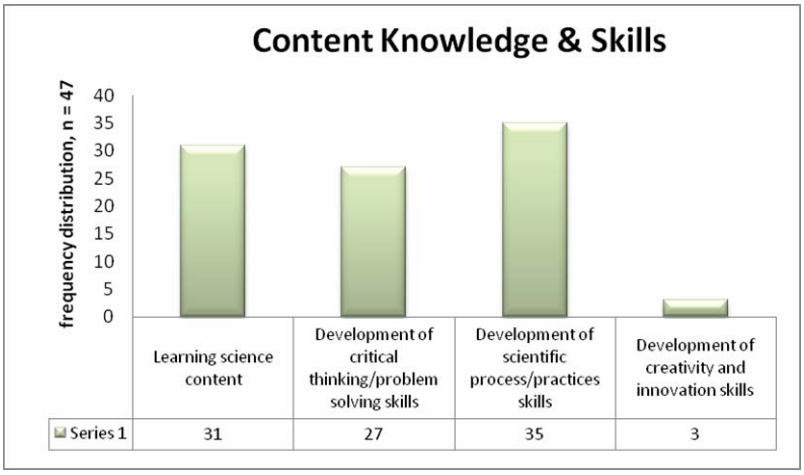

Table 5. Goal of science education: To increase students' content knowledge and skills

The second theme that emerged from the data analysis of the goals of science education in the teaching philosophy papers gave insight into the teachers' attitudes and perceptions toward science and technology. Specifically, they described how science education promotes students' interest toward science and technological careers, stimulates their minds and senses and encourages them to work in teams.

For example, Stephanie said, *"fostering an interest in scientific and technologically-based careers is important to the growth and development of these areas for the future. Upon creating this interest, students should learn about scientific careers and famous scientists so that they may be better focused toward these areas."* According to Stephanie, the future of science and technology depends on cultivating students' interest in pursuing careers in the sciences and technology.

Grace, on the other hand, thinks that hands-on science investigations and experiments stimulate students' minds and senses. *"I believe that the goals of science education should be engaging and motivating…and I feel as though combining a hands-on experience with practical research, while stimulating the visual and interpersonal learners, I am able to get my science lessons across to my students."*

Finally, several teachers mentioned that one of the goals of science education is to encourage teamwork by providing opportunities for students to work collaboratively in groups.

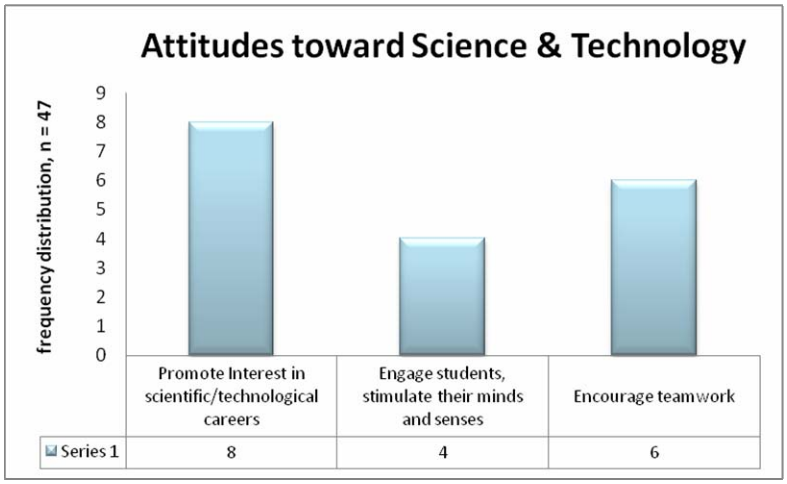

Table 6. Goals of science education: To increase students' attitudes toward science & technology

Teachers' pedagogical approach to foster the acquisition of 21st century skills in their lessons

The second interview question asked what teachers do in their classrooms to foster the 21st century skills they identified. We grouped the teachers' responses to this question by interactions: student- student, teacher-student, and student- technology.

Thirty-three teachers mentioned students conducting science investigations, groups engaging in problem solving activities, students having group discussions, students involved in role playing, and students building models or diagrams as examples of student-student interactions. For instance, Julia described how she conducts her science class with her third grade students. She asks students to work with partners in conducting experiments and writing laboratory reports, *"…Science lab, which is what I teach, and it's special. So, it's forty minutes a week for half the year. They come and we do the hands on activities, so they are actually learning to write lab reports at third grade. Still, they're working with a partner; with a small group, and they're doing activities on experiments, and then they have to do double check on materials, follow the procedure, bring up conclusions. We don't always make a lab report, but they are getting a lot of hands on experience."*

Glenda, on the other hand, describes how she fosters student-student interactions by engaging students in an engineering design activity. Students work in groups as they design a tower using marshmallows and spaghetti, *"…in science we had the kids working with marshmallows and spaghetti, and they work in a group of four and they have to construct the tallest tower and now the marshmallows and the spaghetti have different prices, and they have a limited budget so they have to first collaborate and draw a picture of what they think the tower will stand up tall…they work together on building the tower and the group with the tallest tower wins a little reward. That's an example of having them working together to accomplish their goal."*

Twenty-six teachers depicted student-technology interactions as another approach to implement 21st century skills in their classroom. Examples included students using *Microsoft Office* applications to produce projects and write laboratory reports, engaging in online webquests, and using projectors for multimedia presentations. For instance, Sophie encourages her students to use the Internet and *Microsoft Office* products to research, design and present their science fair projects: *"Ok, every year there has to be a science fair project that involves research on Internet; it also involves using things like Microsoft word, and power point to produce a final project."*

Arthur uses an online, interactive laboratory to engage students in learning science concepts: *"I usually put whatever website I can find that pertains to the lessons…we're doing a simulated virtual dissection with the free demos that they provide online…so that they can see and hear…it's just more fun and interactive for them [students]…it has to be engaging for them to pay attention even if it's for five minutes."*

Finally, Alison mentioned using everyday life materials, such as pencils, to engage students in a discussion of technology, *"…one activity that we do, we do inventions, improving inventions, so we look at existing inventions that we use in our everyday life, let's say pens, pencils, cell phones, automobiles and students are asked to improve upon it to make it better, to make it more*

useful for everybody to use…how they do it is up to them and their group, and we usually get group roles within the group…" This example illustrates a view of technology that is not only computer-based or electricity driven, but thought driven.

Twenty teachers described teacher-student interactions as teacher-prompted discussions and activities in which there is an exchange of work or verbal conversations between teacher and students. Examples include reading newspaper articles with students, teacher-prompted discussions, and lectures.

For instance, Elaine mentioned reading and discussing newspaper articles in class, picking real life problems from everyday life, and thinking about gas consumption as a way to promote 21st century skills. *"After they [students] read an article [from a newspaper], I'll give them a five-question quiz that they need to remember from the article. Picking real life problems from an everyday experience, such as how much gas are you going to need in order to get to school if you live 50 miles from school and your car gets 18 miles per gallon."*

Nancy described how she leads a class discussion: *"…a lot comes out of conversation, that's an opportunity to hear how they would solve the problem, in my class a lot of times I ask them what we should do? …here is what we have, what should we do? …and it is interesting to hear the amazing things they come up with, so this is inviting them to be part of the solution rather than telling them the solution."*

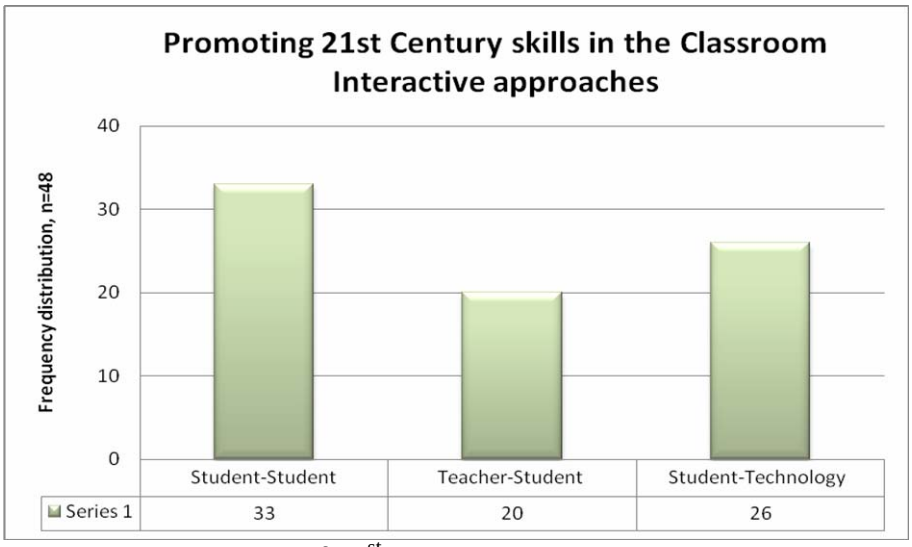

Table 7. Teacher implementation of 21st century skills in the classroom through interactions

The analysis of the second question for the teaching philosophy paper (What are the best ways to teach and learn science in the 21st century?) provided additional information about the teachers' pedagogical approach to foster 21st century skills in the classroom.

Eighteen teachers mentioned problem-based learning or engineering design as a way to learn science. Applying prior knowledge, exercising deductive and inductive skills, collaborative effort, research, brainstorming, trial and error, using math and language arts skills, hands-on activities, and the engineering design process were identified as main characteristics of these learning cycles. These characteristics exemplify student-student interactions when students engage in engineering design or problem-based learning.

Valerie engages students in designing a catapult that will launch marshmallows: *"I like to put my students into collaborative groups when doing labs. The students will share, debate, and learn from each other. For example, during a marshmallow catapult lab, my students had to hypothesize at what angle a marshmallow will go the farthest. The students picked an angle from 10 degrees to 90 degrees and I had them converse with their groups about why they picked that angle. I overheard one student say, 'I picked 50 degrees because when you are throwing a baseball, you let go in order to get an arch to make it go higher.' The other student said, 'Oh yeah! You're right!'"* Her example illustrates learning mathematics through engineering design.

In a different example, Diane mentioned that the engineering design process provides opportunity for her students to think critically, *"Engineering Design Process allows students to think critically, work in groups, and learn a specific science topic at the same rate as their peers. Ideally, I would use as many of these challenges into my lesson plans. When walking into a classroom that is using the engineering design process, students are arrange in groups of four, assigned job titles, testing materials, making discoveries,(what works or doesn't work), sharing ideas, keeping an engineering journal like real engineers or scientist, designing a prototype and competing in a challenge within other teams."*

We coined the term, adaptive instruction, to describe teachers adapting their teaching approaches to meet the various ability levels (cognitive and skills) and different modalities of the learners in their class. Responses from eight teachers were included in this category. Adaptive instruction is characterized as providing multiple pathways through which students can connect to concepts and skills, such as: students creating graphic organizers (visual), reading/answering questions (reading), utilizing digital tools (visual & technology), engaging in small group discussions (group learning), writing journal reflections (meta-cognition), and participating in hands-on activities (kinesthetic). Adaptive instruction can also be characterized by multiple interactions: student-student, student-technology, and teacher-student.

Jennifer describes her different teaching approaches and explains why they are important, *"The ability for student to learn can vary from one student to another. We have to take into consideration that all students do not learn at the same pace or level. Some students are visual learners and others are more hands-on. Understanding that not all students may have different learning abilities, learning in the classroom should be a combination of various activities that addresses the needs of each individual child. The best way to learn science is not to do one activity but a combination of different activities in one lesson. You may want to introduce a lesson visually by showing a clip of a video; then, maybe have the students reflect on the video by writing a short response, after have students work in collaboratively on a hands-on project, and finally present it to the students."*

Two teachers mentioned the KWL as a teaching strategy they use in the classroom. Jennifer explained how the KWL fosters creativity and collaboration skills: *"I use the KWL teaching strategy because through the years I found this technique to be the most effective. Using the KWL teaching strategy helps to activate or encourage students to recall prior knowledge so that they can generate and reflect the new knowledge. At the start of each lesson, I would have to find out what the students already knows about the topic. I use open discussion by asking and answering questions students may have, relating current events from a local paper, discussed about something they saw on television, or anything from personal experiences. Once we're done with that, the students will know what will be taught or what they want to learn. Questions are usually put up and instruction begins. Instructions may include doing experiments, collaborative work, research presentation, creative thinking, or demonstrations. Once instruction is done, I assess what has been learned either by oral or written assessments."*

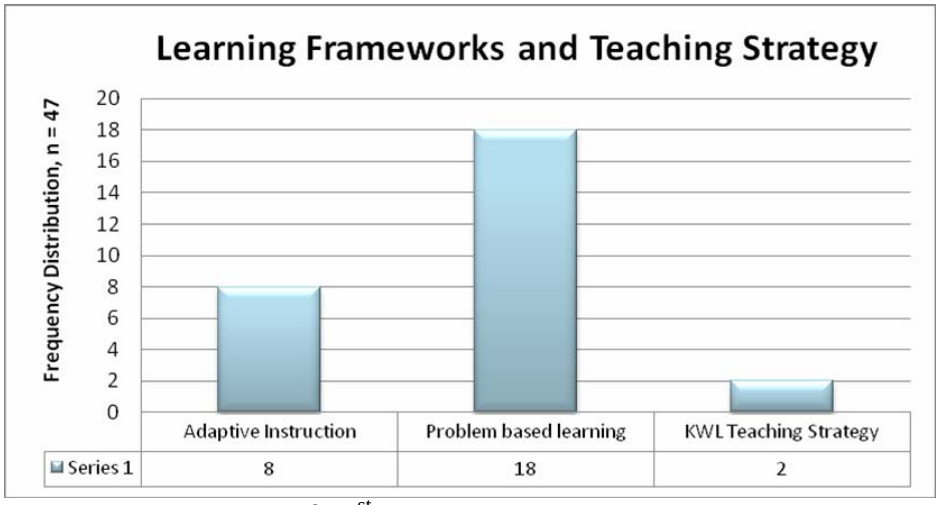

Table 8. Teacher implementation of 21st century skills through pedagogical approaches and teaching strategy

Conclusion and Discussion

The purpose of this study was to describe teachers' initial conceptions of 21st century skills and how they foster the acquisition of these skills in the context of a teacher professional development program in science and engineering. Semi-structured interviews and teaching philosophy papers were collected in the first month of the program (2010-2011 school years). We selected the skills set identified by the Partnership for 21st Century Skills to compare the teachers' initial conceptions.

Analysis of interviews showed varying levels of teachers' awareness about 21st century skills. Specifically, most teachers recognized (medium awareness level) critical thinking and problem solving, communication and information technology as important skills. Few teachers mentioned (medium-low awareness level) reading and listening, social skills and cross cultural sense. Only one teacher (low level) mentioned creativity and one mentioned leadership.

The teaching philosophy papers provided additional information about teachers' conceptions of 21st century skills, although the guiding questions did not specifically ask about these skills The majority of teachers mentioned the following skills: ability to apply science to our own lives (real-world situations), higher-level thinking skills, problem solving and decision making, critical thinking and scientific processes or practices. Moreover, teachers mentioned learning science content as a goal of science education, which was categorized as knowledge and not as a skill. Only three teachers mentioned creativity and innovation.

The interviews also provided a description of 21st century skills in their classrooms. Teachers mentioned students' conducting science investigations, engaging in problem solving activities, and building models and diagrams as examples of student-student interactions that foster critical thinking and problem solving, collaboration, and communication skills. Moreover, teachers mentioned student-technology interactions such as using Microsoft Office applications to produce projects and write laboratory reports, using projectors for presentations and engaging in online, interactive laboratory activities. . These student-technology interactions in the classroom provide opportunities for students to craft their critical thinking and communication skills as well as their ability to assess the credibility and reliability of information available on the Internet (information literacy). Other teaching strategies include teacher-student interactions in which there is an exchange of work or verbal conversations between a teacher and his/her students. These include reading newspaper articles, teacher-prompted discussions, and lectures.

We again used the teaching philosophy papers to provide additional information about what teachers are doing in their classrooms to foster 21st century skills. The majority of teachers mentioned engineering design or problem-based learning as ways to learn science. These include steps such as brainstorming, research, trial and error, using math and language arts, hands-on activities, and collaboration. These steps exemplify student-student interactions, which can promote critical thinking and problem solving, creativity and innovation, collaboration and communication. Several teachers mentioned adaptive instruction to describe when teachers differentiate their teaching approaches for various ability levels and different modalities of learners. Adaptive instruction is characterized as providing different opportunities for students to learn, such as students making diagrams (visual), students reading/answering questions (reading) , students working on computer (visual & technology), small group discussions (group learning), written reflections (meta-cognition), and hands-on activities (kinesthetic). Adaptive instruction can also be characterized by multiple interactions: student-student, student-technology, and teacher-student.

Our findings suggested that the teachers' conceptions of essential 21st century skills, during the first month of the program, showed a moderate degree of alignment with our theoretical framework specifically with respect to (1) Learning and Innovation Skills and (2) Information, Media and Technology skills, which constitute our main focus for this research study. Our findings point to a low degree of alignment to Life and Career Skills, such as flexibility/adaptability, productivity/accountability, and initiative/self-direction, which were not mentioned by teachers. These findings are of paramount importance to our professional development program in order to inform and direct our efforts to increase the overall awareness level of teachers, with an emphasis on creativity, the lowest score among Learning and Innovation Skills.

Teachers in our program operate in a student-centered learning environment as evident in the number of teachers who described student-student interactions in their classroom. Our analysis showed that their teaching strategies foster 21st century skills, while differentiating instruction for the learners in their classrooms. Moreover, our data supports our finding that teachers had some basic knowledge of engineering design and problem-based learning before entering our program. However, missing is an in-depth knowledge of iterative problem solving in both engineering design and scientific inquiry, which can foster creativity and innovation.[13]

Our next step is to collect and to analyze the post surveys (interviews and final reflection papers), which will be administered at the end of the school year (May, 2011). We will use that data to describe the changes in teachers' conceptions and ability to foster the acquisition of 21st century skills in their students after attending a year of professional development programs (courses, workshops, and classroom support visits). Moreover, we will consider using Jonassen's *Framework on Computers as Mindtools for Engaging Critical Thinking and Representing Knowledge*[17] in analyzing the technology components identified by teachers in the interviews, which we categorized as student-technology interactions. We are reconsidering the analysis of interviews because of the wealth of information provided by teachers about computer technology use and implementation (see information technology skills level of awareness). This analysis will hopefully provide a different perspective on the effectiveness of teachers' use of computer and Internet-based technology in their classrooms. Specifically, there is preliminary evidence that shows teachers' use of computers as *passive, productive, or as communication* tools to help students learn in the classroom (see below).

(a) *Passive Tools* – represented by various mechanisms used to transfer science content to students such as ebooks
(b) *Productivity Tool* – represented by application programs to create word documents, spreadsheets, presentation slides, etc.
(c) *Communication Tools*- represented by emails, text messages, video conferencing, etc.

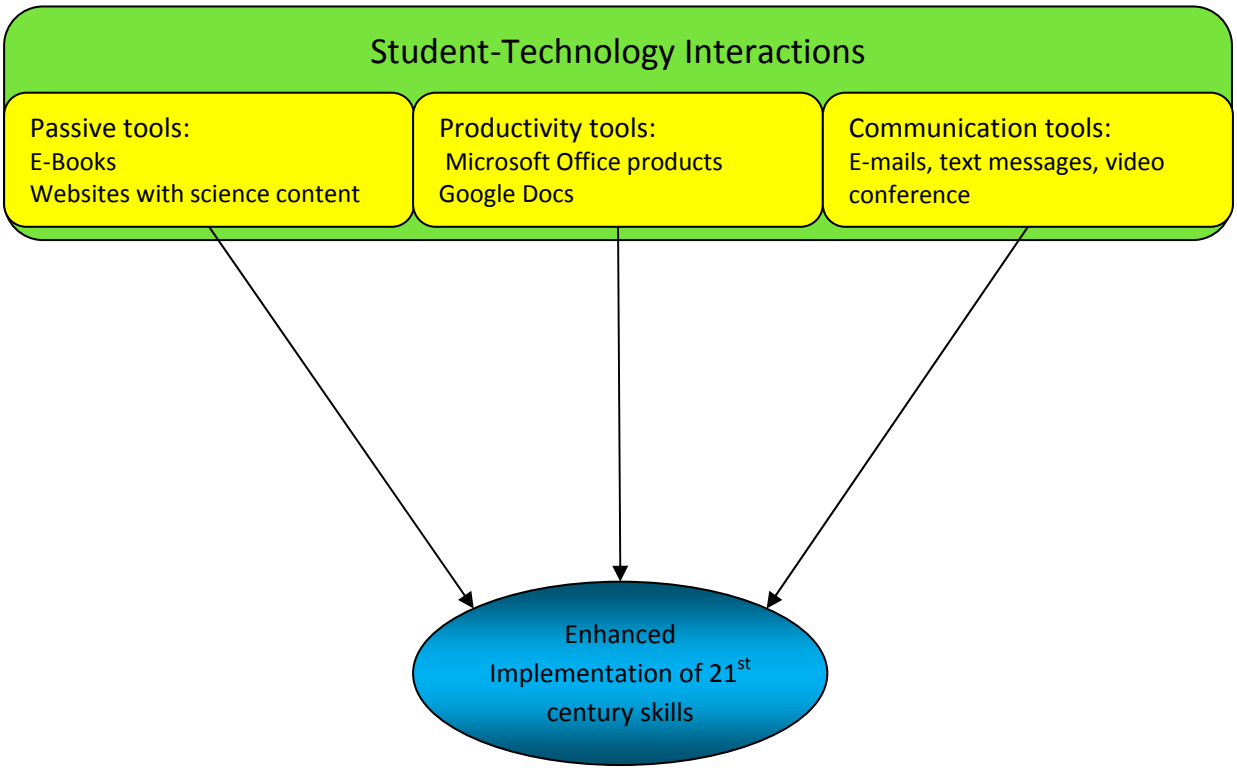

Figure 1. Preliminary analysis pertaining to the effectiveness of teachers' use of computer and internet-based technology in their classrooms using the Jonassen's framework[17].

We are hoping that the teachers' exposure and experiences in the EDP as part of the professional development programs in PISA[2] will help them to achieve a better understanding of these mind-tools and overall, enhance their ability to successfully engage students in engineering design and scientific inquiry to foster 21st century skills, such as creativity and innovation.

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