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Preparing Elementary Teachers for Engineering Design: Perceptions of their Experiences

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The new *Framework for K-12 Science Education: Practices, Crosscutting, Concepts, and Core Ideas* (NRC*, 2012)* includes engineering design as an integral part of k-12 science education. This is the first time that engineering for all students has been included in science education standards. This action research study sought to uncover elementary teachers' perceptions of engineering design. Sixteen elementary teachers in a *Space Science for Educators* course completed a survey of their perceptions of engineering, completed an end-of-course evaluation, and developed a lesson plan which addressed the new engineering concepts and practices. These data showed that overall, teachers were positive about their engineering experiences in the space science class, but most were reluctant to teach engineering to their students. It appears that similar self-efficacy concerns that elementary teachers demonstrate as it relates to science teaching may affect how they teach engineering to their students. As a science education community, we will need to address this issue and provide teachers with in depth, ongoing professional learning support to assist them in gaining the confidence, skills and competence as life-long learners is needed to implement the new *Framework* as intended.

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Introduction

In the U.S., it has been well-documented that elementary teachers face obstacles in delivering high quality science instruction in their classrooms (Howitt, 2007; Morey, 1990; Weiss 1994). In fact, elementary teachers have had to overcome a number of challenges. The 2000 Survey of Science and Mathematics Education, reported interesting statistics about the state of elementary science teaching. About forty per cent of elementary teachers had taken 4 or fewer science content courses and thirty percent of elementary teachers felt confident that they could teach science well. Other researchers concur that elementary teachers often lack the content preparation and confidence to effectively teach science (Appleton, 2003; Crawford 2000; Keys & Bryan, 2001). Therefore, it can be argued that elementary teachers' lack of substantial science content preparation and low level of self-efficacy may be exacerbated by the inclusion of the new engineering teaching expectations as described in the *Next Generation Science Standards, 2011 (NGSS).*

The main focus of this article is to identify elementary teachers' perceptions of engineering and document their experiences in a *Space Science for Educators* course as they are introduced to engineering design. In Florida, as well as throughout the U.S., elementary teachers are required to teach all core subjects and address the developmental needs of an expanding diverse group of learners. They are also expected to be experts in all content areas. The current research on elementary teachers' science preparedness is of concern and may be compounded by the expectation in the *Next Generation Science Standards* (NGSS*, 2011*) that they also teach engineering design along with science in an already packed curriculum. The lack of science content preparedness and now the new added expectation that elementary teachers teach engineering design warrants a closer look at what are their perceptions of engineering practices.

As science educators, we should want to know how elementary teachers view adding engineering to their ever increasing list of curricula and instructional expectations and how best to assist them as they begin to include engineering in the elementary science classroom. Based on what we already know about the professional development needs of elementary teachers, they need ongoing, long-term professional development support to facilitate the inclusion of the new engineering design practices in their classrooms.

Teaching and student learning are inextricably linked. Understanding how teachers navigate their own learning expectations may have strong ramifications for what and how they teach their students. Fullan (1996) stated that "you cannot improve student learning for all or most students without improving teacher learning for all or most teachers" (p.423). He followed up in 2007 stating that "student learning depends on every teacher learning all the time…" (p. 35). In this ever changing education landscape, the need to address teachers' perceptions of the new engineering practices, especially in the elementary grades where they already face science content challenges is essential, if they are to be successful in implementing these additional instructional expectations.

In this article, I provided insights into the journey of sixteen elementary teachers as they experience learning engineering design in a six-week's master's level space/physical science course. In the next section a literature review which explicated the conceptual framing for this research.

Literature Review

Science Education Reform

Science education reform is continuous. Over the past decades in the U.S., a number of science education reform efforts have occurred. In the 1960s the focus was improving science content knowledge through a number of expertly written science education curricula. *Science a Process Approach and Elementary Science Study* are two examples of nationally funded curricula during this period. In the 1970s the focused changed again. The emphasis of science education research reform efforts centered on science literacy. During the 1980s, science education research efforts shifted and the focus was students' misconceptions and conceptual change. A substantial body of research, especially on students' misconceptions in physics emerged during this time. In the 1990s constructivism had a prominent place in the education research literature. Constructivism is a theory which can be generally defined as students constructing their understanding and knowledge of the world through their own experiences. There were numerous articles published that focused on constructivism. One critique of constructivism was that substantial theory-based publications were produced, but fewer publications on its actual implementation in the science classroom existed. Then, in 1996, the National Research Council produced the *National Science Education Standards (NSES)* that focused on inquiry science as the central instructional method. In fact, in addition to the substantial focus on inquiry in *NSES* an inquiry supplement was also written to support its implementation. Now, fifteen years later, we have a new science education document- "A *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2011),* which has added engineering practices as part of the k-12 science teaching and learning expectations.

In the *Framework,* Engineering is defined as a "systematic and often iterative approach to designing objects, process, and systems to meet human needs and wants" (p. 202). This definition is followed up with core ideas in engineering, technology and applications of science. Also, engineering design is described with additional details related to delimiting an engineering problem, developing possible solutions and optimizing the design solution. Core ideas link engineering, technology, science and society. In the new science education framework, grade band endpoints are identified that indicate engineering design practices students are expected to achieve. The combination of these various components along with implementing engineering design practices may be a daunting task for some elementary teachers. Although valuable information about engineering design is provided in the *Framework*, but as currently written, may not be sufficient for teachers to conceptualize how they will carry out engineering instruction in their classrooms. One could argue that this new engineering design component, added to an already pack curriculum, is not a small step, but possibly a *big leap* for elementary teachers to undertake.

The new *Framework for K-12 Science Education* will only be as good as its implementation. Hence the need to better understand teachers' perceptions of engineering is essential. The importance of how elementary teachers understand the new engineering design practices is relevant to their instructional practices. Evaluations of past educational reform efforts show that the teacher is *central to reform implementation* (Fullan,1996). How the teacher conceptualizes, and then enacts reform can either move the reform effort forward or make little to no change.

The ever increasing instructional demands on elementary teachers, coupled with the new addition of engineering practices, along with science instruction, require that university science educators not only know how teachers perceive these changes but find accessible means to support their understanding and implementation of the new science education expectations, in particular, engineering design. In the U.S., this is the first time in science education reform that all k-12 teachers are expected to implement engineering practices in their classrooms. In the new *Framework*, practices are identified as: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics, information and computer technology, and computational thinking, constructing explanations in arguments from evidence, and obtaining, evaluating, and communicating information. One intent of the practices is to add details and explanation to facilitate scientific inquiry. Along with the shift to practices in the new *Framework*, is the focus on "learning progressions." Learning progress implies that learning is developmental and matures overtime. Several *National Research Council's* publications provided the background and research to support learning progressions, including *Taking Science to School (*Duschl, Schweingruber, & Shouse, 2007).

Over the last several decades the focus of science education in the U.S. has continually changed. It has evolved to its current focus-an integration of the crosscutting concepts and core ideas so that students may engage in scientific inquiry and engineering design practices. To see the *Framework* operationalized in the classroom requires that competent qualified teachers implement them as intended.

Elementary Teachers

For decades, science educators have written about the lack of quality science consistently taught at the elementary grades. Elementary teachers, traditionally lack the science content knowledge and pedagogy preparation needed to provide high quality science instruction. Thomas and Pedersen (2003) found that of the 150 pre-service teachers in their study "most were concern about their own limited content knowledge and worried about having "enough knowledge" of science to teach science "or help the children understand" (p. 324). In an earlier study Kennedy (1992) argued that the critical element in improving teaching practices is linked to how teachers view their instructional roles and how that role is enacted in the classroom. Roth (2014), as cited in the *Handbook of Research on Science Teaching and Learning*, reports that in a study of elementary teachers' instructional practices 13% of elementary science lessons received high ratings in providing opportunities for students to engage in the use of scientific practices such as explanation and argumentation. All of this research is disconcerting. Teachers' perceptions of their ability to teach science well may be a factor that affects the implementation of their science instruction. Now, with the addition of engineering design to elementary science, it is even more important that science educators know about teachers' perceptions of engineering.

Engineering is a new requirement in the *Framework*, which has curriculum, instructional and assessment ramifications for these elementary teachers. They are the ones required to implement the new *framework* in their classrooms. Traditionally, engineering in the elementary grades was mostly delegated to staff that work in after-school programs and/ or science competitions. In the 2009 National Academy of Engineering Teacher Professional Development document reports teachers must help children develop knowledge and skills to learn about engineering and they must understand, feel comfortable with, and teach it in a relevant manner. Yet the vast majority of elementary teachers have little education about or experience with engineering. Cunningham, Lachapelle and Lindgren-Streicher (2006) go even further and state that they found that the vast majority of teachers, regardless of their backgrounds and teaching experience have limited understanding of engineering. This concern must be addressed if the new *framework* is to have the intended impact on student learning.

Students in the elementary grades are open to learning about *STEM*. In fact, it is important that students experience high quality science in the elementary grades (Lawrenz, 1986). Other researchers concur that during the early years of schooling children develop important science process skills, observational and reasoning skills (Duschl, Schweingruber & Shouse, 2007; Eshach & Fried, 2005). This observation is not new and dates back to Dewey (1910) when he stated that it is in the elementary years that students' attitudes towards science are fixed. We know that it is important that students experience high quality science and engineering teaching and learning during the early years, but teachers are essential in the delivery of the curricula. Therefore, elementary teachers' perceptions of engineering may have a profound influence on whether or not they facilitate engineering practices in their classrooms.

Taking collectively, science education reform every changing focus along with the various challenges elementary teachers face as they implement the *Framework with the* new engineering requirement necessitate that we learn about teachers' perceptions of engineering. This action research study is one science educator's experience working with a group of elementary teachers as they began the process of conceptualizing engineering practices.

Research Question

How did elementary teachers describe their perceptions of engineering design practices as experienced in their Master's level space science course?

Methods

An action research methodology was used to examine my practice of including engineering design in an already developed Master's level Space/Physical Science course. Action research captures the notion of disciplined inquiry in the context of focused efforts to improve an organization (individual) and its performance. Action research in this study was used to focus on my instructional practices in a six-week summer course, *"Space Science for Educators."* It was a way for me to focus my effort in facilitating elementary teachers' understanding of the *Framework's* inclusion of engineering practices.

Both quantitative and qualitative data were used in this study. The quantifiable survey data were inputted into SPSS and descriptive statistics (mean and standard deviation) derived for teachers' responses. A survey (*Appendix A)* with 10 single-focused questions about teachers' perceptions of engineering was developed; it has a response continuum from (SA) strongly agree, (A) agree, (N) neither agree nor disagree, (D) disagree to (SD) strongly disagree for each statement and ranged from 5= (SA) to 1= (SD). The engineering survey items were derived from the research on engineering in the k-12 setting to purposely construct 10 survey items to elucidate teachers' perceptions of engineering. The qualitative data were obtained from teachers' end-of-course evaluation reported verbatim comments. These data were read and re-read to identify common themes. The combination of these data sources qualitative (student responses) and quantitative (survey response) provided insights into teachers' perceptions of engineering design and course experiences.

In the next sections, a description of the course, a summary of lesson plans developed, results of an engineering survey and comments from end-of-course evaluations were discussed.

Space Science for Educators Course

In this *Space Science for Educators'* course, engineering design has been integral to its design for over a decade. The *Space Science for Educators*' course is designed to provide students with experiences that promote effective science education in the elementary and middle schools. It is focused on principles of air and space flight with particular emphasis on *the historical aspect* of man's experience with flight, space, and rockets. The course provides a framework for understanding an American perspective on U.S. Space Program. Topics included in the course are: History of manned space flight, Newton's laws of motion and gravitational attraction, energy, earth and space environments, communication, navigation, remote sensing satellites, current status of Florida's Space industry and engineering design activities. The *"Space Science for Educators"* course included a number of activities from National Aeronautics Space Administration (*NASA*) engineering curriculum and culminated with a visit to Kennedy Space Center for an all- day professional development with *NASA* Education staff. During the visit to Kennedy Space Center, teachers experience enriching engineering activities and learn more in depth information about the U.S. space program's past, current, and future missions. The *Space Science for Educators'* course has been in existence over 17 years and past teacher participants have often reported using activities they experienced in the class as student enrichment or special assignments in their own classrooms. Added to the course this year was an emphasis on using *"Engineering is Elementary"* design model by the Boston Museum of Science. It is one of several different models of engineering design. It is cyclical and may begin at any phase. The model is not a rigid step-by-step process. The phases in the design are: **Ask-** what is the problem? What have others done? What are the constraints? **Imagine-** What are some solutions? Brainstorm ideas. Choose the best one. **Plan-** Draw a diagram. Make lists of materials you will need. **Create-** Follow your plan and create it. Test it out! **Improve-** Talk about what works, what doesn't, and what could work better. Modify your design to make it better. Test it out! In this six-week space science course, teachers experienced a range of activities focused on space flight and used *Engineering is Elementary* design model.

In addition to including an emphasis on using an engineering design process suited for elementary students, teachers reviewed the new *Framework for Science Education* where engineering holds a prominent position and is now an expectation of K-12 teachers' science instruction. I thought it seemed relevant to find out what were elementary teachers' perceptions of engineering prior to beginning my instruction. Sixteen elementary teachers were asked to complete a short survey on their perceptions of engineering.

The engineering survey (Appendix A) included items about teachers' background information. In Table 1, certification and years of teaching information for all 16 elementary teachers participating in the *"Space Science for Educators' "* course are provided.

Table 1: Background Information: Certification and Years Teaching

Elementary Teachers n=16

Certification	**Number of Years Teaching**
15 teachers Elementary Education	8 teachers 0 to 3 years' experience
1 teacher Early Childhood Education	4 teachers 4 to 7 years' experience
	3 teachers 8 to 11 years' experience
	1 teacher 17 years' experience

Table 1 shows that the majority of these teachers are early in their teaching career. The number of teachers who taught three years or less was 50% and 75% of teachers had less than eight years teaching experience. If these teachers stay in the teaching profession, they have a number of years to affect the quality of science and engineering instruction their students receive and will themselves, experience years of learning and professional development opportunities as it relates to improving their teaching.

Lesson Plan Example Topics and Overall Assessment

This section on lesson plans is intended to give readers an idea of the types of lessons topics teachers selected and my perceptions of their overall performance. Sixteen teachers worked in groups of no more than three teachers per group to develop and present their macro teach lesson on engineering design. Examples of lesson plan titles that teachers developed included the following: "*Lunar Rovers, Lunar Buggy, Egg Drop, Big Wheels, Mission Possible, To the Moon and Mars-or Bust, Parachute, and Prepare for Mission: Robot Communication."* The lesson plan format was provided by the professor but teachers had freedom to select their lesson focus, integrate their own style and thinking as to how they would structure and deliver their engineering lesson. The lesson plan format is located in *Appendix B*. Several essential parts of the lesson plan included detailed section on standards, content taught along with learning expectations, engineering design model used in instruction, and the product that students were to design as a result of the lesson. Teachers presented their lessons to their peers as a culminating experience the last two meeting days of the space science course. Overall, my assessment of teachers' first engineering design lesson in the class was very positive. Teachers worked well in their groups to develop their lessons and the presentations were engaging. Teachers' appeared to be confident as they delivered the lessons they had prepared. Teachers' lesson plans received high marks (average score 95%) which was most acceptable for their first attempt in this course writing lesson plans with an engineering design.

Findings and Results of Survey

The data collected focused on elucidating teachers' perceptions of engineering through survey responses and end-of-course evaluations as a result of their six weeks class integrating engineering design as part of the requirement for the course, *"Space Science for Educators."* The elementary teachers were asked to respond to the survey in *Appendix (A*) prior to any instruction. In *Appendix (A),* sixteen elementary teachers responded to the single-focused questions about their perceptions of engineering by selecting *one* response from a continuum of (SA) strongly agree, (A) agree, (N) neither agree nor disagree, (D) disagree and (SD) strongly disagree for the following statements. Next, is an analysis of teachers' responses to the engineering survey (Appendix A) on their perceptions of engineering design.

A. **Perceptions of Engineers**

Teachers across grade levels as a whole had positive perceptions of engineers' work. They thought 1) engineers make life better and 2) they know something about the work they do (M=4.69, SD=.48) and (M=4.13, SD=.72), respectively. A mean of 4 or higher indicated that teachers had strong positive views about engineers.

Table 2

Perceptions of engineers

	N	Minimum	Maximum	Mean	Std. Deviation
Perceptions 1	16	4.00	5.00	4.6875	.47871
Perceptions 2	16	3.00	5.00	4.1250	.71880
Valid N (listwise)	16				

B. **Engineering-Self-concept Attributes**

The item means for teachers' self-conceptions of skills that are likely associated with engineering (knowing how things work and putting things together) ranged from agree to neutral (not sure). The statement, *"I like knowing how things work."* (M=4.13 SD=.72) was more positive than *"I am good at putting things together" (*M=3.56 SD=.63). Collectively, these elementary teachers' perceptions were acceptable with ability to put things together being less positive than "*I like knowing how things work."*

Table 3

Self-Concept of Engineering Skills

	N	Minimum	Maximum	Mean	Std. Deviation
Self-3	16	3.00	5.00	4.1250	.71880
Self-4	16	3.00	5.00	3.5625	.62915
Valid N (listwise)	16				

C. Openness to Learning about Engineering

The set of questions which had the lowest mean centered on teachers' openness to learning about engineering. Teachers' openness varied from strongly agree to strongly disagree. In statement five, *"I would like to take a class in the future about engineering"* (M=3.50, SD=1.00) was encouraging about teachers openness to learning new things; yet, the statement, "*I would like to teach a class in the future about engineering"* (M=2.75, SD=1.00) was perceived negatively. This is an area of concern in that the new standards are requiring that all K-12 teachers begin including engineering design in their science instruction. Teachers' responses support the need for additional professional development about engineering and how it is implemented in the elementary classroom. Teachers when responding to this statement likely focused on their current level of preparedness to teach engineering and felt that they do not know enough to teach it well. This concern must be addressed as we move forward with the implementation of the new *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, *(NRC, 2011).*

Table 4

Openness to Learning about Engineering

	N	Minimum	Maximum	Mean	Std. Deviation
Openness 5	16	1.00	5.00	3.5000	1.15470
Openness 6	16	1.00	4.00	2.7500	1.00000
Valid N (listwise)	16				

D. Teaching Practices

Mean scores for teaching practices set of questions were variable and all teachers did not respond to each item. Statement 9, *"I connect mathematics and science concepts when I teach"* (M=4.23, SD=.60) had the highest mean in this group; whereas, *I help students see the relationships between engineers' work and scientists' work*" (M=2.80, SD=.63) had the lowest mean. Teachers' positive responses to connecting mathematics and science concepts are encouraging for we want students to see the connections between disciplines. The less positive response to statement 10 is understandable for engineering is rarely a part of the regular elementary school curriculum and teachers likely do not include a focus on the relationship between engineers' work and the work of scientists. In the past, engineering in the elementary grades was often taught as part of after-school programs and/or science and mathematics competitions. This practice is likely to change with the new requirement that all k-12 teachers of science teach engineering design. The other teaching practice statements (7 and 8) allowing *students to figure out how things work and having students think of new and better ways of doing things* had similar means (M=3.93, SD=.62 and M=4.00, SD=.96). These two statements may also apply to other disciplines and viewed as aspects of "good" teaching regardless of what content you teach.

Table 5

Teaching Practices

	N	Minimum	Maximum	Mean	Std. Deviation
Teaching 7	14	3.00	5.00	3.9286	.61573
Teaching 8	14	1.00	5.00	4.0000	.96077
Teaching 9	13	3.00	5.00	4.2308	.59914
Teaching 10	10	1.00	3.00	2.8000	.63246
Valid N (listwise)	10				

Teachers' Course Evaluations

The purpose of providing end-of-course evaluation comments is to elucidate teachers' post-course perceptions and gain insight about their perceptions of their experiences with engineering design. Students' end-of-course evaluations provided them the opportunity to reflect on their experiences in private and at their own convenience; they could include comments on every aspect of their learning during the course. Also, students' end-of-course comments served to foster deeper reflections of my own practice. These comments were important for they help me to think about how I could improve my practice and better support teachers as they begin this journey of incorporating engineering design into their own science lessons. The following are representative of students' comments on the end-of-course evaluation:

"*The subject matter and engineering lessons that could be used in my classroom were great. Of course the NASA trip was great too."*
"Great!

"*I like the professor, but I was disappointed by the use of old video."*

"I really liked class because it had many interesting activities and provided many opportunities to share ideas and knowledge with my fellow classmates. Excellent class!"

"I liked the discussions we had about misconceptions in force and motion and learned how to teach it better."

"The note-taking was very difficult because the information wasn't very organized."

"I liked being introduced to the engineering design model. The engineering models we completed in class were beneficial and could be used in my classroom. I also appreciated that she gave us typed notes so we could focus on the videos. I plan on implementing this in my own classroom. Professor has a love for science, which is evident."

The two main themes from teachers' comments were: 1) "*Affective value is very important in helping elementary teachers be open to learning about engineering design*"; 2) *utility of the engineering lessons need to be apparent to keep teachers interested in learning engineering design."* The collection of 30 comments centered on what teachers "*liked, and how they could use what they learned in their own classrooms.* Teachers feeling good about their experience and being able to use the lessons experienced during the Space Science course in their classrooms were important to them.

The teachers' comments about the video were taken into consideration by the professor. The videos used were indeed old vhs versions of the U. S. Space Program that had the original footage of various stages and events of the space program. I plan to update the videos to a DVD version. Yet, information provided on the DVDs was excellent. The comments about note taking being difficult and not well organized were taken into consideration by the professor; several students actually commented during the course that note taking was challenging. I started providing lecture notes to teachers during the course. From my perspective, it is not that the notes were not well-organized, but rather there was so much information teachers needed in order to prepare them for the engineering design lessons, they may have been overwhelmed. It is obvious that some teachers thought that providing notes would have been a great gesture from the beginning of the course. Teachers having prepared lecture notes may have relieved some of their anxiety about the physics concepts taught in the course.

The real world experience of seeing physics concepts and engineering design at KSC was a highlight of the course for teachers. The university is in close proximity to Kennedy Space Center and the class field trip is a doable experience. Teachers get to walk out near the launch pad area and have an extensive tour of the space center facility buildings along with professional development using the *NASA* engineering lessons located at their website. Teachers' evaluation comments about how much they enjoy the field trip to Kennedy Space Center occurs every time this course is taught; it is a consistent positive experience for teachers.

Overall, it is important that elementary teachers have positive experiences when learning science, for many of them have had negative school science experiences which may have affected their self-efficacy (perceptions of their ability). The comments about the professor's love of science is one that we often take for granted, but it may have a positive influence on how elementary teachers carry out science and engineering experiences for their students. Researchers (Pajares; 2002; Weld & Funk, 2005) have reported that a course that is designed to help teachers teach science well in conjunction with learning science content may have a positive impact.

Discussion and Recommendation

Teachers' perceptions of science reform matters. This study provided important insights into these elementary teachers' perceptions of engineering as they experienced a *Space Science for Educators* course. With about half of the teachers in their early career stage, they will need long term on-going science professional development as they learn to implement the new engineering design practices. As a science educator, this study provided me with insights about these elementary teachers' perceptions about engineering and enabled me to structure the space science course so that I provided substantial opportunities for them to implement the *"Engineering is Elementary"* design process by Boston Museum of Science as a first –step to learning engineering design. The need to have engineering design presented in an engaging and fun way was important. Teachers' end-of-course lesson plan selected topics showed that they could relate the engineering design topics in the space science course as something they could carry out with their students. Their comments about really liking the class, enjoying the Kennedy Space Center trip and class activities seem to foster positive perceptions about engineering design.

Overall, study survey results were positive. Teachers' perceptions of engineers and the work they do, their practices of having students figure things out and think of better ways of doing things, connections between mathematics and science concepts and how things work themselves had high positive means. All of these attributes are important; it could be argued that if teachers are negative about a subject, they may unintentionally translate these negative feelings onto their students. Hargreaves (1998) argued that teaching is an emotional practice. The biggest area of concern was the statement which received the lowest mean "I *would like to teach a class in the future about engineering."* If the new standards remain, teachers will have to teach engineering design in some form. How do we get teachers to be more open to teaching engineering design? Fullan (2007) argues that past professional development practices are insufficient for the new millennium. A better vision of professional development is needed that includes thinking beyond workshops, courses, programs and activities, to a design, which supports teachers learning *all the time in the settings where they actually work.*

As science educators, we can model life-long learning through our practice. This experience revealed areas which I needed to improve in my own instruction. Teachers' end-of-course insights were essential to helping me see weaknesses in my pedagogy that needed to be addressed. The goal of STEM Education will be better realized when we know who it is we are teaching, what are their perceptions of STEM, their academic preparation needs, and experiences, so that we can provide them with the experiences to better prepare them for 21st Century elementary school science teaching and learning. Teachers' perceptions about their learning and capability to carry out high quality instruction are key factors to the successful implementation of any new reform, including the *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, *(NRC, 2011).*

The vision of STEM education, as advocated by the framers of the new *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, is far from becoming a reality in the United States and may not be realized until the goals of STEM education are better defined, innovative STEM education programs and curricula along with appropriate assessments are developed, and teachers are prepared to meet the curricula, instructional and assessment expectations of the new *NGSS Framework.* As science educators, our goal should be to facilitate the learning process for teachers as they become better equipped to carry out the engineering practices as defined in the *NGSS Framework* and promote life-learning as a *Corner stone* of our practice.

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APPENDIX A Teacher Engineering Perceptions Survey

Background Information

Name____________________________ School_________________

Grade level___________Subject(s) ______________

Degree /discipline___________________________________Certification ___________________

Number of year's teaching_________________In each of the following, select the response (***SA-strongly agree, A-Agree, neither agree nor disagree, D-Disagree, SD- Strongly disagree***) which best describes your belief or practice.

Questions	SA	A	N	D	SD
1Engineers help make people live better					
2 I know what engineers do for their jobs.					
3 I like knowing how things work.					
4. I am good at putting things together.					
5I would like to take a class in the future about engineering.					
6I would like to teach a class in the future about engineering					
7I have students figure out how things work.					
8I have students think of new and better ways of doing things.					
9 I connect mathematics and science concepts when I teach					
10I help students see the relationships between engineers' work and scientists' work.					

Appendix B:

The Engineering Lesson Plan Format

Your Name –
Partners Names –

1). Title of Unit

Title of your lesson

2). Grade Level

3). Objectives written in terms of expected student behaviors and identification of Florida State Sunshine Standards Next Generation Science Standards, and English as Second Language Strategies.

4). Materials – List the materials used in your lesson. Give an estimate of the cost and where you might find them so that others may actually repeat the lesson should they wish to do so.

5). Content Overview – Describe pertinent content information about your lesson include:

Identify the important ideas (concepts that you are trying to get across)
Define those concepts, especially in an age appropriate manner
List new terms, define, and explain them
Content overview should be detailed and identify possible misconceptions students may have and how you would address them.

6). Practices – List the engineering practices facilitated in this lesson.

7). Engineering Instructional Procedures – Include: a way to introduce the lesson using ***Engineering is Elementary design model***; how you expect students to follow the method; suggest specific questions to be used in guiding the student's thinking through the various engineering practices relevant to lesson engineering design product

8). Evaluation/Assessment Procedures

9). Safety precautions

10). References – Reference your activity. Optional: List follow-up references where elementary students can learn additional information about the topic of the lesson.