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Examining Teachers' Perspectives on an Implementation of Elementary Engineering Teacher Professional Development

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EXAMINING TEACHERS' PERSPECTIVES ON AN IMPLEMENTATION OF ELEMENTARY ENGINEERING TEACHER PROFESSIONAL DEVELOPMENT

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ABSTRACT

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The emphasis on engaging young learners in science, technology, engineering, and math (STEM) professions is driving calls for educational reform. One movement that is gaining momentum is exposing K-12 learners to engineering. With the advent of the *Next Generation Science Standards* (2012b), engineering is being more formally integrated into standards for the K-12 level. As a result, in-service elementary teachers will need to become familiar with the core concepts of engineering to effectively teach aspects of the subject in their classrooms. Elementary engineering teacher professional development (EETPD) has been identified as a method to disseminate engineering content knowledge to elementary teachers.

The purpose of this qualitative research study was to investigate the perspectives of forty-one in-service elementary teachers from a school district in the south-central United States. Teachers were asked to define a successful implementation of teacher professional development, identify measures of success, describe an ideal work climate for implementing what was learned from EETPD, and share about the value of support from engineers in their community. Data were collected using a modified version of the

National Staff Development Council Professional Development Survey (2005), focus groups, and individual interviews. Data were analyzed using established qualitative coding practices, informed by the Characteristics of Effective Professional Development (NSDC, 2009) as a theoretical framework.

The results of the study revealed that teachers require demonstration of multiple levels of relevance to generate teacher buy-in, a nurturing environment for professional growth, and strong partnerships with engineers in addition to the Characteristics of Effective Professional Development (NSDC, 2009). Unique factors to engineering in particular consist of the need for a practice run of student engineering activities and the need to develop engineering curricula that is age appropriate for early childhood and subjects such as reading, writing, and social studies. Teachers suggested student engagement, rise in student achievement, and high integration of the engineering in the classroom as success measures of the EETPD.

CHAPTER 1. INTRODUCTION

Due to the latest calls to increase the size and quality of the science, technology, engineering, and math (STEM) workforce (Jobs For the Future, 2007), much effort was spent into reforming educational curricula to promote student interest in STEM subjects and, ultimately, career paths (Van Meeteren & Zan, 2010). A report by the National Research Council (NRC) outlined the issue:

> The quality of U.S. education in kindergarten through 12th grade (K-12), particularly in mathematics and science, does not lend itself to major increases in the number of highly qualified STEM workers, and … this factor is exacerbated by the perceived unattractiveness of many STEM careers as seen by young people." (2012a, p. 5)

A movement to cultivate elementary education in engineering is now gaining momentum (National Academy of Engineering [NAE], 2009), based on the prediction that the introduction of engineering in the formative elementary years will inspire a larger number of young people to aspire to STEM careers (Rogers & Portsmore, 2004; Brophy, Klein, Portsmore & Rogers, 2008). Organizations such as the National Science Foundation are funding studies to explore engineering in the K-12 environment (National Academy of Engineering [NAE], 2007), while programs such as *Engineering is Elementary* (*EiE*), created by the Museum of Science Boston (Lachapelle & Cunningham, 2007, 2012), and

Purdue University's Institute for P-12 Engineering Research and Learning (INSPIRE) Summer Academy (Capobianco, Diefes-Dux, Mena, & Weller, 2011) are focusing on delivering instructional modules and engineering teacher professional development. These programs—and others—are being actively disseminated throughout the United States in hopes of introducing the foundational concepts of engineering to teachers, and through them to children at an age where such exposure will have important impact. The benefits include enhancing their mathematics and science abilities in general (Swift & Watkins, 2004), as well as encouraging an interest in the STEM subjects through early exposure (Perrin, 2004).

To further the case for engineering in K-12 education, the creation of stand-alone engineering standards has been proposed, but this proposal has its problems. In March 2011, the Committee on Standards for K-12 Engineering Education presented the following findings (NAE, 2010): 1) There was relatively limited experience with K-12 engineering education in U.S. elementary and secondary schools. 2) There was not at present a critical mass of teachers qualified to deliver engineering instruction. 3) Evidence regarding the impact of standards-based educational reforms on student learning in other subjects, such as mathematics and science, was inconclusive. 4) There were significant barriers to introducing stand-alone standards for an entirely new content area in a curriculum already burdened with learning goals in more established domains of study (p. 1). Instead, two alternatives were proposed: 1) infusion, a concept that involves embedding learning goals from one discipline into the standards of another (e.g., engineering concepts into existing science standards), or 2) mapping, that is, integrating fundamental engineering concepts or "big ideas" into the current standards of existing disciplines (NAE, 2010, p. 2). Infusion was best accomplished during a revision of state or national standards, while the idea of mapping could allow teachers to draw connections to various disciplines through the problem solving nature of the engineering design process. Shortly after the NAE findings were announced, engineering was integrated into the new K-12 Next Generation Science Standards (NRC, 2013), with current implementation strategies focused on addressing the paucity of engineering expertise at the precollege level.

As a result, elementary teachers will need to become familiar with the core concepts of engineering, because content knowledge and situated practice are necessary to effectively teach a subject (Bruner, 2004; Lave & Wenger, 1991). The literature suggested that equipping teachers could be the greatest challenge to developing effective elementary engineering education; elementary teachers' anxiety concerning engineering, weak science knowledge, and doubts about the benefits of engineering in the elementary setting are all documented obstacles that must be overcome (Cunningham, 2008; Liu, Carr & Strobel, 2009). Among the various strategies for bringing engineering to the forefront of the elementary curriculum—such as educating pre-service teachers (Anthony, Garber, & Johnson, 2007), creating engineering education as an undergraduate major (Reid & Baumgartner, 2011), and outreach activities such as industry partnerships (Tate, Chandler, Fontenot, & Talkmitt, 2010)—in-service teacher professional development (TPD) has been championed by several researchers as the best way to maximize impact and effect positive change in the classroom (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; NSDC, 2009; Kennedy, 1998).

Traditionally, teacher professional development consisted of master teacher educators sharing their expertise with less experienced colleagues, but it has since branched out to include university partnerships, action research, professional learning communities, and seminars and workshops (Avalos, 2011). In 2008 alone, Title I schools across the United States spent three billion dollars on TPD designed to improve student achievement and teaching efficacy (Hirsh, 2009). Research in 2003-04 showed that nine out of ten teachers had participated in some form of TPD during their career (NSDC, 2009). Although the measurements of success vary from study to study, since the main motivation to use TPD is ultimately to increase the quality of learning in the classroom, student achievement is the most commonly used index of success (Borko, 2004; NSDC, 2009; Guskey, 2002; Guskey & Yoon, 2009; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007; Villegas-Reimers, 2003). With possible gains in student achievement of up to 21 percentile points on standardized assessments (Yoon et al., 2007), it is no wonder that diverse forms of TPD are viewed as a widespread solution to the demands of educational reform.

However, as with many reforms in education, there is no “silver bullet” or “one size fits all” method of solving key issues (Davis, 2007, p. 575). Not all TPD programs are created equal, which was highlighted in a report by the U.S. Department of Education’s What Works Clearinghouse (WWC), an institution dedicated to identifying sound research (NSDC, 2009). The Clearinghouse examined over 1,300 TPD research studies and identified nine (9) as meeting their standards for evidence of effectiveness. Guskey and Yoon (2009) also addressed the spectrum of TPD quality by analyzing these nine studies in depth. The information garnered by examining the nine studies was powerful: on average these studies involved 49 hours of TPD. This suggests that a substantial amount of continued TPD is necessary to achieve integration of skills into the classroom, although the WWC notes that due to the "lack of variability in form and the great variability in duration and intensity in this small number of studies, discerning any pattern between these characteristics and their effects on student achievement is difficult" (Yoon et. al, 2007, p. 11). In each of the nine studies, teachers received TPD directly from the authors or researchers who had created the training, through workshops or summer institutes. All but one study included follow-up sessions conducted to support the main TPD event; the study that did not have a follow-up session consisted of an intense four-week summer workshop.

The Yoon et al. study has proven seminal in identifying specific key characteristics of effective TPD. The National Staff Development Council (NSDC, 2009) summarizes the scholarly consensus on the four characteristics of effective TPD:

- Professional development should be intensive, ongoing, and connected to practice. The literature shows that an effective TPD requires certain duration of time. The teacher must familiarize him/herself with the innovation, practice it in the classroom, and reflect on the results, while receiving troubleshooting advice and continuous support for situations that might arise (Corcoran, 1995; NSDC, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey & Yoon, 2009; Schifter, Russell, & Bastable, 1999; Villegas-Reimers, 2003; Yoon et al., 2007).

- Professional development should focus on student learning and address the teaching of specific curriculum content. Teachers who participate in effective TPD leave with a better understanding of the subject matter and the skills needed to teach it, while broadening their grasp of how students perceive and develop content knowledge (Borko, 2004; NSDC, 2009; Guskey & Yoon, 2009).

- Professional development should align with school improvement priorities and goals. TPD that falls in line with the mandates of the district, state, and federal levels of regulation and is fully supported by school administration will be valued by teachers, since it is aiding in the accomplishment of goals that teachers are already required to fulfill (Desimone, 2009; Garet et al., 2001; Villegas-Reimers, 2003).

- Professional development should build strong working relationships among teachers. TPD that involves collaboration with other colleagues in the same department or grade level allows teachers to experience a productive collegiality. In addition to fostering creativity and useful discourse, it also nurtures solidarity and a feeling that positive improvement is possible (Borko, 2004; Desimone, 2009; Garet et al., 2001).

There are some variations in the terminology used to describe these four themes, but they are widely recognized. Identifying the characteristics of effective TPD is a valuable step toward producing high quality TPD and can inform the future development and evaluation of any TPD program, such as elementary engineering TPD (EETPD).

Now that engineering has been incorporated into the *Next Generation Science Standards* and the need for effective EETPD has been established, there is a need to examine specific implementations of EETPD and explore what factors lead to its success. I wanted to explore this question, and found an ideal opportunity to do so through a research assistantship at INSPIRE, which had developed a unique EETPD. From 2006 to 2011, many schools agreed to participate by sending their teachers to the week-long INSPIRE Summer Academy that focused on bringing engineering design principles into the elementary setting, incorporating science, math, and technology principles with various activities and projects. Among the schools participating, it quickly became apparent that a particular district's schools stood out - most of its teachers who had attended the academies in 2009 & 2010 were still active in implementing the EETPD and had received support from professional agencies and others throughout their community to nurture their interest in engineering at the elementary level. Based on this observed commitment of the schools, I determined that this particular school district would make an appropriate setting for a case study of EETPD effectiveness.

The methodology of my dissertation was determined through reviewing the EETPD literature and identifying the gaps. The nine studies that met the WWT's stringent criteria for producing scientific evidence, and which provided the foundation for articulating the four characteristics of effective TPD, were all strictly quantitative studies and all conducted from the perspective of the researchers or developers of TPD, not the audience receiving the training. Thus, there is an absence of qualitative research on EETPD. Although quantitative studies are useful in their own right, qualitative studies allow for a depth of information, revealing subtle nuances that can be crucial to filling in gaps in knowledge (Patton, 2002; Merriam, 2009). Qualitative research has been undertaken for various topics in teacher professional development, such as how teachers learn (Ross & Bruce, 2007), teachers' will to learn (Van Eekelen, Vermunt, & Boshuizen, 2006), and implementing professional learning communities (Mindich & Lieberman, 2012). However, very little research has been conducted from the in-service teachers' perspective on what factors are integral to a successful implementation of EETPD. Since the majority of the change in adopting to the *Next Generation Science Standards* requires teachers to add content to their already burdened plate, it is imperative that teachers' voices are heard and considered when designing and implementing EETPD. The inquiry of this dissertation sheds new light on how teachers perceived EETPD in one particular school, and offer new implications for practice in effectively supporting teachers during education improvement efforts. Thus, the purpose of this study is to understand the teachers' perspective on EETPD in the context of an implementation in a school district in south-central United States.

1.1 Rationale for Study

This research is needed, because the current literature lacks inclusion of teacher perspectives on necessary factors for a successful implementation of EETPD. Current EETPD research focuses on increasing student achievement in science and math (NAE, 2009) or maximizing students' engagement in engineering (Lachappelle & Cunningham, 2012). Teacher change has also been studied by measuring teachers' changing definitions of technology and engineering (Cunningham, LaChappelle & Keenan, 2010) and measuring the evidence of increasing proficiency in engineering (Duncan, Diefes-Dux & Gentry, 2011). However, none has been conducted by asking the teachers directly on what they feel are necessary for EETPD success. To address this gap, the goal of this study is on qualitative findings that help develop an in-depth understanding of the teachers' perspective in several areas. These areas include: 1) defining a successful implementation of teacher professional development, 2) describing the climate and environment that are necessary for EETPD implementations, including initiating and sustaining relationships with administration and community members, and 3) determining how much value the teachers place on each of the four characteristics of successful EETPD identified by the research community, as well as naming any additional factors teachers believe are crucial for successful EETPD.

With this study, I intend to explore how EETPD can properly support teachers. These findings will be valuable for 1) EETPD developers that want to design programs that incorporate both the characteristics of effective EETPD and contextual factors, 2) administrators and superintendents who strive to provide the best environment for teacher growth, and 3) the study participants themselves, who benefit from the opportunity to debrief and reflect on their EETPD with their colleagues, and have an opportunity to impact the future design of EETPD programs with their insights.

1.2 Statement of the Problem

Due to the *Next Generation Science Standards*, teachers must become familiar with engineering as a discipline at the elementary level. Therefore, in-service teachers will need effective EETPD to begin integrating basic engineering concepts into their curriculum. Previous research has identified four characteristics of effective TPD to date (Yoon et al., 2007; NSDC, 2009). The purpose of this study is to examine how the current EETPD can be improved to meet the needs of the teachers. Specifically, further study is necessary on how success is defined through the teachers' eyes, what elements are crucial in creating a flourishing environment for EETPD, and how much value teachers place on each characteristic in the implementation of EETPD. This inquiry sheds new light on how teachers perceive EETPD, and point to new ways to more effectively support teachers during engineering education improvement efforts.

1.3 Research Questions

The grand tour research question that this study aims to answer is what are teachers' perspectives on factors crucial for a successful implementation of EETPD? More specifically, the study will address the following questions:

1. From the teachers' perspective, what is a successful implementation of EETPD? What does it look like? How can it be measured?

2. From the teachers' perspective, what work climate or environment is necessary for implementation of engineering? How are relationships with administration and community members' participation initiated and sustained? What role(s) have administration and community members played in the EETPD?

3. From the teachers' perspective, how much value is placed on each of the four characteristics of effective TPD, as defined by the NSDC (2009)? Are there any additional factors that are crucial for EETPD?

1.4 Outline of Dissertation

This dissertation includes six (6) chapters and an appendix section. Chapter one (1) provides a brief introduction to teacher professional development, the rationale for the study, statement of the problem, and the research questions. Chapter two (2) presents a comprehensive review of the literature. Chapter three (3) describes the research methodology and methods including case selection, forms of data collection, strategies of data analyses, validation strategies used to increase the validity and reliability of the study, potential ethical issues, and the role and background of the researcher. Chapter four (4) highlights the results and discussion of the case-by-case analysis. This chapter describes each case in detail along with the themes that emerged from each of the cases. Quotes accompany the themes presented. Chapter five (5) concludes the study with a summary of the findings, implications for administrators, developers and researchers, and facilitators of EETPD, and ends with limitations and suggestions for future research. The appendix section includes copies of the Internal Review Board approval from Purdue University, the informed consent forms, interview protocols, and the NSDC professional development survey.

CHAPTER 2. LITERATURE REVIEW

2.1 The STEM workforce

The crusade to build a sustainable domestic science, technology, engineering, and math (STEM) workforce has captured the attention of Washington, industrial agencies, and educators (NAE, 2009; Committee on Science and Technology [CST], 2010; Cover, Jones, & Watson, 2011). Concern over the lack of a domestic STEM pipeline dates back as early as the late 1970s, when business, political, and intellectual leaders espoused the idea that international competitiveness in STEM fields was indispensable to the economic success of a country (Krugman, 1996). However, the discussion of competitiveness in the 1970s centered on efforts to improve overall productivity and quality of products, for instance “GMC trying to adopt lean manufacturing techniques from Toyota” (Hira, 2008, p. 8). The current, “new” competitiveness debate revolves rather around the belief that a coordinated effort to advance STEM education in the United States is “a necessary, if not sufficient, condition for preserving our capacity for innovation and discovery and for ensuring U.S. economic strength and competitiveness in the international marketplace of the 21st century” (CST, 2010, p. 3). This is no surprise, as some economic studies have suggested that as much as 85 percent of measured growth in U.S. income per capita was due to technological change (Abramovitz, 1986; Solow, 1957).

Studies comparing the ranks of U.S. students and their international peers have painted contrasting pictures. Findings from the 2006 Program for International Student Assessment (PISA) demonstrated that, on both the combined science literacy scale and mathematics literacy scale, 15-year-old U.S. students scored lower than the average (mean) score for students from the 30 countries of the Organization for Economic Cooperation and Development (OECD) (National Center for Educational Statistics [NCES], 2007). This statistic only added to the alarm about the lack of rigor in U.S. education. On the other hand, the 2007 results from the Trends in International Mathematics and Science Study (TIMMS) indicated that U.S. 4th and 8th graders scored higher than the TIMSS scale average; their scores had also improved since 1995 (NCES, 2009a). Both these measurements have drawn criticism: the PISA received dismissive remarks from the research community on the grounds of being: 1) culturally biased, 2) methodologically constrained, and 3) speculation-driven. Hopmann and Brinek advised that no policy making should be based on it (Hopmann & Brinek, 2007). The positive findings in the TIMMS study were partly inflated by the use of averages from 40 countries (as opposed to PISA's 30), many of which were developing, and therefore helped raise the U.S. scores (Kilpatrick, 2009). OECD's (2011) latest analysis of the 2009 data finds the United States ranking average in mathematics and below average in science. Despite the ongoing debates, it is indisputable that the U.S. is *not* in the top ranks for mathematics or science literacy. Summarizing the PISA and TIMMS findings, the NCES reports that the U.S. is consistently performing behind countries such as Hong Kong, Japan, Korea, and Singapore (NCES, 2009b).

One might ask, then, how the United States previously managed to prosper given such a lack of qualified personnel. The NCES (2009b) report sheds light on this issue, explaining that in the United States, of all Ph.D.-bearing members of the science and engineering workforce aged 45 and under, a full 35 percent are foreign-born. The report goes so far as to say, “it would not be an overstatement to assert that America’s science and engineering enterprise would barely function without these talented contributors” (NRC, 2010, p. 53). U.S. News (Kurtzleben, 2011) reported similar findings from the latest Census Bureau, citing that 33 percent of all engineering graduates are foreign-born, as well as 27 percent in other STEM fields such as computer science, statistics, and mathematics, and 24 percent in the physical sciences. Clearly, producing a workforce of domestic scientists and engineers is a continuous struggle.

In addition to such dire statistics, *Rising Above a Gathering Storm,* a report published by the NRC(2007), drew nationwide attention when it advised that while the U.S. was continuing to perform in the top ranks in innovation, government assistance would soon be needed to address discouraging trends in multinational companies’ choices about facility locations (and the jobs that accompany them). Competitiveness indicators mentioned in the report cited grim facts about the U.S. economy, comparative economics, K-12 education, higher education, and research. They recommended four implementation actions to reverse these bleak trends, the first of which was to “increase America’s talent pool by vastly improving K-12 science and mathematics education” (p. 5). Action points under this recommendation involve:

- Annually recruiting 10,000 science and mathematics teachers by awarding 4-year scholarships, thereby educating 10 million minds.
- Strengthening the skills of 250,000 teachers through training and education programs at summer institutes, in master's programs, and in Advanced Placement (AP) and International Baccalaureate (IB) training programs.
- Enlarging the pipeline of students who are prepared to enter college and graduate school with a degree in science, engineering, or mathematics by increasing the number of students who pass AP and IB science and mathematics courses.

These recommendations simply confirmed the necessity of improving STEM education and prioritizing the development of highly qualified STEM teachers (CST, 2010). Actions quickly followed after the publication of the report, often referred to as the *Gathering Storm*. In 2007 the America COMPETES Act was set in motion, with the prime objective of funneling funding to the Department of Energy's Office of Science, the National Institute of Standards and Technology, and the National Science Foundation (NSF), among other STEM organizations (U.S. Department of Commerce, 2012). When NAS revisited the question of the United States' global competitiveness in 2010 with the sequel report *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*, the need for innovation was again highlighted. And in this report, one of the four ingredients recommended to spur innovation was "creating sought-after products and services, often through *world-class engineering*" (NRC, 2010, p. 43, italics mine). Although science and mathematics have always been emphasized in the national discussion on economic competiveness, engineering had hitherto garnered almost no attention (NAE, 2009, p. 16). The need to promote engineering has now become critical, and not only at the graduate level, but at the K-12 level, as "the spectrum of jobs that is available to high school as well as college graduates is increasingly demanding at least rudimentary skills in these fields" (p. 53). Although there is still much work that needs to be done, the funding that is available through the America COMPETES Act has enabled many scholarships, nationwide competitions, and pre-college engineering TPD programs to come to fruition. It has also served as a catalyst to bring engineering education to the forefront of the STEM movement, and brought much-needed attention to the various efforts already being made across the nation.

2.2 Engineering Education in the K-12 Level

In general, engineering is seldom considered a content area at the K-12 level, and is only introduced as a focus area in postsecondary schooling. Engineering literacy is so limited that there seems to be general confusion as to what an engineer is and what tasks engineers perform (Cunningham, Lachapelle, & Lindgren-Streicher., 2005; Capobianco et al., 2011). Pre-service teachers are not educated to integrate engineering into their curriculums (Liu et al., 2009), engineering skills and knowledge are not uniform across standards or across the states nationwide (Carr, Bennett, & Strobel, 2012), and current teachers lack effective engineering teacher professional development opportunities (Brophy et al., 2008). Generally, individuals who lack a basic idea of what engineers do are unlikely to appreciate how engineering and science contribute to economic development, quality of life, national security, and health care. Such awareness is one aspect of technological literacy (NSF, 2005) that is lacking among students and teachers alike. Closing this gap will increase the quality of education in the United States, as well as attract more young people to STEM-related occupations (NRC, 2012).

In recruiting individuals to the STEM workforce, age is a crucial factor: the research suggests that introducing engineering concepts and skills as early as pre-kindergarten will ultimately grow the STEM workforce (NAE, 2009). According to a constructionist philosophy, engineering “has the distinct advantage in the elementary school of being something students enjoy as it incorporates hands-on and creative work” (Rogers & Portsmore, 2004, p. 17). Rogers and Portsmore (2004) offer an example of this in their study: students were given the opportunity to manipulate LEGO components to explore the engineering design process, defined by Dynn, Agogino, Eris, Frey, and Leifer (2005) as “a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients’ objectives or users’ needs while satisfying a specific set of constraints” (p. 103). Use of the LEGO engineering curriculum resulted in evidence of student comprehension of concepts from physics, programming, and math, even at young ages (Rogers & Portsmore, 2004). Not only does the project-based nature of engineering allow students to make connections with science and mathematics, but as a subject it can also tie into other common core subjects such as reading and writing. LEGO engineering bolstered students’ interests in the STEM subjects as they gained confidence through successful design projects.

Brophy et al. (2008) also comment on the benefits of engineering at the K-12 level. The benefits begin with the youngest of learners discovering how to express and then act to implement a plan of construction. Older students can be introduced to the skill of evaluation, learning to identify issues with complex systems such as an elbow or lung, and to envision possible solutions. In their summary of the research, Brophy et al. list the following competencies developed through engineering activities (Brophy et al., 2008):

- Evaluate and explain the structure, behavior, and function of complex systems.
- Develop cognitive models of how “systems” work.
- Design and conduct experiments to inform decision-making.
- Communicate and negotiate ideas with others.
- Apply geometric and spatial reasoning.
- Represent and manage complexity of a system using diagrams.
- Express ideas and results with mathematics.
- Synthesize ideas toward an appropriate solution that meets goals.
- Conduct experiments to evaluate if a design meets criteria for success.

In short, engineering compels young learners to try to explain systems and understand the relationships between variables, a common goal of science instruction. Because engineering develops these skills and easily connects to content matter and skills from various disciplines, it can be an invaluable platform for holistic learning. Engineering, in summary, “provides learners with an opportunity to be generative, reflective, and adaptive in their thinking as they engage in activities of planning, making, and evaluating a device, system or process” (p. 375).

Perrin (2004) posits four goals for a strong elementary engineering education curriculum. 1) Develop a solid foundation of engineering concepts and principles, promoting appreciation of science and later success in college. 2) Activate students' multiple intelligences through experience with the various tools and methods utilized in engineering, from visual graphs to interactive kinesthetic feedback. 3) Utilize 21st century technological tools so students (as well as teachers) can better make associations between concepts and physical reality. 4) Promote understanding of the role that engineering plays in common, everyday concepts such as the light bulb and telephone. When students realize that engineering incorporated into their everyday life, some will become much more interested in creating their own designs, perhaps in pursuing an engineering career.

Having established that engineering was pedagogically useful for developing a number of skills, it became important to address the context of such learning. It was easily understood that the primary and secondary environments are completely different, with primary classrooms offering a unique set of challenges. Swift and Watkins (2004) addressed the constraints that surfaced throughout their engineering outreach with K-4 in-service teachers. To begin, lessons were typically restricted to fifteen to twenty minutes, which is the approximate attention span of elementary students. Elementary teachers generally stayed with the same set of students throughout the day, while secondary teachers usually have periods of different students in the span of a day. Elementary teachers were often licensed in multiple subjects, requiring a broad rather than deep understanding of the subject areas, while secondary teachers can be experts in one or two subjects. As elementary teachers were responsible for the whole spectrum of content in the curriculum, they must be adept at disseminating the various subjects in an even manner. Overall, Swift and Watkins found that elementary teachers lacked the necessary background in the sciences to fully grasp engineering content, but they excelled at understanding how children learn, while engineers were well versed in the technicalities of the subject, but had no knowledge as to how children learn (2004).

In efforts to emphasize the necessity of engineering education, a committee formed to evaluate whether engineering standards should be created. (NAE, 2010). However, as described in Chapter 1, this Committee on Standards for K-12 Engineering Education concluded that the task of creating and implementing such standards had low feasibility. At a presentation in March 2011, the committee gave the following reasons why utilizing such standards were not recommended:

- There was relatively limited experience with K-12 engineering education in U.S. elementary and secondary schools
- There was not at present a critical mass of teachers qualified to deliver engineering instruction
- Evidence regarding the impact of standards-based educational reforms on student learning in other subjects, such as mathematics and science, was inconclusive, and

- There were significant barriers to introducing stand-alone standards for an entirely new content area in a curriculum already burdened with learning goals in more established domains of study.

Instead, the committee suggested two alternatives:

- Infusion – embedding relevant learning goals from one discipline (e.g., engineering) into standards of another (e.g., mathematics).
- Integration – mapping “big ideas” of engineering to current standards in other disciplines.

The Committee further advised that since infusion is best accomplished during a state or national revision of standards, the second suggestion, concept mapping, would be the more viable solution. However, around this same time, the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) began to create the Common Core State Standards, a collaborative effort involving teachers, postsecondary educators, community colleges, and representatives of civil rights groups, English language learners, and students with disabilities (NGA, 2010). The goal of the Common Core State Standards is to ensure “that all students, no matter where they live, are prepared for success in postsecondary education and the workforce” (“F.A.Q.”, n.d.).

With the Common Core mathematics and language arts standards adopted formally by forty-five states and three territories, it seemed only natural to create new science standards as well. In 2010, through funding from the Carnegie Corporation of New York, the NRC's Board on Science Education (BOSE) began to partner with Achieve, the National Science Teachers Association (NSTA), and the American Association for the Advancement of Science (AAAS) to develop a conceptual framework for new science education standards involving three major dimensions (NRC, 2012a):

- Scientific and engineering practices.
- Cross-cutting concepts that unify the study of science and engineering through their common applications across fields.
- Core ideas in four disciplinary areas: physical sciences, life sciences, earth and space sciences, and engineering, technology, and applications of science. (p. 2)

Engineering plays a tremendous role in the Next Generation Science Standards. This, then, leaves no doubt that elementary teachers will need instruction in engineering content knowledge and opportunities to practice engineering (Bruner, 2004; Lave & Wenger, 1991). Future teachers will benefit as engineering begins to be included in teacher education (Anthony et al., 2007), while engineers in the industry will participate in engineering outreach programs (Tate et al., 2010). These measures will not, however, aid the teachers most in need—current in-service teachers. Simply put, more resources must be made available to elementary teachers to mitigate deficiencies in engineering literacy (Swift, Watkins, Swenson, Lasater, & Mitchell, 2003). The most effective method for preparing teachers will lie in effective elementary teacher professional development.

2.3 Teacher Professional Development

The literature on teacher professional development (TPD) is prolific, and serves as a testament to its current significance in the landscape of education. As teachers are being placed under a microscope to assess their teaching abilities and impact on student achievement, the need to support and facilitate professional growth in the teaching context becomes more evident. Often championed as the best way to bring positive change into the classroom (Carpenter, Fennema, Peterson, Chiang, & Loef , 1989; NSDC, 2009; Kennedy, 1998), the field of TPD has grown immensely throughout the past decades, due to the pressures created by educational reforms, such as the standards-heavy No Child Left Behind (NCLB) and Race to the Top. In 2003 alone, the national Schools and Staffing Survey (SASS) reported that 9 out of 10 teachers had participated in some form of professional development (NSDC, 2009). Clearly, TPD opportunities are on the rise.

The modes of delivering TPD have steadily evolved with research findings. Traditional forms of professional development typically consist of in-service training, workshops, and weekend seminars. As technology has continued to progress and become increasingly relevant to learning enhancement, distance education platforms such as online professional development modules and certification programs have become increasingly popular TPD models.

The methods of disseminating TPD are not the only factors that have evolved. A growing emphasis on understanding the true essence of effective TPD and determining best practices has fostered new research. Another area of interest is the link between effective

TPD and classroom impact; in other words, how TPD translates to student achievement. Even if a teacher who receives TPD reports higher job satisfaction, this does not necessarily indicate any significant measureable effect on student achievement, which is the main objective in creating effective TPD. TPD is costly, and it is important that the results improve the United States' flagging educational rankings. The U.S. Department of Education spent $2.5 billion on improving the quality of teachers in 2011 alone (U.S. Dept. of Education, n.d.), and this figure does not count the additional costs of classroom time that is taken from the students while the teachers are attending TPD. Therefore, assessment and evaluation methods for TPD are also a vital division of research.

New models, technological advances, and an ongoing examination of effectiveness have resulted in a plethora of quite different TPD choices available. Therefore, it is imperative to look to the literature to review the following questions: What has research shown to be the characteristics of effective teacher professional development? What are common practices or models of teacher professional development?

2.3.1 Characteristics of effective TPD

Much attention has been placed on identifying the key characteristics of effective TPD, with foci ranging from teacher satisfaction with the training to empirical results in higher student achievement. Because of this high level of interest, many research studies have been launched in hopes of pinpointing the features that make TPD worthwhile. Yoon et al. (2007) conducted an analysis of 1,300-plus TPD studies conducted in the areas of reading, science, and math. From this large number of studies, only nine met the evidence standards of the U.S. Department of Education's What Works Clearinghouse, an institution dedicated to identifying sound research. However, the information that was garnered by examining the nine studies was powerful: “Control group students would have increased their achievement by 21 percentile points if their teacher had received substantial professional development” (p. i), with substantial professional development meaning about 49 hours of TPD, the average among the nine studies. Other points of similarity among the qualifying studies are that all were conducted in the elementary setting, consisted of workshops or summer institutes, and that the teachers received the TPD directly from the authors or researchers who created the training. Further, in all but one study, follow-up sessions were conducted to support the main TPD event; the study that did not have a follow-up session was an intense four-week summer workshop.

This analysis was groundbreaking for many reasons. Guskey & Yoon (2009) elaborated on these results by suggesting conclusions about a number of heavily discussed subjects in TPD: workshops, outside experts, time, follow-up, activities, and content. Each of these factors has been debated, but, accounting for variations in verbiage, the literature as a whole strongly suggests that each is important. Overall, the studies that focused on the characteristics of effective TPD have all suggested that each of these factors must be well designed for the target audience. The following exploration of each factor will discuss the scholarly consensus and how it points toward future improvements.

2.3.2 Workshops

Workshops have come under much criticism, especially short-term, one-time events. They have been described as merely touting the latest fad in instructional strategies, often leaving teachers with no substantial growth in learning (Ball & Cohen, 1999; Grossman, Wineburg, & Woolworth, 2001). Critics believe such in-service trainings fail to robustly develop teachers' understanding, expertise, or ability to employ cutting-edge practices within their own classrooms (Chai & Tan, 2009). Yet, Guskey & Yoon noted "all of the studies that showed a positive relationship between professional development and improvement in student learning involved workshops or summer institutes" (2009, p. 496). Therefore, the common notion that workshops are ineffective is not proven by empirical evidence. Villegas-Reimers (2003) contends that TPD, regardless of the form, must be "planned systematically to promote growth and development in the profession" (p. 12). Workshops can be used as an effective means of dissemination of knowledge; what is important is *how* they are implemented.

2.3.3 Outside Experts

Outside experts refers to researchers and others who design and implement TPD for teachers. Many popular methods of disseminating TPD do not include outside experts: "train the teacher approach, peer coaching, collaborative problem solving, or other forms of school-based professional learning" (Guskey & Yoon, 2009, p. 496). However, none of the nine studies that qualified for Guskey and Yoon's survey utilized these methods. Cochran-Smith and Lytle warn that teachers should be "skeptical about the claims of educational theorists and researchers that are not warranted empirically" (1999, p. 257). What has been proven to be effective is TPD that is administered directly to the teachers by the researchers or outside experts who developed the TPD, as in the nine exemplary studies. Success might be due to a variety of factors—one obvious reason being that the facilitators of the TPD in these studies spent a large and consistent amount of time with the teachers, engaging in activities to support and guide the integration of new training into the everyday classroom. This relates closely to the essential factors of follow-up and time.

2.3.4 Follow-up and Time

Often, these two factors go hand in hand, since follow-up indicates that more time is needed than the initial TPD event. In a policy brief for the Consortium of Educational Policy, Corcoran (1995) considers the need to "provide for sufficient time and follow-up support for the teacher to master new content and strategies and to integrate them into their practice" as one of the core guiding principles for effective TPD (p. 3). Schifter, Russell, & Bastable (1999) assert that "regular school-year follow up support is an indispensable catalyst of the change process" (p. 30) for teachers, suggesting that they need time to reflect on repeated implementations of the new strategy. Garet, Porter, Desimone, Birman, & Yoon (2001) involve the dimension of "sustained, ongoing professional communication with other teachers who are trying to change their teaching in similar ways" (p. 927). Guskey & Yoon's (2009) nine-study survey "confirmed the vital importance of follow-up," and found that time was "a crucial factor in success" (p. 497). All of the studies involved "structured and sustained follow up after the main professional development activities," for an average of thirty additional hours of TPD after the main event. They note that these hours of ongoing TPD were organized and well-directed, as "doing ineffective things longer does not make them any better" (p. 497). The NSDC (2009) offered similar but more condensed findings after conducting a report for the National Staff Development Council. Of the four principles posited in the report, the first states that professional development should "be intensive, ongoing, and connected to practice" (p. 9). The teacher should be allowed to experiment with the new implementation within his or her classroom, and given adequate time to reflect, modify, and receive more instruction and guidance through continued sessions of TPD. Villegas-Reimers (2003) describes time and follow-up as "a long-term process that includes regular opportunities and experiences" wherein the teacher is allowed to assume the role of a "reflective practitioner" (p. 12).

When it comes to the factor of time, considering *when* to offer training is also important. In 2003, SASS reported that there was a stronger focus on offering TPD to beginning teachers with less than five years of experience, of whom 68 percent were required to participate in a teacher-training program, and 71 percent were guided by a master teacher, (NSDC, 2009). There is an interesting correlation between this fact and a study conducted by Torff & Sessions (2008), which revealed that teachers' attitudes toward professional development were most positive in the first two years, decreasing until the tenth year, and then leveling out past the ten-year mark. Therefore, teacher induction programs seem to be of value to teachers when they are starting out their careers.

2.3.5 Activities

Once you have a program with ample time allotted and adequate follow-ups planned, the next crucial design question is what activities to conduct. Guskey & Yoon's (2009) analysis of the nine exemplary studies "identified no set of common activities or designs linked to effect on student learning outcomes," effectively quieting ongoing debates about "best practices" and instead pointing to the necessity of "careful adaptation of varied practices to specific content, process, and context elements" (Guskey & Yoon, 2009, p. 497). Simply put, as with many concepts in education, there is no “silver bullet” or “one size fits all” method to solving key issues (Davis, 2007). What the literature does speak about are three key aspects of TPD activities: constructivism, collaboration, and coherence.

Traditional TPD utilized direct instruction learning theory, which involves passive learning, but recent literature shows that effective TPD should involve active learning for the teachers. Active learning is more “constructivist than transmission-oriented” (Villegas-Reimers, 2003, p. 13), allowing the opportunity to “explore, question, and debate” (Corcoran, 1995, p. 3), as well as “prompt[ing] teachers to understand and reconsider their own prior understandings and to do the same with their students” (Cochran-Smith & Lytle, 2001, p. 259). This induces teachers to edit and add to their variety of knowledge, whether content or pedagogical, and brings about “teacher growth” (Clarke & Hollingsworth, 2002). A constructivist or active learning philosophy is evident in the nine exemplary studies in the form of workshops that “involved active-learning experiences for participants” (Guskey & Yoon, 2009, p. 496).

Effective TPD activities also involve collaboration of some sort, whether it is collective participation (Garet et al., 2001; Desimone, 2009), a collaborative process (Villegas-Reimers, 2003), or the NSDC’s fourth principle, which is to “build strong working relationships among teachers” (2009, p. 11). Although the structure of most schools entails an individual instructor isolated in a classroom, TPD that involves professional collaboration and promotes productive teamwork mentalities within departments or grade levels has been found to be most effective. The conversation and discourse that follows from a group tackling a similar problem can foster a solidarity among teachers, becoming a "powerful learning tool" (Desimone, 2009), and "reinforcing the sense that, with time, improvement is possible" (Garet et al., 2001). Borko (2004) also supports the notion that "teachers generally welcome the opportunity to discuss ideas and materials related to their work, and conversations in professional development settings are easily fostered" (p. 7).

The last aspect of effective TPD activities is coherence, described by Desimone (2009) as "the extent to which teacher learning is consistent with teachers' knowledge and beliefs" (p. 184), in terms of the constraints within their particular school, district, or state. Teachers are constantly bombarded with guidance on the content and strategy of teaching from multiple sources. When the TPD activities are respectful of the constraints of a school- or district-wide reform, teachers are more apt and willing to participate than when an activity is not plausible within their context. The NSDC based their third principle on this idea of aligning TPD "with school improvement priorities and goals" (2009, p. 11). Villegas-Reimers (2003) posits that effective TPD is contextual, with roots very much based in school reform, and each implementation will be unique to the setting in which it takes place (p. 13). Garet et al. (2001) suggest that coherence can be accomplished in a variety of ways, such as organizing TPD activities around a goal that is emphasized by the governing authority (e.g., raising standardized scores in a specific subject) or around a pedagogical strategy (e.g., problem-based learning) that the school district has asked teachers to use.

2.3.6 Content

The NSDC's (2009) second principle suggests that TPD "focus on student learning and address the teaching of specific curriculum content" (p. 10). The 2003 SASS survey reported that teachers placed priority on the desire to learn further "about the content they teach (23 percent), then classroom management (18 percent), followed by teaching students with special needs (15 percent), and lastly, using technology in the classroom (14 percent)" (p. 6). In the NSDC study, less than half of American teachers reported TPD to be useful (NSDC, 2009). Therefore, the most valuable TPD for teachers will help them acquire the latest knowledge on how to teach specific content and how students will best absorb that content. Borko elaborates on this further by emphasizing the need for teachers to have a "rich and flexible knowledge in the subjects they teach" and understand "how children's ideas about a subject develop" so they can properly guide student thinking (2004, pp. 5 – 6). Guskey emphasizes that the content from the nine exemplary TPD studies "focused on specific subject-related content or pedagogic practices," which "help[ed] teachers better understand both what they teach and how students acquire specific content knowledge and skill" (p. 497).

To summarize, teachers find TPD most effective when:

1. It is provided directly by the researcher or the developer of the TPD.
2. It is disseminated in a manner that allows for a substantial amount of time and includes follow-up sessions after the main event.

3. Activities allow for constructivist learning, facilitated collaboration with other teachers, and coherence with the teacher's existing framework of mandates and goals.
4. The content is specific and relevant, and allows teachers to be reflective practitioners.

2.3.7 Common Models of TPD

There is an overabundance of TPD models. Upon examination, however, they can be sorted into a few main types according to key characteristics. Gable and Burns (2005) suggest that there are three common models of TPD that are most prevalent today: 1) standardized TPD programs, 2) school-centered TPD, and 3) individual or self-directed TPD. Each of these models has its own strengths and limitations, which will be explored in detail. Because of their unique elements, it is imperative that the type of TPD chosen specifically fit the context of the target audience in need.

2.1.1.1 Standardized TPD programs

According to Gaible and Burns (2005), most TPD programs fall in line with the standardized TPD model, which typically involves presenters disseminating their particular instructional strategy or new knowledge to a large group of educators, whether in the context of workshop, conference, or a training session. The impact of this model, when executed correctly, is threefold: 1) to introduce teachers to the latest concepts and procedures and to provide opportunities to meet collaborative peers, 2) to distribute skills and strategies to teachers in a particular area, and 3) to clearly exhibit the pledge of a body (e.g., school district) to pursue a specific policy.

Often, this approach involves the use of the cascade model of scaled delivery, in which training is received by a group of chosen educators who, upon completion of training, return to their schools to conduct the same training for their peers (Hayes, 2000; Gaible & Burns, 2005). Since this method has the potential to reach a large audience in a relatively short amount of time, and utilizes existing teaching staff as trainers—an automatic financial benefit (Gilpin, 1997)—it is widely implemented by organizations seeking to effect large-scale change.

Standardized TPD programs have been criticized as doing little more than touting the latest fad in instructional strategies. A summary of criticisms include: 1) one-time events such as workshops have little or no impact in the long run (Ball & Cohen, 1999; Grossman, Wineburg, & Woolworth, 2001); 2) programs that offer no support or follow-up lack accountability of TPD implementation (Gaible & Burns, 2005); 3) expertise is concentrated at the top rung of the cascade and is diluted as it moves down the tiers (Gilpin, 1997; Hayes, 2000); and (4) standardized training may not be applicable to the unique context of the school in need (Gaible & Burns, 2005).

For standardized TPD programs, specifically the cascade model, to be successful, detailed conditions must be met, according to Hayes (2000): 1) the training must be experiential and reflective, rather than passive; 2) the training must be flexible to contextualization; 3) expert knowledge must be dispersed throughout the levels of the cascade; 4) stakeholders must be assessed while developing the material for training; and 5) there must be an equal distribution of duties within the cascade levels.

2.1.1.2 School-centered TPD programs

The main focus of school-centered TPD is to promote communities of practice (Lave & Wenger, 1991) that aim to employ a new instructional strategy or solve a problem that is specific to the situation. This type of TPD is generally more of a long-term solution, where the emphasis lies on mastery learning as championed by Bloom (1968). The benefits of using school-centered TPD are several, according to Gaible & Burns (2005): 1) it unites a group of people to address local issues for a span of time; 2) it promotes individual inventiveness and joint approaches to problems; 3) it produces training that is more accommodating, continual, and concentrated than other models; and 4) it creates consistent possibilities for professional development among a singular group of educators.

Although school-centered TPD has garnered many accolades, it also brings with it its share of demands. The idea of school-based TPD stems from an industrial model based on the classic work of Coch and French (1948), where factory workers were found to have increased worker satisfaction after participating in changing their work roles. However, as Conway and Calzi (1996) observed, increased worker “satisfaction is not the same as productivity” (p. 45). It must also be noted that teachers and factory workers differ significantly in terms of work environment and responsibilities. Thus, while the model predicts that when educators in each school meet and discuss their specific issues, their resulting collective knowledge and experience will be maximally effective, the reality is not necessarily proven to match the model. It is better to see such collective knowledge as a starting point for effective programs than an end-all (Guskey, 2011; Holloway, 2000).

Time, as always, is a precious and vanishing resource, and arguably the biggest limitation in this model. Since school-centered TPD is structured to occur over a significant period of time, with personnel required to prepare the program, run the training, and provide follow-up, it is quite an expensive endeavor (Gaible & Burns, 2005). Low-resource schools must be paired with facilitators who are trained to aid teachers in such environments, and some schools may be located in remote areas, making it a challenge to send long-term TPD providers (p. 22). However, once a school-centered TPD program has been set in place, new educational innovations, from strategies and tools to administrative practices, can be disseminated in a frugal manner.

School-centered TPD is unique in the sense that it can be utilized as a follow-up or accountability measure added on to standardized TPD programs (Gaible & Burns, p. 22). Once a new instructional strategy has been introduced to a large group of teachers, school-centered TPD can be used to follow-up with the implementation of the innovation, with facilitators to provide support in handling the local issues and complexities that arise.

2.1.1.3 Self-directed TPD programs

Self-directed TPD involves individual teachers creating their own personalized set of professional development goals and taking whatever steps are necessary for the completion of these goals (Gaible & Burns, 2005; Villegas-Reimers, 2003). Because of the individualized nature of this type of TPD, teachers can choose their own preferred methods of learning, whether it is watching video examples, attending workshops, or taking a university extension course. Some teachers seek the advice and wisdom of master teachers in the subject field, or conduct their own observations of classes being taught by their colleagues (Gaible & Burns, 2005). The administrator's role here is to guide, support, and provide objective feedback to nurture growth (Gaible & Burns, 2005; Villegas-Reimers, 2003).

When reviewing this model through the characteristics of effective TPD, it is obvious that the benefits of building relationships with a TPD provider and other colleagues are absent. However, there are strategies to address this lack. For example, Easton (1999) reports on a method that is part of a model created by David Allen and Joseph McDonald: it involves the use of "tuning protocols," where a teacher presents his new idea or strategy garnered from the self-directed TPD and asks a panel of colleagues for constructive feedback.

Because self-directed TPD assumes that the teacher is motivated to pursue their own development as an educator, it holds little benefit for teachers who are beginners and still developing their basic teaching skills and mastery over their content (Gaible & Burns, 2005). This type of TPD is best suited for advanced teachers who are intrinsically motivated to hone and advance their skills, and should be offered as an addition to a standardized or school-centered form of TPD, not as the sole source (Gaible & Burns, 2005).

In choosing a particular model of TPD, one must first observe the constraints of each particular context, whether they have to do with time, resources, meeting goals, policy, teacher attitudes, etc., and then make an informed decision about how to proceed. As stated before, there is no "silver bullet" that will work in every setting, but with a careful analysis of the needs of the target audience and the resources available, an appropriate method can be chosen to suit the unique setting of the TPD.

2.4 Elementary Engineering Teacher Professional Development

The two major current programs for introducing engineering to the elementary setting are *Engineering is Elementary* (EiE) and the INSPIRE Summery Academy. EiE, focused on nurturing literacy in engineering and technology, was created by the Museum of Boston in 2003. Utilized across all fifty states, its curriculum covers twenty elementary science topics with the use of storybooks, lesson plans, duplication masters, student assessments and rubrics, and background information and resources for teachers' reference. EiE is research- and standards-driven, and its findings show positive results: participants who completed five EiE units improved significantly on engineering ($p<0.001$, all scales) and science questions ($p<0.001$, all scales) (Lachapelle, Cunningham, Jocz, Kay, Phadnis, Wertheimer, & Arteaga, 2011). EiE is integrated into the classroom via the use of teacher professional development workshops.

INSPIRE Summer Academies consist of week-long teacher professional development courses focused on deepening teachers' understanding of engineering (Duncan et al., 2011). Utilizing TPD facilitators who are connected to practice as well as research, the Summer Academies take an interdisciplinary approach, integrating hands-on learning, state standards, and a modified version of the EiE curriculum. Recent research has provided evidence that EETPD has “the potential to successfully have impact on students’ knowledge” (Dyehouse, Diefes-Dux, & Capobianco, 2011, p. 14). Teachers who participated in past academies “positively changed their perceptions of design, engineering, and technology” (Yoon, Diefes-Dux, & Strobel, 2013. p.79), and “increased their confidence in teaching science, mathematics, and engineering” (Yoon, Kong, Diefes-Dux, & Strobel, 2013, p. 115).

Overall, programs such as EiE and INSPIRE have demonstrated success by delivering instructional modules and engineering teacher professional development. However, not much is known as to why the disseminated EETPD flourished in one school as opposed to another. The aim of this study is to investigate how and why a district in the south-central United States distinguished itself from among other schools in its adoption of engineering through the perspectives of teachers.

CHAPTER 3. METHODOLOGY

3.1 Introduction

An initial inquiry identified a number of lenses that might be appropriate for this study, such as ethnography, phenomenology, and case study. An examination of the research questions led to selection of the case study method as most fitting for the context. Ethnography, as Wolcott (1992) defines it, describes the "everyday life of persons" or a culture (p. 109), and ethnographical research is primarily based on observations and being in the context of study. The goal of this study, however, is not to observe the everyday experiences of teachers, but to focus on teachers' reflections and insights on a specific experience of EETPD. Phenomenology would limit the inquiry to a pure description of the experience of the EETPD, since it focuses on the "lived experience" of a phenomenon (Patton, 2002). This study does not inquire about teachers' lived experience of EETPD, but rather their insights on specific elements of the EETPD: measures of success, the impact of work climate and relationships with members of administration and community, and reflections on how to improve the program. There is no intent to report on individual participants' experiences—a key tenet of phenomenology.

This study seeks to elicit and examine teachers' perspectives on a specific implementation of EETPD. Yin (2011) explains that case studies are appropriate when the research questions address a descriptive inquiry (e.g., “What is or has happened?”) or an explanatory question (e.g., “How or why did something happen?”) (p. 5). Flyvberg (2011) describes a case study as an intensive analysis of an individual unit stressing developmental factors in relation to context. In short, the case study methodology seeks to answer the “how” or “why” questions. Since EETPD is a program or a process, the goal of soliciting teachers’ in-depth exploration of how and why it is successful justifies the use of case study research methodology. The intent of this study is to understand from the teachers’ perspective how EETPD success is measured, how work climate and relationships impact the implementation of EETPD, and why certain factors are crucial for implementation. To answer these questions, I traveled to the sites of the two school campuses and spent a period of two weeks conducting the focus groups and individual teacher interviews. I chose this method as it was most convenient to the teachers, eased the development of relationships through frequent interaction, and provided for the observation of facial cues and body language while collecting data. Through the collection and analysis of data from multiple sources, this study portrays a range of teacher perspectives. In presenting the participating teachers as embedded units of analysis within a multiple-case study, this study seeks to develop a stronger grasp on the perspective of teachers participating in EETPD. The knowledge gained can inform researchers and future developers of EETPD as they strive to improve their programs.

3.2 Research Design

Merriam (2009) defined a case study as an “intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit" (p. xiii). My research questions include both descriptive and explanatory aspects, as I am investigating how success is measured, how the work climate and relationships with administration affects EETPD, and why teachers perceive certain factors as crucial for the success of EETPD. Denzin & Lincoln (2011) states that a case study involves a constructivist paradigm, which "assumes a relativist ontology (there are multiple realities), a subjectivist epistemology (knower and respondent co-create understandings), and a naturalistic (in the natural world) set of methodological procedures" (p. 13). The probability of multiple realities, then, is very high and essential to create the intensive, holistic description as described by Merriam. Yin (2009) highlights that although case studies are often considered a form of qualitative research as touted by Creswell (2007), evidence of data are not limited to just qualitative evidence, but can include a mixture of quantitative and qualitative evidence. The instruments utilized in this study include both quantitative and qualitative measures, through the quantitative NSDC survey data and the qualitative focus groups and teacher interviews.

I am aware that this design might cause one to wonder why I did not utilize Creswell & Plano-Clark's (2011) mixed method convergent parallel design, as it might seem most fitting. However, because the main weight of the study lies on the qualitative evidence, with the quantitative data serving as frame, I decided my planned analysis of the strands of data would not serve as a strong execution of a convergent parallel design. Because of this, I refrain from perceiving my study as a mixed methods study, as it would not properly do the method justice.

By traveling to the data collection site and conducting the focus groups and individual interviews in their natural setting (visiting the schools and/or workplace), knower and respondent co-create understandings in the descriptive and explanatory EETPD questions. Since the two buildings participating in the study have dissimilar populations of teachers, the use of a multiple case study was appropriate to the research purposes of this dissertation.

3.3 Contexts and participants

As the aim of the study required a specialized population, purposive sampling was utilized, as suggested by Bernard (2002). Purposive sampling, also known as purposeful sampling, is defined as a "type of non-probability sampling that is most effective when one needs to study a certain cultural domain with knowledgeable experts within" (Tongco, 2007, p. 1). Purposive sampling is applied through the maximum variation strategy, which is appropriate for small samples where much heterogeneity is found within the individual cases, as "any common patterns that emerge from great variation are of particular interest and value in capturing the core experiences and central, shared aspects or impacts of a program" (Patton, p. 172). My research purpose required teachers who meet the following criteria: 1) received EETPD through Purdue University's Institute for P-12 Engineering Research and Learning (INSPIRE), 2) have the experience of implementing the EETPD in the classroom, and 3) the desire to continue teaching engineering at the elementary level. Finding such a specialized population that met all of the criteria would have been difficult if it were not for the fact that I ran across such an environment during my graduate research assistantship. The site of this study is a city located in the south-central United States is an area that is primarily industrial, with the population reaching about 26,000. The participants of the study all have a connection to INSPIRE's EETPD. The teachers received EETPD through either attending a weeklong Summer Academy session at the Purdue campus, workshops and seminars through a research partnership with Purdue, or through mentorship with an experienced teacher who had attended INSPIRE sessions. The teachers for this particular study come from School A and School B, the two schools (out of the twelve elementary schools in the district) that participated in the EETPD. In addition, these two elementary schools serve all of the gifted population in the district.

Table 3-1 Structure of multiple case study

Case Study	**School A**	**School B**
Units of Analyses (n=20)	K – 2 Focus Groups (3) Individual Interviews (5)	3 – 5 Focus Groups (3) Individual Interviews (7)
Teachers (n=41)	Kindergarten (3) First (9) Second (8)	Third (8) Fourth (6) Fifth (7)

Due to the unique structure of each building in terms of teacher responsibilities and grade levels (Table 3-1), School A and School B serve as separate case studies. In the two buildings, students belong to the gifted ability group, named PACE, or the average ability group, named PACK. School A houses kindergarten through second grade (K-2) PACE students and first through second grade PACK students. Teachers in School A only teach one ability group, whether it is PACE or PACK, and are self-contained, therefore teaching all subjects throughout the day.

The School B building focuses on grades three through five (3-5) PACE and PACK students, but divides the responsibilities of their teachers differently than the School A building. To begin, all of the teachers are not self-contained, but focus on one or two subjects (e.g. math and science or language arts, social studies, and reading). A team teaching approach is utilized, so that each teacher works with another teacher that covers a different subject area (e.g. a math and science teacher is partnered up with a language arts, social studies, and reading teacher). However, there is a division where the third and fourth grade teachers instruct both ability groups, spending half a day with each population, while the fifth grade teachers teach only one ability group.

An initial demographic survey was administered online to create framing data for the study. From a sample of forty-one (N=41) teachers, thirty-five (35) participated in the online survey: fifteen (15) from School A and twenty (20) from School B. Their descriptive demographics such as age, ethnicity, highest degree earned, total years of teaching experience, grade level currently teaching, and the level of EETPD received are found in Tables 3-2 and 3-3.

Table 3-2 Demographics of School A participants (n = 15)

Demographics	***n***	**%**
*Age**		
21 - 30	1	6
31 - 40	4	27
41 - 50	5	33
51 - 60	4	27
61 – 70	1	6
Ethnicity		
African American	1	7
Caucasian	13	87
Hispanic	1	7
Highest Degree Earned		
Bachelors	10	67
Masters	4	27
Other*	1	7
Total Years Teaching Experience		
01 - 03	0	0
04 - 09	2	13
10 - 14	3	20
15 - 19	3	20
20 - 24	2	13
25 - 29	2	13
30 +	3	20
Grade Level Currently Teaching		
Kindergarten	3	20
First Grade	7	47
Second Grade	5	33
Level of EETPD Received		
INSPIRE Summer Academies (Purdue Campus)	7	47
Workshops with University Researcher (1/2 day or 1 day)	7	47
Working with a mentor teacher/team teaching	1	6
None	0	0

*15 of 20 participants completed the survey
**National Board certified

Table 3-4 Demographics of School B participants (n = 20)

Demographics	***n***	**%**
*Age**		
21 - 30	9	45
31 - 40	2	10
41 - 50	5	25
51 - 60	3	15
61 – 70	1	5
Ethnicity		
Caucasian	19	95
Mixed	1	5
Highest Degree Earned		
Bachelors	15	75
Masters	5	25
Total Years Teaching Experience		
01 - 03	8	40
04 - 09	3	15
10 - 14	2	10
15 - 19	0	0
20 - 24	3	15
25 - 29	2	10
30 +	2	10
Grade Level Currently Teaching		
Third Grade	7	35
Fourth Grade	6	30
Fifth Grade	7	35
Level of EETPD Received		
INSPIRE Summer Academies (Purdue Campus)	4	20
Workshops with University Researcher (1/2 day or 1 day)	9	45
Working with a mentor teacher/team teaching	4	20
None	3	15

*20 of 21participants completed the survey

The focus groups were divided according to grade, resulting in six focus groups, from grades kindergarten to five. For the individual interviews, I approached two teachers from each grade level about participation. To get a range of perspectives from each grade, I selected one teacher who was experienced, meaning having had one year or more of teaching engineering in the classroom, and one who was a novice, with less than one year of experience teaching engineering in the classroom. The reason the most experienced were chosen for individual interviews was that these teachers are most knowledgeable about the process of the EETPD. The reason the novice teachers were chosen was that these teachers give insight into their EETPD experience from a beginner's perspective. Choosing two teachers, one novice and one experienced with EETPD from each grade level, is in alignment with the maximum variation strategy, which Patton (1990) asserts results in "high-quality, detailed descriptions of each case, which are useful for documenting uniqueness, and important shared patterns that cut across cases and derive their significance from having emerged out of heterogeneity" (p. 172). However, upon my arrival to the campus, I came to realize that there had been quite a lot of turnover, and that my original scheme would need to be altered. Since the kindergarten PACE teachers were all novices, I was only able to interview one teacher from the group. This left me desiring an additional teacher to interview in order to satisfy the minimum sample size required. I therefore then chose to interview an additional math and science third grade teacher, as her perspective as a novice math and science teacher would be useful to compare with the other experienced math and science third grade teacher. As a result, twelve individual interviews in total were garnered from the sample of participating teachers, five from School A and seven from School B. These units of analyses were used to produce rich case descriptions for School A and School B.

3.4 Case Descriptions

Of the twelve primary and elementary schools in the district, School A and School B are marketed as magnet schools with an emphasis on STEM subjects. Engineering in the elementary setting plays a role in attracting parents to these schools, and the administration of both schools advertise this heavily. Although they are located in an area described as “the projects”, School A and B are distinct from the rest of the district because these campuses house all of the gifted and talented students in the district, referred to as PACE students. The local population of average ability students is referred to as PACK students, and the differences between the groups are stark and must be noted, as the teachers’ perspectives are heavily related to the population of students they are teaching.

3.4.1 Student Populations

It is important to note the difference in student populations to understand the context of this study. PACE students are recruited from the whole district, not just the surrounding neighborhoods. In addition, students who meet the requirements for the gifted and talented program from surrounding districts are also accepted. Although the majority of the students are Caucasian with a few Hispanic and African American students, teachers mentioned countries such as India, Vietnam, and Puerto Rico (Paula, Candace). Parents of PACE students tend to be “helicopter parents” (Kacey), which are described as “extremely well educated” (Candace) and “want their child to succeed, and they are very competitive” (Patricia). Because PACE students must pass several exams, including an “IQ test, creativity test, teacher check list, parent recommendation, and teacher recommendation from prior schools” (Erin), “it is a choice to be on our campus and in our program. You often see way more parental involvement, because they’ve chosen this… they are fully supporting it because it was their decision in the first place” (Peggy).

PACE parents "just really truly want to be involved with their kids' school and make sure that they know everything that is going on", and tend to give their children greater "exposure to things", through "family trips and having parents with higher educations, that they get so much more basic skill at home" (Peggy). Academically, PACE students "can take it to a deeper level" (Daisy), desire "choices" (Paula), are able to "grasp vocabulary" (Sabrina), and "are problem solvers" (Daisy). In addition, PACE students are less likely to be unruly, allowing teachers to "get our projects completed. We can go back and we can talk about it because of the lack of inappropriate discipline" (Paula). Teachers' challenges with the PACE students mostly revolve around "making school interesting without boring them to death and the pressure of the standardized test" (Candace).

PACK students, on the other hand, seem to exist on the other end of the spectrum, where most come from a "very low socio-economic group" (Sabrina) with "working parents – have-to-work parents" (Madeline). Most PACK students are Hispanic or African American. A high percentage of the PACK population is on "free or reduced lunch" and is becoming a "very fast growing ESL population" (Kacey). Teachers expressed worrying about their students' health, as some of them "only get to eat when they come to school here" (Mackenzie). PACK students tend to "lack a lot of experiences" (Sabrina), such as "knowledge about common things… even just having a normal family conversation" (Paige). The parents of PACK students seem to be "not involved at all" (Mackenzie) in their child's academic life, which leaves the PACK teachers feeling like "we are basically on our own. There is very little involvement." (Paige). Due to the lack of prior knowledge and support from home, the major challenge that teachers face with the high-risk PACK students is "getting everyone caught up" (Madeline), with a typical class consisting of "a third of your class not passing math, other third not passing reading" (Amber), or "fifth graders that are on a first-grade reading level" (Mackenzie).

The difference between the two populations of students is distinct, ranging from socio-economic status, parental involvement, and a "huge prior knowledge difference" in life experiences (Peggy). Since the populations are quite different, teachers also have distinctive needs. Teachers struggle to keep their PACE students engaged, while others are left with the challenge to bring their PACK students up to standards.

3.4.2 Partnership with university researcher

The university researcher's partnership with School A and B played a significant role in building up the teachers' knowledge of engineering. After the first summer cohort of PACE teachers attended the INSPIRE Academy in 2009, the university researcher was encouraged by the teachers in the cohort to speak with the superintendent of the district. After a phone conversation in September of 2009, the superintendent was very supportive of engineering and requested additional professional development for the teachers in the district. The university researcher scheduled a two day workshop in December, where all teachers from both campuses were invited, along with the coordinator of the local zoo, and engineers in the area who wanted to participate. The first day was a compressed version of the academy, going over basics of engineering, drivers for K-12 engineering, how it benefits the students, and activities such as paper tables and pop-up cards. The second day was focused on engineering design and science inquiry, which was modeled by talking through an EiE. The MEA sticker activity was also discussed, and the rest of the time was spent planning engineering activities with the teachers.

The university researcher returned in May 2010 and collected information on possible engineering activities that could take place in the future. The researcher also met with local engineers Brady and Steve to discuss greater participation with engineering events. Because of the university researcher's partnership with these schools, a second cohort of PACE teachers came to Purdue and attended the INSPIRE Summer Academy in 2010, further strengthening the engineering program in these schools.

After the Summer Academy, the university researcher was recruited by the superintendent as an EETPD facilitator for the following school year. The funding for this endeavor did not appear to be limited for the 2010 – 2011 school year. The researcher came to visit the schools for a week at a time in September, October, November, and December of 2010, and January, February, and April the following year. During these visits, the university researcher met with both individuals and groups of teachers to collaborate on engineering projects, participate in the engineering club, and foster connections with the local zoo coordinator and the engineers interested in outreach. Beginning in April 2011 and beyond, PACK teachers began to get involved in engineering, as the principals of the schools felt that it was valuable for all students.

In August 2011, the university researcher held a day long workshop to introduce engineering to the PACK teachers. There is no record of attendance for the meeting, but it is noted that it was open to all PACK teachers. It is around this time that a concentrated effort was pointed towards preparing the PACK teachers to integrate engineering into their curriculum. The university researcher fully trained the 4th grade PACK teachers, but at the time of this study, the trained teachers had already left the school.

In May 2012, the university researcher and the author of this study visited the campuses to reflect with teachers over the engineering activities of the past year. Some time was also spent planning for the upcoming year. In October 2012, the author of this study visited the schools to collect data and also facilitate EETPD activities. For detailed descriptions of activities, please refer to Table 4-2. Only teachers who were currently working at the time of the study are included.

Table 4-2 Timeline of EETPD Activities at School A & B

Year	Participants	PD Activities
Summer 2009	Kyra, Jasmine, Candace, Peggy, Ava	Full Summer Academy
September 2009		Spoke with Superintendent, was asked to spend more time training teachers
December 2009	All teachers from both campuses, Zoo, engineers (Brody)	1st day - Compressed academy with technology, what students should learn, paper tables, drivers for engineering in k-12, pop-up cards. 2nd day – engineering design and science inquiry (talked through an EIE), MEA sticker activity, planning hours
May 2010	1st, 2nd, 4th & 5th Grade PACE teachers	Gathered information about engineering activities that could be taking place. Grades 1, 2, and 5 completed MEA's. Meeting with Brody and Steven
Summer 2010	April, Camila, Stephanie, Sarah, Paula, Jane	Full Summer Academy
September 2010	1st, 2nd, 4th & 5th Grade PACE teachers (Ava, Camila, Kyra, Jasmine, Kristin, Candace, Charlotte, Peggy, Brenda), Zoo Coordinator	Cleaning pennies activity (chemical engineering), planning for Zoo collaboration, Chair for Mother activity, "What is Technology?" connections
October 2010	1st – 5th Grade PACE teachers (Ava, Camila, Kyra, Jasmine, Kristin, Sarah, Stephanie, Paula, Sabrina, Charlotte, Desiree, Peggy, Candace)	Amazon unit (gorilla), results from research, Frank Lloyd Wright designs, Fiddle Stix chair, engineering club, student dynamics, client and constraint vocabulary, Jack O'Lantern design, paper table prep, Columbus Day Boat
November 2010	1st – 5th Grade PACE teachers (Sarah, Jane, Kyra, Ava, Jasmine, Kristin, Camila, Sabrina, Stephanie, Charlotte, Desiree), Zoo Coordinator	Gorilla exhibit design (working with the Zoo), EiE Plant package design, EiE Alarm circuit design, volcano build project, Geobot design, building up teamwork with the students, planning MEA for next year
January 2011	1st – 5th Grade PACE teachers (Candace, Stephanie, Sabrina, Charlotte, Desiree, Sarah, Jane, Camila, Ava, Kyra, Paula, Jasmine, Kristin)	Windmill blade system design, Potato chip delivery MEA, Pop-up cards, Geobots, Styrofoam cup chairs, debriefings of engineering activities, EiE Bridges unit, EiE electricity unit, Meeting with Brody (engineer)

Table 3-2 Timeline of EETPD Activities at School A & B (continued)

Year	Participants	PD Activities
February 2011	1st – 5th Grade PACE teachers (Jane, Sarah, Camila, Kyra, Ava, Jasmine, Paula, Kristin, Sabrina, Charlotte, Candace)	Gearing up for engineering week, geodesic dome design, water filters, pop-up cards, assembly line, Golfin' Green design activity
April 2011	K – 5th Grade PACE teachers, 1st & 2nd PACK teachers (Allison, Erin, Patricia, Chloe, Hannah, Lauren, Madeline, Violet, Amber, Jennifer, Paige, Stacy, Candace, Peggy, Ava, Jane, Camila, Kyra, Sarah)	Intro to engineering, What is Technology, What is Engineering, Tower Power, EiE Best of Bugs, EiE Bridges, EiE Solar Ovens
August 2011	PACK teachers who are new to engineering (no record of attendance)	Intro to engineering, science notebooks, rudimentary activities, bat puzzle, windsock
May 2012	All School A & B teachers	Meeting with teachers to plan for the upcoming year, reflect on what went well and what needed improvement
October 2012	All School A & B teachers	What is technology with quick activities (compare/contrast, maps of students' homes, assembly lines, integrating city history), basics of engineering design process. School B – full day planning for the year with engineers.

3.4.3 School A

Upon arrival to campus, the atmosphere at School A is very light and energetic, and teachers and staff are very friendly and helpful. School A campus is home to first and second grade PACE and PACK students, in addition to PACE kindergarten students. School A has been under the headship of the principal, Dana, for the last nine years, and appears to be content with its leadership. The campus employs twenty teachers who teach self-contained classes, as shown in Table 4-1. Not all of the teachers have a classroom, with a few teachers working out of trailers; so it seems that the campus has outgrown its

Table 3-1 Structure of participants at School A (n=20)

Grade	Ability	Pseudonyms
Kindergarten	PACE (3)	Allison, Erin, Patricia
First	PACE (4)	Ava, Camila, Jane, Kyra
	PACK (5)	Chloe, Hannah, Lauren, Madeline, Violet
Second	PACE (4)	Jasmine, Kristin, Paula, Sarah
	PACK (4)	Amber, Jennifer, Paige, Stacy

building. In general, the campus has quite a bit of experience (Figure 4-1), with half of the staff boasting over twenty years of teaching experience. Additionally, four teachers have earned a Master's degree, and one is National Board Certified, a prestigious and difficult certification to attain. Class sizes at School A average around 19 students per class, and teachers have access to one instructional specialist.

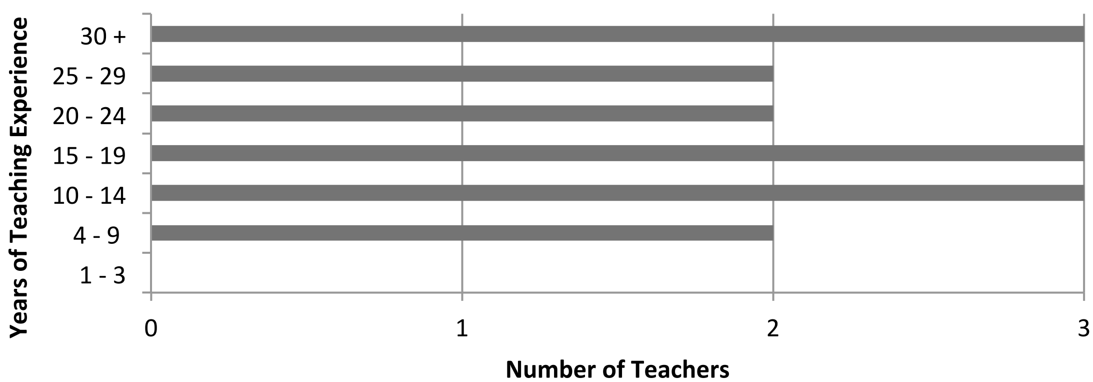

Figure 3-1 School A: Total Number of Years Teaching Experience (n=15)

Teachers at School A had seven teachers who attended Purdue's INSPIRE training, with seven teachers having attended workshops with the EETPD researcher, and three working with mentors. There were no teachers that reported having no EETPD at all (Figure 4-2).

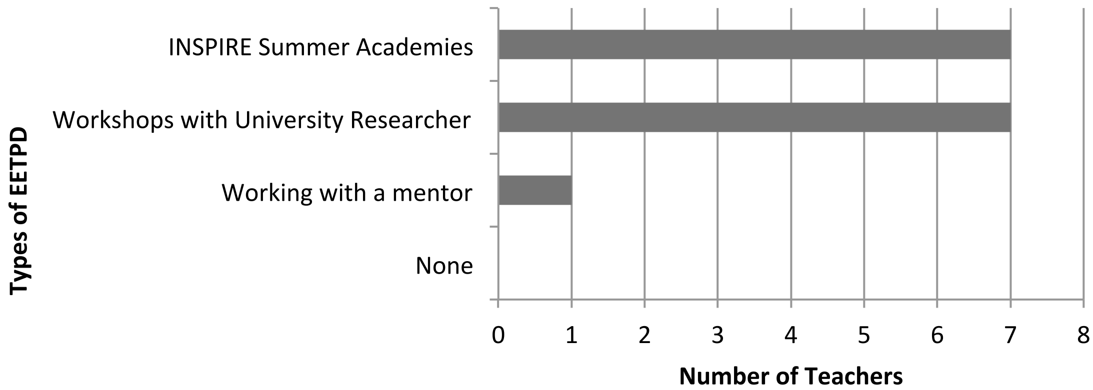

Figure 4-3-2 School A: Participation in EETPD activities (n=15)

The seven teachers who had attended INSPIRE have been participating in EETPD for 2 – 3 years, while four had some experience, and the remaining four felt that this year was their inaugural year in implementing engineering in their classrooms (Figure 4-3).

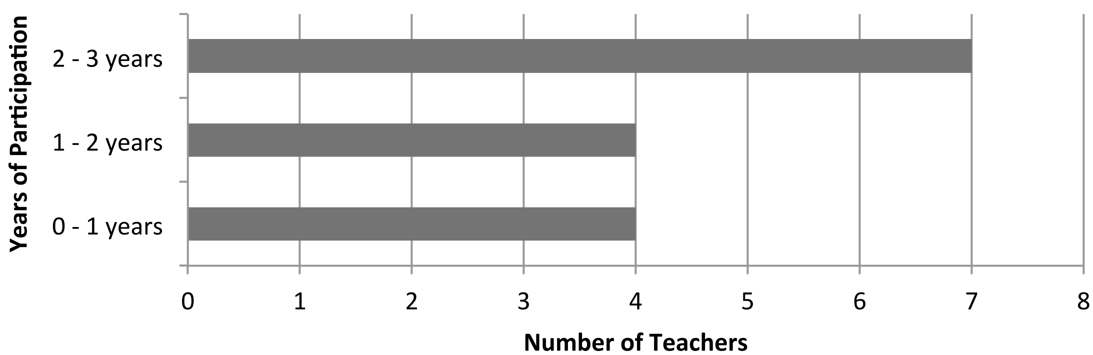

Figure 3-3 School A: Years of participation in INSPIRE's EETPD Program (n=15)

Overall, the environment at School A seemed to be positive, with no additional factors to consider outside of the study. The principal had been there for some time, the teachers were experienced with no turnover, and those who attended INSPIRE were actively implementing engineering.

3.4.4 School B

School B's initial impression on arrival to campus was one that consisted of a bit of disorganization, although the teachers and staff were welcoming. The building seems larger and branches into clusters of grades tucked into corners of the school. School B focuses on grades three through five (3-5) PACE and PACK students, but the students are structured in a unique manner. First, the teachers focus on one to three subjects (e.g. math, science, language arts, social studies, and reading) and practice the team teaching

Table 3-2 Structure of teachers at School B (n=21)

Grade	Ability/Subject	Pseudonyms
Third	PACE & PACK M/S (3)	Desiree, Kacey, Sabrina, Stephanie
	PACE & PACK LA/R/SS (4)	Daisy, Jocelyn, Kate, Marie
Fourth	PACE & PACK M/S (3)	Andrea, Emily, Kaila
	PACE & PACK LA/R/SS (2)	Brooklyn, Peggy
	PACE & PACK LA/SS (1)	Michelle
Fifth	PACE M (1)	Charlotte
	PACE LA/R (1)	Candace
	PACE S/SS (1)	Brenda
	PACK M/S (2)	Mackenzie, Megan
	PACK LA/R/SS (2)	Kim, Pearl

Legend: M=Math, LA=Language Arts, S=Science, SS=Social Studies, R=Reading

approach. Each teacher is part of a team in the grade level, and work together with their partners to cover the curriculum and plan activities. Second, third and fourth grade teachers spend half of the day teaching PACE students, and the other half teaching PACK students, which is referred to as "the split" by the teachers. Fifth grade teachers teach one ability group (Table 4-2). This "split" has only been in place for about two years, and beforehand, teachers only taught one ability group for the academic year.

School B has been under the guidance of principal Kitty, who has been on this campus for about five years. Teachers reported that before Kitty's arrival, School B had gone through numerous principals, who often did not stay longer than a few years, and this instability greatly affected the climate of the school. Kitty's years as principal were also not without hardships; the split of teaching PACE and PACK was implemented by Kitty as a way to break down the division between PACE and PACK teachers. The split was not well received by the teachers. For this reason, School B experienced a high rate of turnover in the past few years, with approximately forty percent of their teaching staff consisting of first or second year teachers (Figure 4-4).

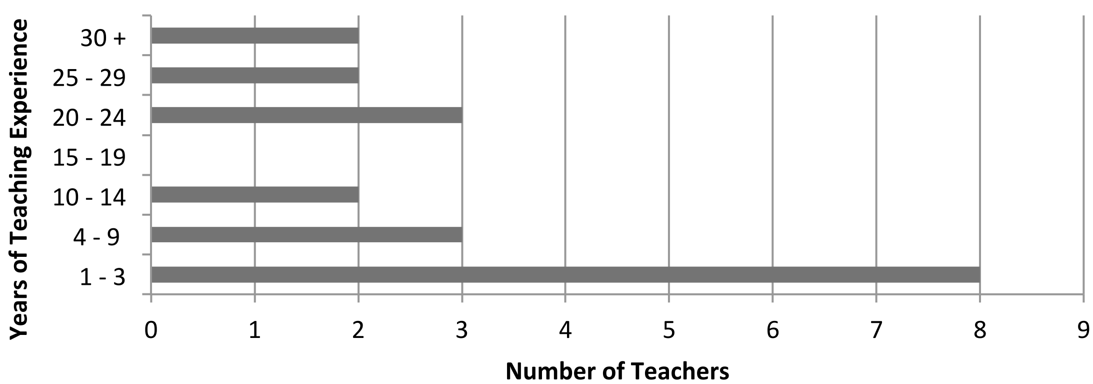

Figure 3-4 School B: Total number of Years Teaching Experience (n=20)

Not surprisingly, the turnover affected the number of teachers who have participated in EETPD. Only five teachers remain on campus that attended an INSPIRE Academy, and one of the five was promoted to assistant principal last year, so does not actively practice EETPD. Most of the campus has trained with the EETPD researcher, while four teachers worked with a mentor, and three teachers reported having no EETPD training at all at the administration of the survey (see Figure 4-5).

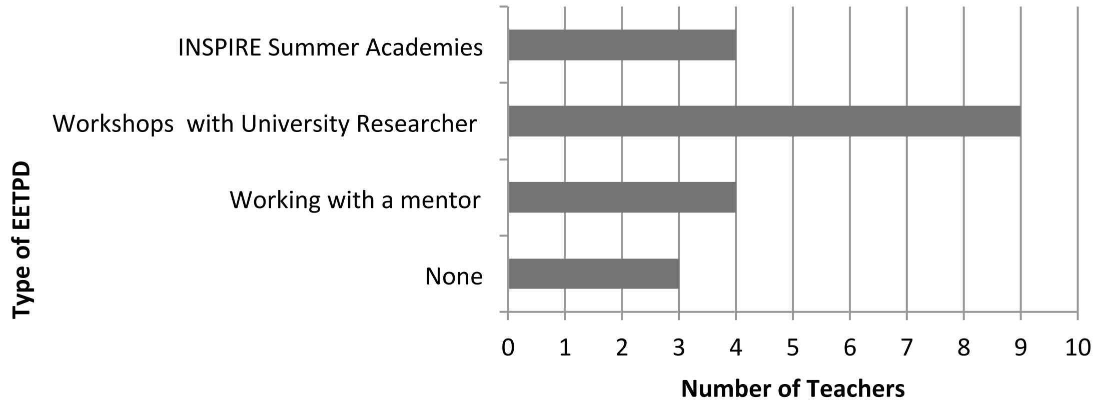

Figure 3-5 School B: Participation in EETPD Activities (n=20)

Due to turnover, the four teachers that attended INSPIRE had participated in engineering for the past few years. Four teachers reported having some experience, while twelve reported beginning their first year in implementing engineering (see Figure 4-6).

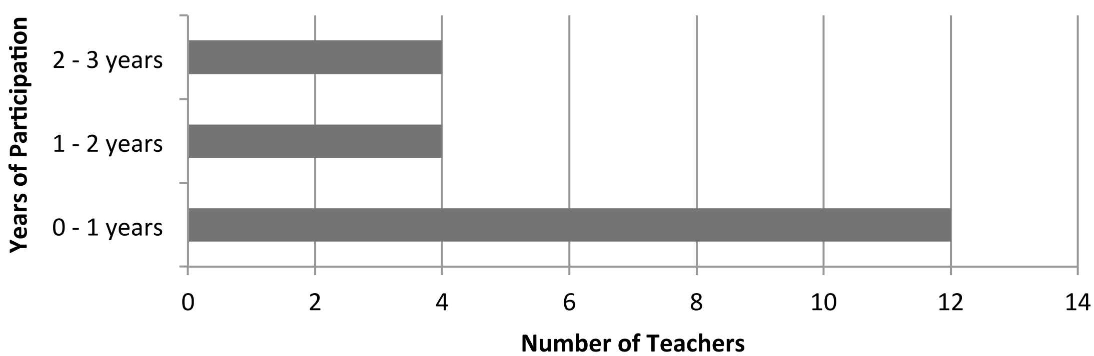

Figure 3-6 School B: Years of participation in INSPIRE's EETPD Program (n=20)

As a result, School B's environment struck as a bit more tense than usual. School B has endured a lot of changes in principals over the years, with Kitty being one that has been on campus fairly long compared to other principles in the past. In addition, a fair number of teachers have left the campus in the last two years, bringing in a large influx of first and second year teachers who have yet to implement EETPD.

3.5 Instruments

To answer my research questions, I gathered three types of data: survey data, focus group interviews, and individual teacher interviews (Patton, 2002). Following are detailed descriptions of each instrument utilized in the study.

3.5.1 NSDC PD Survey

Teachers participating in this study completed a modified version of the NSDC's Professional Development Survey instrument (Lowden, 2005; see Appendix). This survey consisted of two sections. Section one (1) focused on the professional development process, format, and content. Modifications for this study consisted of including basic demographic questions about gender, age, and ethnicity, as well as clarifying which questions apply to the INSPIRE EETPD specifically rather than teacher professional development in general.

Section Two (2) of the NDSC survey instrument is informed by the five critical levels of evaluating professional development developed and the Model of Teacher Change (Guskey, 2002). Guskey posits that there are five critical levels of information that must be analyzed to understand the true impact of effective teacher professional development. Evaluation should begin with 1) the *participants' reactions* (e.g., Did they like it? Was it worth their time?) and continue by interrogating 2) *participants' learning* (e.g., Did they gain the intended skills and knowledge?). The focus then shifts to 3) *organization, support, and change* (e.g., Did teachers receive support and resources? Was the organization impacted?). Finally, evaluators need to look at participants' use of 4) *new knowledge and skills* (e.g., Did participants effectively apply the new skills and knowledge?), and the resulting 5) *student learning outcomes* (e.g., How were the students impacted? Did it influence students' physical or emotional well-being?). If all five critical levels of evaluation show positive change, then according to the Model of Teacher Change, the result should be a change in *teachers' attitudes and beliefs*. The theory says that the point when student learning outcomes change as a result of teachers' classroom practices is the pivotal moment when a teacher begins to invest or lose interest (Guskey, 2002). Therefore, questions on the NSDC survey instrument focus on six categories, the five critical levels of information plus the desired outcome: 1) participant reactions/satisfaction, 2) participant learning, 3) organizational support and change, 4) participants' implementation of new knowledge and skills, 5) participants' perceptions of student achievement, and 6) change in participants' attitudes and beliefs. Questions are formatted along a five-point Likert scale: Strongly Agree (5), Agree (4), No Opinion (3), Disagree (2), and Strongly Disagree (1). Content and face validity were validated by a jury of experts in the field of education and professional development (Lowden, 2005).

The NSDC survey instrument is designed for formative evaluation of TPD and allows for teachers to share their perceptions of the teacher professional development they have received. The purpose of using this instrument in this study was to begin to answer the descriptive research questions, those concerning how the EETPD under study was initiated and sustained. Descriptive statistics consisting of means, standard deviations, and frequencies provided means of identifying patterns in the responses. The data from the variables of the NDSC survey instrument inform us in two ways: 1) by recording basic demographic data on the participants, and 2) by letting participants evaluate the EETPD they received. The results were utilized for the descriptive demographics as well as the focus groups and participants in the individual interviews.

3.5.2 Focus Groups Protocol

Focus groups allow for guided discussion and in-depth information gathering with a homogenous group of six to thirteen participants in a short amount of time (Krueger & Casey, 2009). Focus groups can be characterized as: “1) People, who 2) possess certain characteristics and 3) provide qualitative data 4) in a focused discussion 5) to help understand the topic of interest.” (p. 6). Not only is the use of focus groups appropriate for this study’s aim of understanding, from the teachers’ perspective, what is necessary for a successful implementation of EETPD, the focus groups also nurtured an environment conducive for a more holistic inquiry. Focus groups “bring out aspects of the topic that would not have been anticipated by the researcher and would not have emerged from interviews with individuals” (Babbie, 2001, p. 294). Lastly, the observations from the focus groups were taken into consideration when selecting participants for individual interviews, and provided additional material to address in those interviews, benefits highlighted by Bogdan and Biklen (1998). The six (6) focus groups utilized in this study were determined by grade level. Sessions were scheduled to last around sixty minutes. The composition of the focus groups is outlined in Table 3-3.

Table 3-3 Grade Level Currently Teaching

Grade	***n***	**%**
Kindergarten	3	7.3
First	9	22.0
Second	7	17.1
Third	9	22.0
Fourth e	6	14.6
Fifth	7	17.1
Total	**41**	**100**

The Focus Group Interview Protocol (see Appendix E) was utilized in each session. The first set of open-ended questions focused on defining EETPD success from the perspective of teachers. The protocol was informed by a report from the American Institute of Research (Coggshall & Ott, 2010), which explores teachers' conflicting ideas of measuring effectiveness or success, stating "how to precisely define and measure teacher effectiveness or success in the classroom is still under considerable debate" (p. 1). I further reviewed the literature to find that it is a complex topic that can be defined in various means. Success is determined in ways that vary according to context, literature, and practice (King, 2002). Ways of measuring success include changes in student achievement or improved teacher knowledge or pedagogy (NSDC, 2009, Desimone, 2009, Guskey 2002). In addition, we must consider that studies conducted with quantitative methods may miss some of the finer details that case study research could explore. An illustration of finer details is the information that was gathered through qualitative research of self-directed TPD, when teachers individually pursue TPD on their own volition (Van Eekelen, Vermunt, & Boshuizen, 2006). Results from a study by

Mushayikwa and Lubben (2009) identified seven factors that drive teachers to pursue professional development: 1) perceived professional identity, 2) career development needs, 3) theoretical and content knowledge, 4) practical knowledge and professional skills, 5) pedagogical content knowledge, 6) professional networking, and 7) benefits to teachers and students (p. 379). In a similar fashion, I sought to record how teachers in my study define success. Accordingly, questions on defining success were written in broad terms so that the teachers could give insight on what they deem to be success instead of responding to my own definitions.

The second set of questions was designed to gather descriptive data about the environment in which the teachers operate. Research shows that the culture of an organization can promote teacher satisfaction with TPD if it nurtures the perspectives and considerations of individuals (Nir & Bogler, 2008). Nir and Bogler composed questions about relationships with the administration and the community members, and how they were initiated and sustained. They found that teachers' satisfaction levels rose when administration catered to the needs of the teachers rather than higher-level bureaucrats. My second set of focus group questions were based on this approach.

The last set of questions is in alignment with the NSDC literature, probing what teachers think about each of the four characteristics of effective TPD named by the NSDC. These questions left room for participants to give additional feedback about EETPD improvement and to bring up any crucial factors that had not yet been mentioned in the focus group. After the conclusion of each focus group, I wrote down my observations and thoughts about the session in my research journal to preserve a fresh perspective on each focus group.

3.5.3 Individual Teacher Interviews

While conducting the grade level focus groups, it quickly became apparent that participants had varying perspectives, some of which were not discussed explicitly but could be discerned based on facial expressions and body language. Therefore, the questions for the individual interviews were developed based on the focus groups and observations that were noted in my research journal. The interviews aimed to understand each individual teacher's perspective on her experience with EETPD. To begin, the participant was asked about the joys of teaching, to help ease her into the interview and to gauge what motivated her to pursue teaching as a career, followed by questions about the unique burdens and challenges of teaching, to further paint a picture of the participant's current teaching experience. Next, I inquired about the population of students that the participant teaches, as the focus groups revealed that the population of students played a large role in the participant's perspective on EETPD. I then inquired about their level of EETPD, not only to gain data points, but also to get a sense of their attitude toward engineering in the classroom. The next question probed what factors are necessary for the participant to effectively integrate engineering into their teaching. The focus groups had already shown that participants had varying needs depending on their EETPD experience, and I wanted to understand what each participant felt was most important to her individually.

3.6 Data collection

Following the approval of the research proposal, an application was submitted to the university's IRB office. Authorization from the district and the individual schools' principals was required and received. After the final revision, IRB exemption was granted on October 12, 2012. On October 14, 2012, I arrived at the site of the study, and visited the campuses of School A and School B on October 15 and 16, 2012, respectively. I began with an initial meeting with the principals to confirm the focus group schedules and the timeframes for when teachers would be available for individual interviews.

Prior to my arrival, after the IRB exemption was received, I emailed the NSDC Survey to principals for dissemination. I sent email reminders about the NSDC Survey on October 15 and October 24, 2012. Each email consisted of a link to the Qualtrics survey and clear instructions as to how to complete it. Of the forty-one teachers solicited, thirty-five completed a modified version of the NSDC Professional Development Survey, which took approximately fifteen to twenty minutes to complete based on access times.

Table 3-4 Schedules of Focus Group Interviews

Grade	Date	Time	Location
Kindergarten	10/17/2012	8:30am	Science Lab
First	10/16/2012	3:20pm	Science Lab
Second	10/15/2012	3:20pm	Grade 2 Room
Third	10/24/2012	3:00pm	Resource Room
Fourth	10/22/2012	3:00pm	Resource Room
Fifth	10/18/2012	3:00pm	Resource Room

The School A focus groups took place in the following order (see table 3-4): The second grade focus group occurred on October 15, 2012, at 3:20 pm in a second grade teacher's room. The first grade focus group occurred on October 16, 2012, at 3:20 pm in the science lab. The kindergarten focus group occurred on October 17, 2012, at 8:30 am in the science lab. The School B focus groups took place in the following order: The fifth grade focus group occurred on October 18, 2012, the fourth grade focus group on October 22nd, and the third grade focus group on October 24th, 2012, all at 3:00 pm in the resource room.

At the beginning of each focus group interview, teachers were provided with an explanation of the study's purpose and procedures. Teachers were made aware that participation was voluntary, and, if they chose to participate, signed a consent form. The focus groups were conducted with the use of the Focus Group Interview Protocol, and additional questioning or probing was conducted for clarification purposes (see Appendix E). The interviews were recorded using a digital voice recorder, and, to ensure accurate transcription, each participant was asked to identify him or herself at the beginning of each interview.

Individual teacher interviews were scheduled during the teacher's prep period or after school, depending on the schedule of the teacher. To obtain consent and participation, individual interviewees followed the same procedure described previously for the focus groups. All interviews were transcribed and stored in the researcher's laptop, along with an identifier list. Data using pseudonyms and IDs was stored on the researcher's laptop during the analysis phase. These pseudonyms, ID numbers, research journals, focus group and individual interview transcripts were then uploaded to Dedoose (SocioCultural

Research Consultants, LLC., Redondo Beach, CA), a mixed methods research software, for analysis.

3.7 Methods of data analysis

3.7.1 Interview Analyses.

Best practices for analysis of case studies are not as well defined as in other methods, making this the most difficult aspect of using case studies (Yin, 2009). The focus group and individual teacher interviews serve as units of analysis in this study. Since the case study is descriptive and explanatory in nature, the analytic strategies used rely on theoretical propositions and the development of a case descriptions. Yin advises utilizing a theoretical orientation to guide analysis. For this study, the four characteristics of effective TPD serve this function, and addresses the explanatory questions of which factors are crucial for success. However, Glaser and Strauss (1967) warn not to let theoretical propositions deter the emergence of new categories. Since one of my research objectives is to explore any factors that have not previously been addressed in the literature, I began my analysis by utilizing open coding, so that I could remain open to themes other than the four characteristics (see Figure 3-2). Eisner calls such themes "recurring messages construed from the events observed" (1991, p. 189). Throughout this time, I had many hypotheses running through my mind that needed to be set aside in order to maintain focus on the actual utterances of my research participants. Before breaking up the passages, I read the transcripts and listened to the audio files several times, making notations or comments in the passages, consistently with the requirements of both open and axial coding (Strauss & Corbin, 1990) and inductive and deductive coding (Fereday & Muir-Cochrane, 2006). Using the Dedoose research software, the first round consisted of open coding all of the transcripts, which resulted in a loosely grouped long list of codes. I placed all of these codes on a concept map using the MindNode software, which allowed me to have a visual representation of the connections and themes that were emerging. With this tool, I then proceeded with axial coding, and sorted the codes into categories that focused on answering the research questions, or priori codes, and then utilized this refined code set to complete my second round of coding. After the second round of coding, I reviewed the codes that were added, collapsed codes that were too similar, and created sub-codes for codes that were too broad. With this coding scheme, I conducted my third and final round of coding. Afterwards, I constructed assertions that came from my findings, reviewed the assertions in the context of each unit of analysis, and developed a discussion of each assertion based on the existing literature.

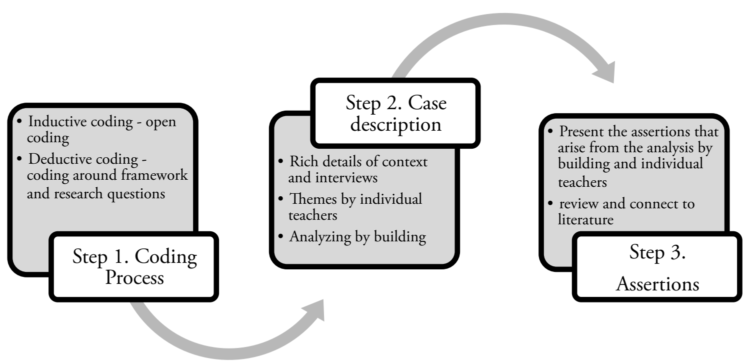

Figure 3-7 Interview Data Analysis

3.8 Role of the Researcher

The role of the researcher in this study necessitates the identification of personal values, assumptions, and biases at the outset of the study (Moustakas, 1994). My own past involves experience as a teacher, including teaching English at the secondary level for about two years. In addition, the present study is not my first encounter with the topic of EETPD. I served as a graduate research assistant in developing professional development modules, and have conducted related research by interviewing teachers implementing engineering in the elementary setting at other participating schools in a different school district. I also consulted with faculty in co-constructing online courses, trying to grow the population of teachers who are comfortable using online learning tools for TPD. I believe that the sum of my experiences enhances my awareness, knowledge, and sensitivity to the issues addressed in this study and in working with the key participants. Although every effort was made toward neutrality, my personal bias may shape the way I understand and interpret the data collected (Denzin, 1989, Mehra, 2002). Efforts to reduce bias included recognizing the need to be open to the thoughts and opinions of others, and to set aside my experiences to understand those of the participants in the study. To keep an open mind, I utilized a research journal to stay transparent and conscious of "my history, values, and assumptions" (Ortlipp, 2008, p. 698). This research journal served as the space where I voiced my "subjective I's," a technique derived from Peshkin (1988), with the aim of checking myself so "I can create an illuminating, empowering personal statement that attunes me to where self and subject are intertwined" (p. 20). In a similar vein, Hall & Callery (2001) also address the necessity of incorporating reflexivity and relationality throughout the data collection and analysis. Since the researcher serves as the main instrument in qualitative research, the researcher helps to construct the data set through interacting with the subjects. Examples include steering the conversation toward a topic both hold in common (e.g., researcher realizes that the conversation has centered around nursing, due to shared nursing background, and makes a conscious effort to explore neglected areas), and noting how a participant responds to a question (e.g., the researcher explores feelings about work, and the participant moves quickly into family life). This kind of relational approach to the research, which involves reciprocity and equity, helps to "develop trust and demonstrate caring" (p. 268). As a result, relationality increases the rigor of the research process by helping participants become more transparent and willing to share (e.g., the researcher often used empathy, affirmation, and self-disclosure to create a "common" ground). The practice of reflexivity attends to these effects of researcher–participant relationality on the construction of data. To this end, I noted in my journal: 1) the presence of any subjective I's, 2) evidence of reflexivity, and 3) efforts toward relationality made in conducting each interview.

3.9 Trustworthiness

Lincoln and Guba (1985) state that establishing the trustworthiness of research involves providing evidence that the following constructs are present:

- credibility—confidence in the truth of the findings
- transferability—showing that the findings have applicability in other contexts
- dependability—showing that the findings are consistent and could be repeated
- confirmability—a degree of neutrality, or the extent to which the findings of a study are shaped by the respondents and not by researcher bias, motivation, or interest (p. 300).

The following paragraphs describe the measures taken in this study to provide evidence of each construct of trustworthiness.

Techniques to establish *credibility* consist of member checks and the triangulation of the survey instrument, focus group interviews, and individual interviews. Member checking consists of allowing participants to review the transcription of the interview and correct any errors in interpretation (Creswell, 1998). Triangulation of data consisted of comparing the three data sets: the survey data, interviews from the focus groups, and interviews from individuals (see Figure 3-3). Through the triangulation of sources, I can determine the consistency of the data sources (Angen, 2000). This allows for a comprehensive descriptive and explanatory understanding of the EETPD that occurred.

Transferability in research is dependent on the richness and detail of the case study. These qualities, also known as thick description (Holloway, 1997), allow one to draw explicit patterns from different case studies that share relevant elements of context. This can only be achieved by the researcher making painstaking efforts to collect as much evidence as possible, written in a manner that paints a true portrait of the case study. I plan to produce this with the various methods of data collection present.

To establish *dependability,* I recruited a teacher who is not familiar with my dissertation topic to evaluate the accuracy of preliminary findings and give feedback on areas that are unclear (Miles & Huberman, 1994). This gave me an outsider's perspective in identifying areas that need clarification. I also verified the accuracy of my analysis and themes with my advisor, to ensure that all terms and descriptions are clear. He served as a sounding board and verified the codes with the textual statements attached in Dedoose. Any disagreements were discussed and clarified either by the creation of new themes or the collapsing of categories.

Lastly, *confirmability* was determined through the use of reflexivity—namely, the research journal entries following each interview. Each entry names my subjective I's that surfaced while conducting the interview, any means of reflexive action that took place during and following the interview, and measures of relationality that were utilized. This close description of the data gathering process frames the data to depict a true account of my inquiry.

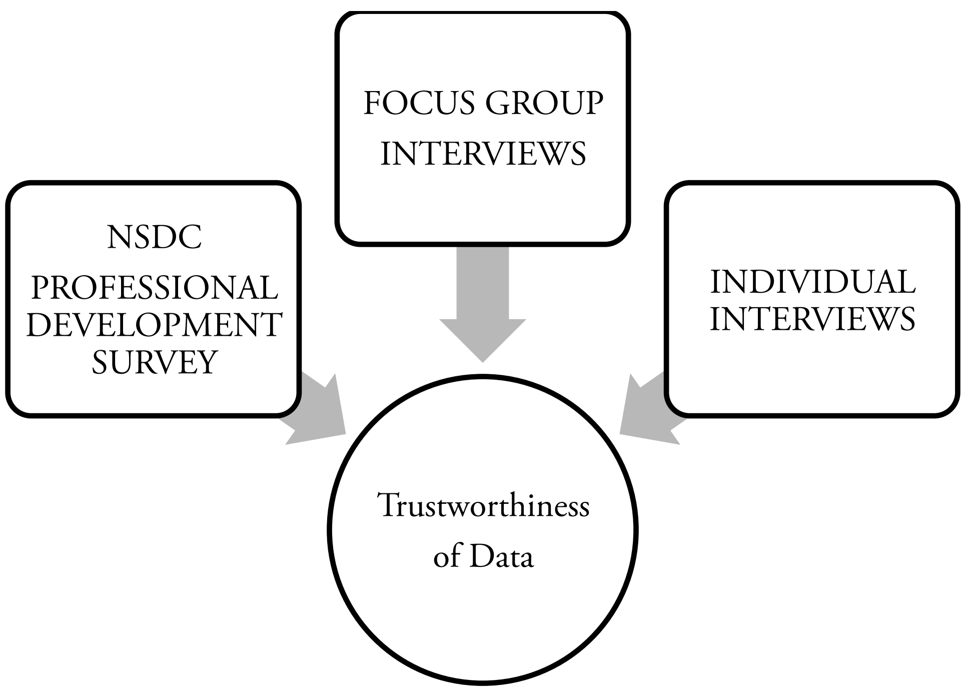

Figure 3-8 Trustworthiness of Data

CHAPTER 4. RESULTS

The purpose of this study was to examine teachers' perspectives on a successful implementation of EETPD, the importance of work climate and community support to EETPD, value of the four characteristics of effective TPD, and any additional factors that are crucial for EETPD. The purpose of this chapter is two-fold. The first portion (1) provides the context and setting of the study site and case descriptions of the two buildings involved in the study. The second portion (2) states the results and discussion of the study, which are provided in a holistic approach that is structured by the four characteristics of effective teacher professional development and three other themes that emerged from the data. The teachers' voices are preserved, with grammar corrections noted by brackets when necessary. All teachers were given pseudonyms (see Table 4-2 and 4-3). This is followed by a summarizing synthesis of the results, and leads into the conclusion.

4.1 Results and Discussion

The first research question focuses on defining teachers' ideas of effective EETPD: *From the teachers' perspective, what is a successful implementation of EETPD? What does it look like? How can it be measured?* The second research question concerns the teachers' workplace atmosphere, interactions, and functions of administration and community members: *From the teachers' perspective, what work climate or environment is* *necessary for implementation of EETPD? How are relationships with administration and community members' participation initiated and sustained? What role(s) have they played in the EETPD?* This research question focuses specifically on the EETPD they have experienced in the past. This is necessary to understand the data that was collected in the interviews, as teachers are referring to past events. The last research question focused on the four characteristics of effective TPD as a theoretical framework, and the possible emergence of new crucial factors not listed in the literature: *From the teachers' perspective, how much value is placed on each of the four characteristics of effective TPD, as defined by the NSDC (2009)? Are there any additional factors that are crucial for EETPD?* When teachers responded to the interview questions, teachers found it difficult to place a percentage of value. Instead, teachers automatically interpreted the question with an evaluative lens, and spoke about whether the characteristic was present in their implementation of EETPD. Therefore, this research question focuses on teachers' perspectives on whether the characteristic is aptly present or needs improvement.

In addition, the NSDC survey data is shown within the appropriate characteristics of effective teacher professional development. Evaluation levels 1 and 2, which pertain to participant satisfaction and learning, is placed under the intensive, ongoing, and connected to practice characteristic. Evaluation level 4, concerning teacher perception of student learning, is placed under the characteristic focusing on student learning and teaching content. Level 3, which concerns organizational support and change, as well as a number of questions concerning awareness of school improvement goals and offerings of TPD, was placed under the school improvement priorities and goals characteristic. Level

5, change in teacher knowledge, skills, and instructional pedagogy, was placed under the characteristic of building working relationships with peers. Lastly, changes in teacher attitudes and beliefs are placed under the factor of teacher buy-in.

Since there is much overlay between the answers to the research questions, the results and discussion have been organized into the four characteristics of effective teacher professional development and additional themes that emerged from the data.

4.1.1 Intensive, ongoing, and connected to practice

The survey results on NSDC's Evaluation Level 1 (see Table 4-3) indicate that teachers' satisfaction level were positive. The EETPD was led by instructors whom they felt were well informed and engaging above all other statements. Teachers also had an upbeat experience and considered the EETPD a constructive use of their time. The majority of teachers did not find engineering threatening after the conclusion of the EETPD. The lower means, although still quite positive, indicated areas of improvement for meeting the needs of teachers and offering the EETPD at a convenient time.

Table 4-1 NSDC Evaluation Level 1: Participant Satisfaction

Statement: EETPD in my school district:	**Strongly Agree**	**Agree**	**No Opinion**	**Disagree**	**Strongly Disagree**	**Mean**
Is offered by instructors who are well-informed and effective	13	18	2	2	0	4.20
Is generally a positive experience	12	17	4	2	0	4.11
Is time well-spent	10	18	6	1	0	4.06
Is nonthreatening	9	18	6	1	1	3.94
Meets my needs	5	19	8	3	0	3.74
Is offered at a time convenient for me	5	20	6	4	0	3.74

Table 4-2 NSDC Evaluation Level 2: Participant Learning

Statement: Because of EETPD, I have learned:	**Strongly Agree**	**Agree**	**No Opinion**	**Disagree**	**Strongly Disagree**	**Mean**
New knowledge and skills	13	18	3	1	0	4.23
The theory behind the practice	12	17	4	2	0	4.11
Practical instructional strategies	10	19	5	1	0	4.09
New concepts connected to prior knowledge	12	16	4	3	0	4.06

Survey results also reported the learning that teachers experienced because of the EETPD (see Table 4-6). High marks were given throughout, with acknowledgement of new knowledge and skills and understanding the theory behind the practice being the top two results. Teachers felt approximately the same in terms of gaining practical instructional strategies and connecting new concepts to prior knowledge, but the slightly lower scores indicate that there is room for improvement.

4.1.1.1 Solid foundation of basic engineering concepts.

In the qualitative data, teachers commented on the need for a solid foundation of knowledge and understanding of basic engineering concepts, as engineering is “intensive by nature” (Camilla). Since their campuses are considered magnet programs, where engineering is an attractive bonus with parents, teachers were aware of the need for intense training: “It really needs to be, because we know we are going to be a part of that, as coming up, we need to be doing it" (Lauren). Allison explained, "If this going to be implemented in the correct way…Then to me, it's going to have to start with us having a real understanding, about what it supposed to look like, and the expectation".

An element that helps build a "real understanding" of engineering is presenting the information in a manner that is digestible for teachers. Lauren describes a positive experience where concepts are pieced together in a fashion that is easy to understand, despite being outside of her area of expertise: "I'm comfortable enough to start it, because I was able to get the vocabulary, get the words to say to the students, to get the project going, so I mean it was broken down well enough".

Teachers who did not attend INSPIRE felt they had received a "disconnected piece meal [of training]" (Stacy) or learned about one activity but desired more: "We learned something with the science notebook and how to do things like that, but it was only half a day, it's kind of like, 'Hey, this is what you learned', and I wanted more" (Kaila). The reality is that "not everybody will be able to go to the Boston (referring to Museum of Boston's Engineering is Elementary) workshops, so we will need some extra training to stay up on it." (Lauren). This affirms the findings in the previous literature, as teachers who lacked engineering content knowledge were aware of their deficiency (Brophy et al., 2008; Duncan et al., 2011), which translated to the reduced practice of engineering in their classroom. Several teachers spoke of their lack of confidence when answering questions or addressing potential issues in implementation (Rogers & Portsmore, 2004). On the other hand, those who had attended the INSPIRE training felt that it was phenomenal: "I thought that was the greatest thing ever." (Peggy), and comprehensive: "If you went to Purdue, you don't have any issues" (Candace). When teachers were asked whether INSPIRE training gave them confidence to implement engineering, there was a resounding yes (Kyra, Jasmine, Paula). Although teachers who attended INSPIRE expressed immense satisfaction of the intensive training it provided, there is evidence that indicates that the INSPIRE Academy is not a means to an end, as illustrated by the lack of implementation by School B teachers. In addition, teachers who attended INSPIRE had no intention to mentor their fellow teachers upon return, as it was originally intended for the gifted PACE classrooms only. Therefore, the knowledge and expertise presented at INSPIRE could have been diluted, as previous research suggests with train the trainer approaches (Gilpin, 1997; Hayes, 2000), especially since PACE teachers in both buildings did not begin to work with fellow teachers until quite some time later.

Often, teachers would continue their own research outside of the TPD training to cement the concepts they had learned:

> I think it's all of the above, it's just you know, we're kind of collecting information, and gathering our thought to be able to model it, and present it to a 5 or 6 year old human, so, we're getting the training ourselves, and try to understand. And kind of like, organize our thoughts to be able to present it in early childhood, age appropriate manner, to where it's meaningful to the kids, as well. (Ava).
>
> Like I said I had to do my homework, you know. I had to do my research, I had to be familiar with the concept and, just like, the kids to understand the end goal. You know the driving goal, the need? (Peggy)

When teachers seek to deepen their engineering knowledge, many naturally turn to the Internet. However, Bagiati and colleagues (2010) warn against this practice as teachers can develop the habit of establishing a “piecemeal utilization” of engineering activities (p. 10). Since some of the teachers in this study express having a disconnected EETPD experience, it would be profitable that all resources given to the teachers would be part of a comprehensive program. *Since there is no way to control where teachers look for resources, a key finding of this study is the need for a vetting agency whose mission is to aggregate a web collection of vetted engineering resources for the primary grades.*

4.1.1.2 Consistent and frequent training.

The necessity of consistent frequent training emerged was a strong theme that emerged from the data. Continued chunks of instruction is a consistent request from all of the teachers, as Erin shares that the EETPD can “overwhelm us”, and that it might be wiser “to take baby steps” (Ava). Madeline also shares Ava’s sentiment and profited from a slower approach: “I think I tried to do too much and didn't understand myself what I was doing, and so this year I'm just taking it step by step, and then it's a little bit easier for me” (Madeline). Ava adds that they have “learned in phases, you know different groups... Like we went as the first group, and Camila went the next year, and so they've learned, it's been a phase of learning over the years”.

Teachers revealed ongoing training as “important just because we need that support, it's not something we can just move on with” (Camila), indicating that teachers did not feel confident in progressing on their own. Without these frequent check-ins that are “ongoing, [engineering] would die" (Sarah). The accountability of knowing and having a connection with the EETPD facilitator also surfaced:

> Jasmine: I think it needs to be continual, I don't think there's ever, I think we've got a good foundation, but I think it needs to be continual mentoring, or I don't know what you want to call it, but where we, have someone that we can always be in contact with, and then, it's not like, a checkup thing, but when you know someone, it...
>
> Stacy: Keeps you accountable.
>
> Jasmine: Yes, the accountability.

As the teachers gain more understanding and experience, they then look to frequent trainings for added depth as they continue to grow in their knowledge of engineering. Jasmine shares that as she becomes more experienced, she seeks help from the EETPD facilitators to coach her on new activities by "partnering with her, and working on getting new lessons and new ideas". Kyra also mentions the value of frequent trainings because it gives her "some kind of an update to keep [up with], things are always changing, getting fresh ideas". The accountability to keep growing with the engineering by frequent trainings and meetings with the facilitators are highly valued by the teachers. Knowing that there was a steady amount of support outside of the school was also an encouraging reminder:

> I think every time you guys are here it enriches, you know, what we've got going. And it's good reminders of, hey, you have some support out there besides those

> walls. Which we know, we do, but sometimes, we need those reminders. It's been nice seeing, we saw [university researcher] last summer, we saw [university researcher and EETPD facilitator] again last spring, now we're seeing [EETPD facilitator] in the fall again, and I think that's been a nice pace. (Kacey)

Having a personal relationship with the university researcher and EETPD facilitator was valuable to the teachers, as it allowed them to feel more comfortable collaborating together.

Frequency of ongoing support was also discussed, and most teachers sought a visit from the EETPD facilitator at least once a semester (Kyra, Violet, Kaila, Jocelyn), with one teacher requesting every quarter (Sabrina) and one suggesting once a year (Camila). Teachers suggested solutions that involved INSPIRE teachers going "back to Purdue, you know, for a follow-up" (Sarah), while others pondered the possibility of video conferencing with EETPD facilitators through Skype, so that EETPD facilitators "didn't have to come down [to campus]" (Patricia). There was also acknowledgement that the beginning of training would need more guidance than maintaining: "Maybe as not quite as often. At the beginning when you're mentoring someone, you're meeting with them very frequently, but then, as the years go, maybe not quite as frequent, but there is still needs to be [follow-up]" (Jasmine). All teachers acknowledged that follow-up should remain as long as the EETPD was being implemented, to keep up on new ideas and resources:

> On-going instruction is vital to making it successful, and going out and seeking new things, not just Purdue, but we went to the ASEE conference, I mean, that

> was a whole new group of people that had ideas, and it wasn't the same ideas we'd been getting, so just exploring different avenues and like, we're applying to the Boston grant for the EIE, just learning new things like last year, I just found that design brief was also kind like an MEA, so it's just knowing how to find things and getting different ideas." (Kyra)

Even teachers who attended INSPIRE in this study claimed that it was an effective EETPD, but required follow-up to make sure it was actually implemented in the classroom. This connects to the suggestion that teachers need consistent chunks of training. Previous research placed great significance on allowing teachers the time to digest the information and receive follow-up sessions (Corcoran, 1995; Schifter et al., 1999, Garet et al., 2001, Guskey & Yoon, 2009; NSDC, 2009, Desimone, 2009). *The findings from this study suggest that EETPD facilitators continuously follow up with teachers once a semester after intensive training such as INSPIRE.*

4.1.1.3 Connections to practice.

Engineering is unique from other subjects because it almost requires teachers to complete a run-through of the engineering activity from the perspective of a student. Other TPDs rarely require that the teacher complete the work of the student – but part of implementing engineering successfully in the elementary setting is by experiencing the learning that takes place when completing the activity. Teachers could not stress enough the value of having a "practice-run" of the processes, as the benefits include: 1) time saved in the long run because teachers can identify and prevent mishaps, 2) tweak the activity to their students' needs, and 3) raise the confidence of teachers understanding of engineering, perhaps the most valuable benefit of the three. Kacey explains that while participating in the activities as a student, teachers think of “ideas that go through that process of creating, it building it, physically having it in your hands, it’s different. It builds your confidence as if to say, ok, I can do this, it’s not as bad as it looks”. Mackenzie is more direct: “Have a run-through day instead of us just being our first time with the children as well. Even some of the seasoned teachers, you know – in our fifth grade meeting, they haven’t done it yet. They don’t get it”. Erin advised that she does not feel confident in implementing EETPD unless she has the opportunity to have run through “because I haven’t been able to do it actual hands on, to take back to my classroom, and say: ‘Okay, now, we’re going to do this with 5 and 6 years olds”. Having a practice run of the activities as students was also deemed as necessary, so teachers could experience hands-on training and understand the students’ perspectives while completing the exercises. Previous research supports the inclusion of active learning components in the TPD, allowing teachers to engage and experiment before implementation (Villegas-Reimers, 2003; Corcoran, 1995; Cochran-Smith & Lytle, 2001; Guskey & Yoon, 2009). Specifically in engineering, going through the process beforehand often cements engineering concepts. The Massachusetts Department of Education (MDOE) demonstrates interaction between forces and materials by using pieces of foam under tension, and as a result, “teachers begin to understand how different materials react under altered conditions (Rushton et al., 2002, p. T1C-25). Candace, who spoke very highly of the impact of INSPIRE, mentions the hands-on learning, “We spent from 8:00 to 5:00 with this, probably 20 PhD candidates working with groups of four or five learning how to do this activity, and then doing it ourselves”. *Therefore, a key* *finding of this study was the necessity of providing teachers with the hands-on practice runs of engineering activities before implementation with the students, to give teachers another chance to connect engineering principles to the information they received in the training.*

Another aspect of connecting to practice is exposing the students to the engineering on a regular basis results in long-term gains. Kyra states, “I’m trying implement it into more of my day on a natural basis”, while Emily explains further that “it can’t be isolated, just an isolated day here and there because the kids are going to wonder, ok, why is this important to me? Why should I do this, is this just something that is done once a month or you know, how is this relative, you know relevant to what we are doing every day?”. Sabrina further explains, “And if, what we’re doing can be broken down into charts for each day, you know, day one do this, that’s better, because what we end up doing is nothing, but they have this big project and we have to shut down everything, and we want chunks”. Integrating engineering on a consistent basis is more meaningful to students rather than one-time events, as “they are not gaining anything” (Michelle).

4.1.2 Student learning and teaching of content

According to results from the NSDC survey (Table 4-5), teachers perceived that the top three benefits of engineering on student learning were: 1) students were more engaged, 2) EETPD made a positive impact in their students’ learning, and 3) students were more involved in their own learning.

Table 4-3 NSDC Evaluation Level 5: Teacher Perception of Student Learning

Generally, EETPD impacts my students in the following ways:	**Strongly Agree**	**Agree**	**No Opinion**	**Disagree**	**Strongly Disagree**	**Mean**
Students are more engaged in learning	12	17	6	0	0	4.17
It makes a positive impact on my students' learning	12	16	7	0	0	4.14
Students are involved in their own learning	10	18	7	0	0	4.09
Student achievement increases	8	14	12	1	0	3.83
Students' confidence as learners has improved	5	17	12	1	0	3.74
Classroom management has improved	5	15	14	0	1	3.66
Student achievement has risen on teacher or classroom assessments	2	12	19	2	0	3.40
Student achievement has risen on state or district assessments	2	9	22	2	0	3.31

Though teachers assess that students' confidence increased, and that managing the classroom was easier, measuring a rise in student achievement on classroom and state or district assessments was not as obvious.

4.1.2.1 Focus on learning.

Qualitatively, teachers felt that the EETPD focused on student learning in several different ways. Teachers promoted EETPD because engineering allowed students develop problem-solving skills in a manner that was engaging, and provides an opportunity to gain experience working in a team. Because of participating in engineering events, students began to hone their planning and creativity:

> My students love it. They love the process, the engineering process, the planning. They love each step of it and they love the creating. And with the process that's used to the engineering it applies to other areas to it ties over to reading, or book projects, and it's just applicable to so many subjects. And it's just for every child. (Paula)

Planning was an area that the teachers felt the students could grow in, as the students usually preferred to dive into an activity. The EDP promoted planning and improvement as an iterative process, and the teachers found this valuable:

> Kids learning to, you know, we have different jobs, also quality, the quality control, the quality of what you are doing and again not just jumping in, doing something but seriously planning and asking questions about what is it that we are supposed to do, and will this really work. And many times kids want to just to get busy with the hands on and not do the… planning. The planning in anything is so very important, so just jumping in and making a mess of it. As well as going in, and when they have their prototype of their little product, then going and being able to see where they made their mistakes and make corrections and improve on those things. (Jasmine)

> I think that anything that's hands on, anything that is going to engage the students, and help them understand how to actually plan something out. I think that's

> definitely very important to me, and I think that it will be more meaningful for the kids, and so at the end of the day, that's what is all about. How can they connect to it? (Allison)

Being allowed to fail was another theme that was explored because of the EDP process. Since it is a cycle that often repeats several times, students were not alarmed or did note lose confidence when a design did not perform as expected:

> Like I said, the safety net of not having to be perfect the first time and knowing it's ok to rework an idea, teamwork, it's always been beneficial, it's always been evident that those things are part of the engineering activities that we do. (Kacey)

Understanding that in engineering, failure can be the best way to solve a problem allowed students to try without the fear of making mistakes. Even when teachers did not have the time to work on their content area, they were supportive of the EETPD effort. A language arts teacher recalls how she did not focus on writing at all during the boat day event, but thought it was a justifiable use of time:

> I had one group that just barely got two sails. They were so methodical. But then others were like, 'Okay let's just, what we're gonna do is just change this and change this'. And the kids really, really, really enjoyed it. I just thought it was a very worthwhile day. We did not do the language arts part which was to write a step-by-step. We didn't have time to do that. But I didn't feel badly about that…at all. (Candace)

Although students were not engaging in the writing process, they were practicing their problem-solving skills in a manner that excited the students. Being able to get students excited about learning while covering basic skills was what attracted another teacher to engineering:

> Our students need such basic skills that we need a way to help teach our students some basic skills in an interesting way, in a fun way and the problem solving still be built in. So that they still learning these basic skills that they need, but yet they are getting their problems solving through it. (Stacy)

When students were participating in engineering, teachers agreed, "the thinking skills are what they get from the engineering" (Candace). Teamwork and social skills were also brought up as a major benefit. Students were able to exercise value judgment with each other's ideas:

> Really, just that teamwork that it brings about is great. Usually, that's a really hard thing. They do much better independently, and they don't want to share. But generally that is part of the real draw to engineering is having to compromise, and consider some else's ideas and things like that. You know, to think more, beyond just an answer. (Paige)

Working together was difficult for some students, especially with PACE, as gifted students were often competitive and wanted to focus on their individual work rather than teamwork. Practicing engineering was seen as an engaging method that "really makes them have to focus on, working as a team. Especially, like when we started the robotics team last year, and that was really tough for them to release the responsibility" (Kyra). Ability grouping at School B also promoted leadership skills as well, where the PACE students took on the lead to teach the PACK students. This promoted social learning and collaboration, as well as school unity:

> We've really worked hard at grouping our students, with a variety of abilities and leadership skills, and it worked out really well Friday and so, I saw that they fed off of each other, everyone brought great ideas, and it was a good experience. (Peggy)

Teachers were satisfied with the results of mixing abilities, and planned to design more activities in the future. Teachers expressed satisfaction with the student learning that resulted from the EETPD.

4.1.2.2 Integration of engineering in specific curriculum content

The NSDC Survey revealed what changes in knowledge, skills, and instructional pedagogy occurred for the teacher after EETPD. Teachers acknowledged that their first reaction was to either fully implement or at least experiment with the new instructional strategies. Some teachers noted positive changes in their teaching, became committed to the new strategies, and made long lasting changes in their teaching.

Table 4-4 NSDC Evaluation Level 4: Change in Teacher Knowledge, Skills, and Instructional Pedagogy

After I have participated in an EETPD experience, I usually:	**Strongly Agree**	**Agree**	**No Opinion**	**Disagree**	**Strongly Disagree**	**Mean**
Implement/apply new instructional practices	9	20	5	1	0	4.06
Go back and experiment or practice with new instructional strategies	9	17	9	0	0	4.00
Note positive changes in my teaching	9	15	10	1	0	3.91
Become committed to new teaching strategies	8	14	12	1	0	3.83
Make long-lasting changes in my teaching	7	16	10	2	0	3.80

The qualitative data divulged that the majority of teachers desired training on integrating engineering into their specific curriculum content. Since engineering is “not second nature to us” (Madeline), teachers requested strategies on incorporating engineering into their specific curriculum content. One teacher recalls blending an initiative in the curriculum with the EETPD:

> We do have the DI teams, the destination imagination teams. Which there is a lot of engineering in that, and we’ve found that pulling some of those aspects into engineering, and then reversely pulling engineering into the DI and students of EDP is really helping them connect that. And so that’s something that we’re going to put in this year. (Kacey)

Because the teacher saw a connection between a required portion of their curriculum and engineering, she was excited to include this in her lesson plans for the upcoming year. Another teacher also mentioned that student learning would improve if the engineering was integrated, as students could get overwhelmed with engineering days:

> If we can start incorporating it into the curriculum it would be a lot easier, cause it would flow and build up to it like, ‘Okay, we’re going to learn all this stuff for the week that ties in with what we’re already learning, and then on Friday, it will be our engineering day’ versus right now it’s just ‘Friday is an engineering day, guys’ and we’re throwing everything at them. (Mackenzie)

Teachers in the humanities disclosed the need for grade and subject appropriate lesson plans and resources: “If they can give us more that has a lot of language arts and social studies pulled into it. That would really help us, I think. Cause right now it's kind of like, how do I tie that in?” (Daisy) Another described searching for resources, but finding few that were appropriate for the scope of her curriculum:

> We looked hard for books that we might read that would have engineering ties. We asked [university researcher] too, if she knew anything. There’s just very little literature that has any kind of engineering connection. Maybe Sally Ride and, you know the first astronaut. But that’s really a stretch… first woman astronaut, that’s really a stretch. (Candace)

Teachers needed more help in finding appropriate resources and strategies to incorporate the EDP process in their curriculum. Some of the struggle is due to the fact that not much material has been produced for integration into various subjects. The lack of grade and content appropriate materials is a need acknowledged by Lachapelle and Cunningham (2012), prescribing a solution of "teacher guidebooks" that are specifically designed for novice teachers through advanced engineering teachers. Novice guidebooks would include step-by-step directions and meet engineering knowledge deficiencies by providing in-depth content, while advanced level guidebooks would focus on deeper discussion and improving implementation. These guidebooks are exactly what some of the teachers asked for at either buildings, calling it a "manual" or "something that is scripted".

However, most of the EETPD literature focuses on STEM connections, with some writing included for lab reports (Sharp, Harb, & Terry, 1997; Beck, 2004); there is little research for suggestions on how to integrate engineering into language arts outside of technical writing. Sharp, Olds, Miller, & Dyrud (1999) present four ways to integrate effective writing assignments into engineering classes, but at the college level. As all of the humanities teachers at School B report, finding connections or literature that is appropriate with engineering is difficult. Rushton et al. (2002) offers a way to include engineering in social studies by having students design a river system. The researchers argue that this would allow students to gain a wider understanding of how flooding impacts civilizations. However, realistically, with the pressures that the teachers already have in School B, this is not feasible. Perhaps if the teacher was self-contained and could connect this exercise to various topics within the curriculum, then it would justify the use of the time and energy it takes to create such an activity. Teachers that are not in the

STEM subjects will have a difficult time incorporating engineering on a regular basis in their classroom. Though some research exists on ways to incorporate social studies (Rushton et al., 2002) and language arts (Brophy et al., 2008), there is a clear paucity of engineering curriculum for early childhood and the humanities. *Therefore, a key finding is the need for developing engineering curricula for the kindergarten grade level, as well as non-STEM subjects such as reading, writing, and social studies.*

4.1.3 School improvement priorities and goals

The NSDC Survey displayed that thirty-three of the thirty-five teachers surveyed were aware of their district's professional development plan. Thirty-four teachers also confirmed that the professional development plan is connected to overall school improvement and increased student achievement, with one teacher being unsure. Lastly, twenty-three teachers advised that the district's professional development plan was related to the teacher evaluation process, with eleven teachers being unsure, and one teacher stating that it is not related to the teacher evaluation process.

The survey also measured when teachers were offered TPD, and ninety-four percent of teachers reported that TPD was usually offered in the beginning of the school year.

Eighty-nine percent of teachers reported TPD during the school day, while eighty-six percent reported TPD offered in the summer. Eighty-three percent of teachers stated that TPD was offered before or after school. Seventy-one reported offerings during conference periods, and fifty-four percent of reported TPD at the end of the school year. Forty percent mentioned the evenings, and twenty-six percent of the teachers were offered weekends. Only twenty teachers recalled online professional development as an option. One teacher mentioned “other”, and no professional development was offered during the lunch hour.

Organizational support and change was also measured by the NSDC survey. Teachers agreed that EETPD had a positive impact in their school climate and culture, was often conducted during the school day, and had a positive impact on the school as a whole. A lower number reported that EETPD leads to in-service credit or a stipend, so the teachers are unclear of how the EETPD is beneficial in that aspect. The building administrators, the individual teacher, and district administrators perceive EETPD as extremely important, while teachers perceived that it was slightly less important to their colleagues, board of education, and the parents of the student.

Table 4-5 Offerings of Professional Development

Professional Development in my district is offered: (Check all that apply)	**Responses**	**Percentage**
At the beginning of the school year (end of August/early Sept.)	33	94%
During the school day	31	89%
During the summer	30	86%
Before and/or after school	29	83%
On conference days	25	71%
At the end of the school year (the week after school closes)	19	54%
In the evenings	14	40%
On weekends	9	26%
Online	7	20%
Other	1	3%
On my lunch hour	0	0%

Table 4-6 NSDC Evaluation Level 3: Organizational Support & Change

EETPD in my school district:	**Strongly Agree**	**Agree**	**No Opinion**	**Disagree**	**Strongly Disagree**	**Mean**
Has a positive impact on the culture and climate in my school	8	21	4	2	0	4.00
Is often conducted during the school day	8	21	3	3	0	3.97
Has a positive impact on the organization as a whole	8	20	4	3	0	3.94
Leads to in-service credit or a stipend	2	15	11	3	4	3.23
Is recognized as being extremely important by the following:						
Building Administrators	16	14	4	1	0	4.29
Myself	13	15	7	0	0	4.17
District Administrators	12	15	7	1	0	4.09
My Colleagues	9	16	9	1	0	3.94
Board of Education	10	12	13	0	0	3.91
Parents	4	14	16	1	0	3.60

When teachers speak of what is necessary for a successful implementation of EETPD, an overwhelming number express the need to integrate the EETPD into the already packed curriculum. Teachers desire to multi-task effectively and accomplish several tasks at once, as discussed above as a factor of buy-in. Stacy describes engineering as most effective when, “Instead of being something additional that we are doing, that it helps us meet the state standards that we already have to teach. So whether it’s a lesson in a classroom or an hour in a science lab, something that helps us with our job”. Teachers are looking for EETPD that is written into the curriculum and aligns with state standards. As Madeline demonstrates, “Not having to do it separately but kind of bringing it into what we're doing" is a dominant theme. In the interview data, a common topic that arose in terms of school improvement and goals were state standards, which will be measured by the state standardized test. The new standardized test was implemented beginning 2012, and teachers were acutely aware of the many changes that are happening across the state. When teachers were asked about awareness of school improvement priorities and goals, teachers mentioned (1) the concern of covering all the state standards, (2) the absence of engineering in the state standards, and (3) how engineering could help teachers meet the existing state standards. Teachers acknowledged that they were all aware of the improvement needs on campus: "We just looked at our campus needs assessment, and there were too many of our items that were on it" (Kacey). Although they "have a lot of input into the campus improvement plan, and what we're doing extra" (Camila), they did not have input into the creation of the state standards. Teachers complained about the standardized testing:

> Scores, scores, scores. That's what we all, that's all we ever hear. That's all we hear from the district. That's all we hear from…they use that data to bring up those scores, bring up those scores. And it's kind of a shame because I've been in the PACE program for 22 years, 20. And the PACE program really shouldn't be so test-driven. We really should be working… yes, we should be getting kids more excited about learning and stimulating them to want to learn more and do more. (Candace).

Another teacher told of her frustrations with the state system:

> I think my greatest challenge of being a teacher – you probably don't want to get into that – but it's really how the state handles things. Especially me having PACK, which is regular, as you all know, which I don't really like that term anyways because my kids might be in a regular class but are gifted at certain things. So to say, I don't like the fact that I have fifth graders that are on a first-grade reading level and they're expected to pass a state standardized test is absolutely ridiculous. So that's what I'm working with is, the state pushes these kids on whether or not they learn the material. (Mackenzie)

Teachers perceived the standardized test as poor measurement and reflection of students' capabilities. Regardless, since teachers know that they must cover the state standards, teachers advised that it would be helpful if the EETPD was designed to focus on covering the standards:

> Yes, yes. Things that go along with our state standards, and not necessarily sending, I have to look at and go, 'Where, in my standards could I make that work?' but more things are like:" Yes, that goes for this." (Paige)

Teachers appreciated engineering activities that met state standards, such as the science notebook:

> We were talking about the charts with community helpers, and picking out something that's science and nature made, so they're able to do that and then document it, and document it in their science journal, because that's one of the

> state standards that’s in science you have to observe and you have to document and everything like that so yeah, it’s a good start. (Lauren)

Covering the state standards once again highlighted the need for integration, as teachers were able to garner some flexibility if engineering helped meet goals:

> That's why it's best if we can integrate it, and our administrator is pretty good if you can prove you can do the state standards through this engineering project, she would let you know have some leeway there, you know, you know have some leeway, but that's just where you just got to work a way to get it all together. (Kyra).

Teachers hoped that the continued EETPD would assist in creatively producing ideas on how to use science lab time to meet various standards:

> I was interested in you guys helping us with, was we go to the science lab every week, could you help us in a great, in that one hour, that we are pulling engineering in to maybe that one hour to meet one of our science or social studies standards. Can it be something that we can go to the science lab that we can accomplish maybe in an hour, so that, like I have said instead of being something additional that we are doing, that it helps us meet the standards that we already have to teach. So whether it’s a lesson in a classroom or an hour in a science lab, something that helps us with our job (Stacy)

A few teachers had a negative perception of how the state was handling the students and engineering. One teacher described the lack of alignment with the standards:

> Our fifth grade science standards do not align with engineering at all. When we came back from Purdue, we went over it chapter and verse. And there is no engineering in our current text or very limited. And that's why we added the math components to it, mainly in that part. We tried to add math components to it so the people wouldn't question us about why would we spend time doing this when it's not really aligned with our state standards. (Candace)

The only way this teacher saw how engineering helped meet the state standards, was in producing thinking skills:

> The thinking skills are what they get from the engineering. It's a means to an end, but it is not teaching the specific standards or list outlined in our state science curriculum. I think it does align with that, 'cause the one thing they can't do on the standardized test is think. And I think the engineering will help them to think. So, in that area I think they align beautifully (Candace).

This characteristic elicited mixed reviews from teachers, since administrators at the district level did not explicitly include engineering standards or integrate engineering into the curriculum. However, a fair amount of teachers reported that they believed engineering activities would sharpen students' thinking skills, which would aid them in standardized testing. Although the district provided funding in the beginning of the engineering venture, the district provided no special funding the past couple years for further EETPD or materials. Although teachers were supplied with materials to complete the actual activities, teachers reported that instructional manuals were scant and incomplete. The literature shows that it is crucial for the district to support TPD of any kind, and that long-term efforts of TPD cannot be sustained otherwise (Archibald et al., 2011; NDSC, 2009; Turnbull, 2002). Instead, all of the support for the EETPD came from the principals. The principals provided leadership by seeking out EETPD opportunities for teachers to attend. Upon return, teachers' efforts to implement what they had experienced were supported by the principals, motivating teachers to take risks and try new skills (Zepeda, 2012).

4.1.4 Strong working relationships

EETPD was cited as a great way to build working relationships with their colleagues. Evidence of such relationships was apparent in the (1) creation of engineering curriculum between the schools, (2) engineering mentorships, (3) and desire to plan in groups.

When the initial group of teachers attended INSPIRE in 2009, the group included PACE teachers from both School A and School B. Upon return, teachers experimented with what they had learned in their respective schools, and initiated "follow up days with just the GT teachers – School A and School B teachers" (Peggy). These meetings kept the schools abreast of what each campus was doing and slowly created an engineering curriculum for the two schools:

> We met at the end of that school year, again with those groups of people, and we're kind of divided out those activities to where they were more age appropriate. So, that's why the kids wouldn't be repeating activities over and over again. So that's why we came up with that squares that she tried to copy [for you]. That was the initial division of everything. (Madeline)

This initial division is a chart that has all of the INSPIRE activities divided up by grade, from 1st grade to 5th grade. The teachers still abide by this division and are sure to add things that only supplement this plan. It was through this initial relationship that was built by attending INSPIRE together, that the PACE teachers set the groundwork for campus wide implementation of EETPD.

Engineering mentorships also fosters rapport among the teachers, where the teachers partnered up with each other to plan and implement engineering. Teachers were comfortable in approaching each other for help: “If I have a question, I can run down to the other teachers, you know, Miss Kyra, Miss Paula, and Miss Sarah, they don’t hesitate to help” (Patricia). Building the trust between the experienced and inexperienced teachers was a goal: “We kind of have to rely on each other, because we don't have someone here all the time to help us, we have to use our own ideas, and try to work together and try to get a trust built between us” (Camila).

Lastly, planning in groups was perceived as an instrumental way to build working relationships and successfully implement EETPD. Teachers viewed these planning sessions as an essential part of exercising their creativity: “We’ve started planning, and designing lessons, and the fun part is being able be creative because lot of teachers, that’s reason why you get into the profession” (Jasmine). Teachers also felt a “connection” with each other that was not otherwise felt:

> Jocelyn: I think so. I mean I think that it’s like, I mean we always work together, but when we’re all collaborating, it felt like a strong…

> Daisy: Felt a connection.
>
> Jocelyn: We've planned a lot more together just on this, and we have in a year or two years.

After receiving a day of planning with her fellow 4th grade teachers, Kaila shared her joy "that we're getting in the planning today, it's just wonderful, and I'm very excited to implement that in our curriculum" (Kaila). Planning with each other allowed teachers to brainstorm about specific curriculum: "As we integrate, the language arts teachers can take part, take the writing, the assessment and evaluation and do that component of the engineering process (Brooklyn). Teachers desired the time to "talk with the other science teachers in my grade level" (Sabrina). Also, because of structural differences, teachers at School B did not share a conference period together, so being given planning time as a group was perceived as extremely profitable:

> Yes. I mean, we're, we barely have enough time as it is right now just planning our own curriculum. So definitely having time would be very helpful. And be able to talk with our math and science teachers at the same time too. (Daisy)

The instructional specialist was also mentioned as a helpful resource while planning: "I know that if we ever need information, I know that Linda will research ideas about different things… she's very helpful as well." (Andrea). Teachers appreciated the research that the instructional specialist would complete, saving the teachers time in planning.

Both campuses reported great working connection to their colleagues, which was strengthened by the EETPD. Teachers expressed a solidarity of “being in the same boat” several times, which is in alignment with previous research that a tackling a common problem can build solidarity among teachers (Desimone, 2009), can give hope that improvement can occur (Garet et al., 2001), and teachers enjoy engaging in conversations related to their profession (Borko, 2004).

4.1.5 Teacher Buy-In

A significant theme among the teachers entails the idea of buy-in, defined here as when teachers see the value in implementing an EETPD, and therefore, agree to invest in learning, planning, and implementing the EETPD. The qualitative data revealed that teacher buy-in was necessary for a successful implementation of EETPD. Teachers requested multiple levels of relevance to generate buy-in. Buy-in was related to the affective and attitudinal position of the teacher, and generated by: 1) excitement about the EETPD, 2) participating in active learning activities, 3) understanding the rationale behind the TPD, 4) viewing evidence of student success, and 5) increasing efficiency by utilizing engineering as a strategy to accomplish goals within the curriculum. Teacher buy-in is critical in producing higher levels of commitment towards learning, planning, and implementing the EETPD.

Naturally, the conversations led to what elements would cause teachers to attach value to an EETPD, and ultimately, buy-in. It was then when it became evident that teachers’ attitudinal aspects played a key role. Ava shared that “professional development has to excite you, ‘cause if it doesn’t capture your interests, then you’re not going to be very likely to take it back to your classrooms”. Teachers need “something that engages us and engages our students as well” (Sarah). Teachers, like students, are motivated to attend EETPD that is considered “fun” by including visual and hands-on components, rather than just hearing about what and how the EETPD would work in the hypothetical classroom. Paige summarizes this by stating, “I need some more intensive fun things, new ideas and things, you know, instead of just hear it in second hand. It’s not the same thing”. This confirmed previous literature about teachers’ reactions to engineering. Teachers’ excitement about engineering in the classroom is noted in several studies (Elton, Hanson, & Shannon, 2006; Adamczyk & Fleischmann, 2003; Kendall & Wendell, 2012).

Excitement was often the result of active learning exercises, which included hands-on and visual training. Stacy commented on the value of actually going through the exercises as students: “The hands-on has been really good, because that helps me know, first of all there’s something I can do in my classroom and then how to follow through with it”. Mackenzie shared her enthusiasm after watching a visual demonstration: “I went yesterday, which I wish everybody could have gotten to go because… it’s really a lot of fun. It’s great. After watching that video, I would love it”. Training that included active learning components were perceived as more valuable since it allowed teachers to experience engineering firsthand. This was also observed in the work of Blank and de las Alas (2009), who suggested the inclusion of active learning methods so that teachers can have several opportunities to reinforce ideas and concepts.

In addition, buy-in was achieved when teachers understand the rationale behind implementing engineering. One exercise that teachers appreciated was when the research instruments were explained to the teachers in detail, such as how they were utilized to gather data on student growth in engineering knowledge. Teachers spent time coding the data with the same coding schemes as the researchers, and then viewed the rate of growth in student knowledge between the first two years. When teachers were elevated to research collaborators by understanding the research instruments, teachers' willingness to participate grew. Lauren illustrated this when she claimed, "Just like you showed at the end [of the coding exercise], how the growth, I see the reason behind it, you know, the method behind the madness". Timperley, Wilson, Barrar, & Fung (2007) highlighted teachers' engagement when the rationale for the TPD was based on valued student outcomes.

Additionally, when teachers observed evidence of student engagement and success, it motivated teachers to invest further. Sabrina described how she felt throughout an engineering event:

> "When the students are successful, and you see that light bulb come on and they are so excited about what they're learning, and I love to see them actually engaged in learning, rather just sitting and receiving. It's a joy to see them being engaged in learning. And that's possible with engineering." (Sabrina).

Candace told of another student who loved engineering and how it inspired her as a teacher:

> “Two years ago, maybe three years ago we had a child who had raised a goat or a sheep or something for 4-H. On 4-H day, she told her mother, “I’m not going, I’m not going to do it. I don’t want to miss school, we’re doing an engineering day”. And so her mother called us and was like, “Could ya’ll please do it on Thursday?” And we finally made an arrangement where she came for the morning… but it was really, you know that when kids are that excited about what you are doing, you feel like you’re doing something right.” (Candace)

When students took ownership of their learning and exhibited growth, teachers continued to implement engineering, which is similar to the second characteristic of effective TPD, which focuses on student learning.

Along the same vein, when engineering helped teachers become more efficient and productive in the classroom, its value rose. Stacy stated that effective EETPD would be a method “that is actually helping us accomplish what we already have to do. So that helps me have buy-in to the development, to the staff development”. When the TPD was not appropriate to what the teacher was trying to accomplish in the classroom, it was difficult to buy-in. Kacey reported previous trainings when engineering “just wasn’t part of my current focus”, while Stephanie recalled a time when “some of that [EETPD] didn’t make sense [for my classroom]”. Kate brought up the point that “just because it’s easy to implement in a classroom, doesn’t mean it’s good for the classroom”. Candace stressed, “even for teachers, it has to have a purpose and it needs to be meaningful. If it doesn’t, why are we doing it?” Therefore, in order for teachers to buy-in to engineering, the EETPD must equip teachers to complete tasks that are already required by the district in a more efficient or productive manner, similar to the third characteristic of meeting school improvement goals.

The importance of teacher buy-in was illustrated in previous literature, where teachers' position on the TPD was a significant factor on the implementation's success or failure. After analyzing the results, I came to the realization that teacher buy-in was really a process of vetting to make sure that teachers have all that is necessary to truly embrace a new instructional strategy. Turnbull's (2002) findings revealed that there were seven predictor variables connected to supporting implementation: (1) training, (2) administrator buy-in, (3) developer support, (4) resources, (5) knowledge of budget; (6) influence in school-level implementation, and (7) control over classroom implementation. These seven predictors were discussed by the teachers throughout the interviews, confirming that the type of support teachers needed for implementing any new strategy was very similar. Teachers desired quality EETPD (training), support from the district and principal (administrator buy-in), support from EETPD facilitators (developer support), and engineering ideas, lesson plans, and supplies (resources). The teachers were aware that engineering was not in the budget (knowledge of budget), that they could collaborate with their colleagues on how to implement it (influence in school-level implementation) as a building as well as a regular routine in their own classrooms (control over classroom implementation). In addition, Turnbull alleged that teacher buy-in predictors changed as time passed. By the end of the second year of implementation in Turnbull's study, there was a considerable shift in predictors: (1) buy-in from year one, (2) school-level support, (3) administrator buy-in, (4) control over classroom implementation, and (5) training. This was reflected in the data when Jasmine advised that teachers needed more support in the beginning, and then follow ups: “At the beginning when you’re mentoring someone, you’re meeting with them very frequently, but then, as the years go, maybe not quite as frequent, but there still needs to be [follow-up]”.

Kincaid, Childs, Blase, & Wallace (2007) reported similar findings with the school-wide implementation of positive behavior support (SWPBS) in Florida. Both high and low implementation groups identified issues concerning teacher buy-in “as critical barriers to the success of SWPBS implementation” (p.178), with almost twice as many statements regarding buy-in than any other theme. As teachers in both buildings described, teachers who were not part of the original INSPIRE groups felt somewhat forced to implement engineering without being given a choice. When situations like this arise, Cooper (1998) suggests adequately addressing those who are resistant. Even with 80% of faculty buy-in, the collective 20% of non-adopters posed risk to the whole implementation with “negative feedback and subversive activities” (p.13). Cooper suggested that it was crucial that TPD facilitators not only focus primarily only on the adopters of the program, but also worked with the resistors were not supportive or present at adoption. Dana exhibited effort to change the minds of those teachers by providing a day of training and encouraging the teachers. Kitty also made similar efforts by providing a day of training and another full day of planning for the newer teachers, but would have reaped greater benefits by working directly with those teachers who had negative feedback, whether it was about implementation or lack of training. This would also improve the work environment because teachers would perceive to have clearer communication with the principal. Desimone (2002) summarized, “Without wide-scale teacher buy-in, not only can slow implementation result, but the effort may affect only a few select teachers and their students, and not the whole school” (p. 447). This further cemented the findings that integration of engineering was most prevalent in the PACE group at School A, where teachers had “bought-in” to the EETPD. *Therefore, key findings of this study confirmed that teacher buy-in is necessary for a successful implementation of EETPD, that extra effort must be spent on working with the minority of teachers who are resistant to the program, and that the needs of teachers will change with time.*

4.1.6 Nurturing environment for professional growth

Teachers’ ideas on the ideal work climate necessary for a successful implementation of EETPD evolve around strong leadership from the principal, equal access to training, positive working relationships with other teachers, and engineering activities that integrated into the curriculum. Since the data revealed distinct differences between the buildings, I present the results by building rather than an overview of all the teachers.

4.1.6.1 School A

Jasmine recalled that engineering first came onto the horizon when the “superintendent wanted to make sure that our district was driven towards math and science”. Kyra corroborated this by adding that the superintendent “said we were teaching engineering in the news”, where he declared, “I want to see our students prepared to be engineers and doctors” (Sarah). The focus of this effort was initially only “for PACE classes, he said that we were teaching medical and STEM” (Kyra). Stacy, however, perceived it being directed more at offering families a greater variety rather than just STEM: “I remember our superintendent talking about that, not just the emphasis on science and math but also what we have to offer our students and families… to see that we are doing something that other schools might not be doing". Therefore, School A teachers credit the superintendent as being the first member of the administration to announce that EETPD would be taking place in their district, which caught some teachers by surprise, such as Violet: "Oh? We're teaching engineering?" Regardless, the announcement by the superintendent placed engineering on the teachers' plate.

4.1.6.1.1 Leadership of the principal

However, outside of the public announcement that the superintendent made, the teachers regarded the majority of their administration support to come from Dana, School A's principal. In describing the principal, a common thread of leadership, encouragement, and support was apparent from the teachers' perspective. It was Dana "who found INSPIRE and pursued it" (Kyra), being the first point of initiation. After the initial announcement from the superintendent, Jasmine recalled how Dana was proactive and took charge of the situation:

> Our principal started looking for ways to make that happen, and I am really not even sure how she found that online, somehow found out about Purdue and brought it up to us and asked if that would be something we were interested in, and of course we were.

After applying to the grant "last-minute" through the leadership of the principal, the 1st and 2nd grade PACE teachers, along with 3rd, 4th, and 5th grade PACE teachers from

School B, attended INSPIRE's Summer Academy. Upon their return home, Ava shared how supportive the principal was of the teachers:

> When we came back from Purdue, we were so pumped and excited, the group went to administration and told them what it was, and what we learned, and how excited we were, and how we wanted to implement it, and they stood behind us and hooked up with Purdue and that's where we are now."

All of the teachers were positive in their description of the principal and spoke about how she promoted professional growth for teachers. Paige described School A's campus as "really supportive, in engineering, and our principals are very supportive, and, try to get us involved in work, professional developing, those things. She's very encouraging in these things." (Paige). Patricia shed light that not only does Dana praise teachers' EETPD efforts, her administrative skills provided excellent support in moving things along: "Miss Dana makes sure that it's followed, followed up on and I just feel like, we feel like if we have that backing, then we know we have got that backup coming" (Patricia). Anytime the teachers were in need of supplies or help with their curriculum, Dana, with the help of an instructional specialist, "usually go above and beyond and go find those things that we need, and find the way to pay for it, and make sure we have those things" (Jasmine). Overall, Erin summarized, "Administration does take a big part to where, she pushed it, she encouraged her teachers to pursue it".

The positive impact of Dana, School A's principal was felt by the teachers. PACE and PACK alike commented on the principal's excellent leadership, promoting a culture of professional learning and supporting the teachers in EETPD efforts by providing whatever training is possible within the constraints of the budget, along with time and supplies for activities. Even teachers at School B mentioned the proactive nature of Dana in procuring the EETPD opportunity. What is important is that Dana has been at the school for nine years without any major changes that the teachers mentioned, other than the standardized testing practices in the state. Teachers often talked about the open door policy that Dana had for discussing anything about the workplace. This bridge of communication between the teachers and the principal seemed to be an effective method to diffuse any issues, in agreement with previous scholars (Boyd, Lankford, Loeb, Ronfeldt, & Wyckoff, 2011, Ladd, 2011). In general, I also observed the principal being more present during the EETPD and always encouraging teachers to think of ways to integrate engineering into their classes.

4.1.6.1.2 Training opportunities

Besides the support of the principal, teachers frequently mention the need for equal access to training, such as that offered by INSPIRE, and the opportunity to buy-in. After PACE's initial year of implementing engineering, the principal initiated expanding the EETPD to the PACK teachers, and opened up the after-school engineering club to PACK students. Dana contacted the university researcher and coordinated sessions of training for the PACK teachers, as well as refresher sessions for the PACE teachers who had attended INSPIRE. However, since the training was not as thorough as attending INSPIRE, much of the inner workings of EETPD was left to be modeled by the PACE teachers that were experienced. Still, in spite of the willingness of PACE teachers to help, the PACK teachers and kindergarten PACE teachers were quick to note that they lacked the level of passion that the PACE teachers who had attended INSPIRE often spoke about. Beginning with the kindergarten PACE teachers, the main problem was the lack of intensive training that is appropriate for early childhood. Erin struggles with looking for age appropriate material, as there are not many kindergarten engineering resources available: “I feel that we’re kind of scrounging around, looking for materials, other than us coming out with ideas that making sure that we’re guiding the kids the right way”. Allison added, “I need a manual, and I need more training”. The PACE teachers seemed sympathetic to the situation, such as Sarah, who explained “it was that experience INSPIRE that set us on fire now. It wouldn’t be the same if they just listen to what we have to say”. Jasmine wonders what the campus would have been like if all of the teachers could have attended INSPIRE:

> You can send a core group, but really everyone, needs that opportunity to get the, I mean, I think our campus has done very well, we’ve got teachers again, they haven’t experienced that, but still, really are working at it in our classroom, but if they could just go, and be there, what a difference.

Both PACE and PACK teachers acknowledged that receiving INSPIRE training was of significant impact. When the PACK teachers were asked if they would be interested in attending an INSPIRE workshop, the desire to attend was strong: “I would love if there is opportunity to end up, you know, to go to Purdue or something like that, I would just love that experience” (Paige).

4.1.6.1.3 Positive working relationships

Positive relationships with other teachers were also a factor in an ideal work climate. After the PACE teachers had returned from INSPIRE, the enthusiasm from the workshop sparked teacher initiated planning for special engineering days and a mapping of the engineering curriculum. Kyra, a member of the initial group that attended Purdue, described their beginnings:

> I mean, just for coming back from there, we were really excited, and wanted to implement this in our classroom, and we immediately try to figure out how we can get it into our day, because the time constraints. That's where we started the first year, we did, me and the other two first grade teachers that teach PACE. We did like a rotation on Fridays, where one of us did engineering, one of us did technology, and one did science. So, that we could keep focus on it, and then the next year, we change little bit, because the prior we did like an hour long, it wasn't enough time for the engineering to get it all in. (Kyra)

In addition to the teachers' concerted effort to organize an engineering curriculum, an after-school engineering club was formed, which Jasmine claimed, was initiated purely out of the teachers' enthusiasm:

> It's voluntary, the teachers [run it], we do. And then we also have people in our community from some of the industries that come in and also help us… we were excited when we came home from work one day and decided that it would be a good extension, and it also helps with the parental, you know, parents understanding what we are doing and being excited about it.

This data exemplified the thought process and long range vision that the teachers had in designing the after school club. It was a way to garner and sustain engineering interest in the students, involve the community members who wanted to contribute, and promote clarity and support from the parents who were unclear about the EETPD efforts that were occurring at the school. Though this effort was again, initially focused on PACE, it did not stop PACK teachers from participating in the club. The club was also utilized as a supplemental source of training for PACK teachers who wanted to get up to speed on the EETPD:

> The after school program, I volunteered to do it, even though the first time they did it was just PACE kids, because I wanted to see what they were doing and also enjoyed getting to see, not for comparison purposes but, what their students do in that setting and how, to kind of help me, as far as my thinking, how to organize with my student or what to say to them to help them work through their problems and that kind of thing. So, one of my first contacts with it, before they were even promoting it to all the teachers, was volunteering after school. (Stacy)

Although the students in the club were PACE students, Stacy saw the value of observing the activities of the after school engineering club to understand the engineering design process, participating in the engineering activities herself, and mentally planning for her students and their ability level.

Teachers began to pair off and work together to implement engineering on a campus-wide level. Hannah outlined how engineering mentorships began to form during pie week, a school-wide thematic unit: “We partnered in engineering on one project, and that’s when the PACK class came in and paired up with the PACE class, and their kids worked with our kids and going through that whole process". Lauren spoke about being mentored by Camila: "Yes, our team works with Miss Camila, so yes - she has the experience and I can just follow along and learn from there". Camila followed this with another benefit outside of engineering, "I think we kind of have to rely on each other, because we don't have someone here all the time to help us, we have to use our own ideas, and try to work together and try to get a trust built between us". Kyra noted that the relationships among the teachers at School A were "non-threatening", with Violet adding that often times "I'll pass down the hall and say, 'Kyra, what are we doing for our engineering lesson in two weeks, and she'll tell me". In this sense, the PACE teachers seemed to understand that the PACK teachers were missing the intensive training they had received at INSPIRE, and voiced the necessity of PACK teachers to attend such training on their behalf, which diffused some of the tension. This exemplifies how the working consensus can mediate between stress factors in the workplace (Johnson et al., 2011). Some tension was noted between the PACK and PACE teachers during the focus group interviews, which was related to not having the INSPIRE experience. It is unknown whether PACK teachers perceived that the PACE teachers received more TPD or privileges in general, or whether the PACK teachers felt that I was comparing their performance to the PACE teachers, both possible explanations for their tension.

4.1.6.1.4 Management of a heavy curriculum

Lastly, the challenge of integrating engineering into a packed curriculum was an important factor in the work climate. Teachers described their curriculum as very specific and stressful: “It's written down minute by minute of how many minutes you do this, how many minutes you do this, and it's like, we don't have time to go potty.” (Hannah).

Further, the PACK teachers brought up the differences between the PACE and PACK populations. Violet described the “difference in between knowing PACE can start a particular project at an earlier rate when we're trying to… get the basics. The basics, we've got to get that done first, then we can move into the area of doing the engineering projects”. As PACK teachers, the challenge seemed to lie in equipping the students with basic skills such as reading, writing, and math. Amber gave the example of “when we have a class full of kids and you have, a third of your class not passing math, other third not passing reading, you kind of need to address that”. Hannah highlighted the fact that the PACK students lack “just the background knowledge, things that our kids have not had any experience or exposure to”. Finally, Stacy mentioned the level of support that PACK teachers receive from parents and the community: “I think sometimes, we probably feel differently about community support, because they get a lot of parental assistance that we do not see”. Teachers seemed to suggest that in the future, more interest could be generated when parents are made aware about the engineering activities in the classroom.

Moreover, since School A classrooms were self-contained, Camila touched upon the fact that “we don't just teach one subject we have to teach everything”, rather than just honing in on a specific content area. This was a struggle for both PACE and PACK teachers alike. Kyra spoke about covering the weekly “science and a social studies topic that we‘re supposed to integrate into their literature and reading. You really have two diverse things going on at same time” (Kyra). Patricia stated that covering the entire curriculum is a constant source of stress: “I think that’s the biggest part, is me, I will be on schedule, it’s like, we barely get in what we are supposed to get in” (Patricia). The level of stress seemed similar for both PACK and PACE teachers, although PACK teachers were more concerned about “covering the basics” (Violet), while PACE teachers focused keeping “the gifted and talented students going” (Paula). Madeline struggled to fill in the gaps for the PACK students:

> Some of them not having knowledge and background… you have to start from the basics, and the curriculum, sometimes, it seems that they want you to teach, I mean, all of it, all at once, it seems like. I think it would be better just to do reading and math and get the basics down, at least the first semester, and then go into everything else. (Madeline)

While Madeline struggled to get her students up to speed on the basics, Paula’s struggle to keep her students occupied impacts her personal life:

> The greatest challenges are to keep the gifted and talented kids going. It’s a constant challenge. It takes work from home and just thinking ahead all of the time and thinking about real world projects and how can I apply this information for these kids. I’m preparing at home on the weekends. My home life comes second. That’s sad to say, but it has because I’m thinking of projects, doing schoolwork, contacting parents or planning activities for the kids. You’ve got to stay ahead of the gifted and talented children.

Despite the heavy workload, teachers reiterated that they were willing to implement engineering if it could be integrated into their current curriculum. When teachers understand the flexibility of the engineering design process, it became easier to integrate: "To me, I like the engineering process because you can adapt it to any part of your curriculum. I mean, it's just steps and they get used to it and they can apply it to anything that they're doing in the classroom" (Ava). It also served as a fun way to equip students with problem solving skills: "Our students need such basic skills that we need a way to help teach our students some basic skills in an interesting way, in a fun way and the problem solving still be built in" (Stacy). Therefore, the teachers were willing to keep trying to implement the EETPD and did not view their heavy workload as an unbearable obstacle, but an important factor in their work climate.

4.1.6.2 School B

Fifth grade teachers described the climate as "tense", although some of the tension was attributed to "personal things we're dealing with, too" (Kim). The history of EETPD in School B begins with a reference to Dana, the School A principal, as being the point person to find INSPIRE and start the EETPD effort. Peggy recalls that, "it was first discussed by Dana, the principal at School A. I think she stumbled upon some information, and I could be wrong, but it came from School A. And then we all jumped on board, those that could go". When asked if anyone else other than Dana was involved, the teachers did not mention any other names:

> Researcher: Who played the major role in bringing that to the table on the administration?

Kacey: Our principal.

All: Kitty.

Sabrina: I know 4th grade had a big push in getting it started to . . .

Daisy: Some of them went to Purdue and they . . .

All: Yes.

Kacey: Some of them actually went.

Researcher: All right. So Kitty is the one that made, played a major role in bringing engineering to you guys, right?

Sabrina: And that's what we're assuming. If someone else did, we don't know.

Based on the data, it seems that most of the teachers did not recall much administration involvement other than Dana's initial mentioning of INSPIRE, and Kitty, the principal for School B. This is a reflection of the high rate of turnover that occurred at School B – as Andrea reports, "forty-four percent of the campus is a new or second-year teacher". Since members of the new group were not present during the beginnings of EETPD at School B, the data on the history of EETPD are only relayed by the handful of teachers in the experienced group that are still part of this campus.

As with School A, teachers reported that the EETPD was intended for the PACE group only. Candace relays that "We envisioned this as a PACE activity that would strengthen our PACE program", so those that attended INSPIRE consisted of only PACE teachers.

Upon their return, Candace continues, “Julia [no longer at School B] was teaching with me and so Julia and I made a commitment… we were trying to do an engineering day every other week, every other Friday. And we were pretty successful”. The enthusiasm of the teachers illustrate the impact of the INSPIRE training, and after the first year, Kitty initiated the move to provide engineering for all of the students.

4.1.6.2.1 Leadership of the principal

In School B, teacher perceptions on the leadership of the principal appeared negative from the experienced teachers at the school. According to Candace, the EETPD was assigned to the whole campus without the teachers having much of a choice:

> Because of our excitement, everybody said, “Well, if it’s good for PACE kids, then it’s good for all kids.” And we felt like it didn’t just get kind of cast upon the water. It’s just kind of like, ‘Okay, you all do it’…So, I think our principal’s really trying to get it going again by saying, ‘Okay, we’re going to do these Friday days’. And everybody has to do them. So, she’s trying to get it going.

What is interesting is that Candace perceives Kitty to play a major role in getting engineering started again on campus through engineering events, but this is a miscommunication because Kitty would like the new teachers to learn how to integrate engineering into their curriculum. In contrast to the experienced teachers, the new teachers specifically mention the principal’s leadership and are aware of the significance of EETPD at their school. When Kacey was hired two years ago, Kitty made it clear that EETPD was important because “one of the first trainings that I was sent to was engineering training, and the second being GT certification training”. Brooklyn corroborates with Kacey: “This is my first year at this campus, but the principal set me up with a half day workshop before school started and then another two half-day workshops before school started, to sort of introduce the process and the concept”. Clearly, Kitty plays a significant role for EETPD at School B, and the new teachers testify to the abundance of overall school administration support under her leadership. Mackenzie simply stated, “They [School B administration] want us to do it”, while Kacey demonstrates the support of the administration: “Now as far as support from administration, we have that, and even supplies, if we go say – we need this, we can get there”. Kim also generalizes administration with “I mean, everybody’s been great, and I have my supplies and that type of thing”.

Therefore, only the new teachers mention Kitty specifically as an initiator, leader, and supporter of EETPD. Teacher perceptions on the leadership of the principal appeared negative from the older, experienced teachers at the school. Candace’s frustration about lack of leadership in how to implement engineering as well as the difficulty of integrating engineering in language arts are valid issues that should be addressed. Previous research indicates that a relationship of mutual trust and respect is necessary to nurture an environment of professional growth (Zepeda, 2012; Fernet, Guay, Senecal, & Austin, 2012), and if not handled carefully, can result in teacher burnout (Schaufeli & Bakker, 2004). The high turnover rate at the school from the previous year also suggests that previous teachers were unhappy under the leadership of Kitty, which might explain the lack of engineering that occurred the previous year.

4.1.6.2.2 Training opportunities

In addition to Candace, Peggy, Sabrina, and Stephanie also attended INSPIRE workshops. Peggy speaks about the impact of INSPIRE and the EETPD opportunities that she has:

> I did, INSPIRE was fabulous. And then, I mean, we did follow ups after that, we've had whole days with Heidi, I remember two days at the administration building with engineers from the groups of the engineers from our city and administrators from, you know, above us, and lots of teachers, and so we did those days, we've done follow up days with just the GT teachers – School A and School B teachers. So we've had quite a bit… (Peggy)

From Peggy's viewpoint, there were lots of opportunities for EETPD in the past, but only for the PACE teachers. Candace's feelings were similar to Peggy's, sharing that the INSPIRE experience gave her confidence: "I went to Purdue so I was real comfortable with it. So if you went to Purdue, you don't have any issues. I think it's hard on the teachers who had, who didn't go to Purdue" (Candace). Yet, Sabrina and Stephanie did not seem to have the enthusiasm or energy that the language arts teachers had towards engineering, despite having attended INSPIRE. Sabrina notes, "My greatest challenges are probably the fact that this whole idea of engineering is fairly new to me", while Stephanie responds, "We have so much to do". Although the INSPIRE experience is repeatedly credited by other teachers as the inspirational event that caused teachers to buy-in, it seems that it was not such an energizing event to all attendees.

It is not surprise that the other teachers emphasize the need for further EETPD. Teachers were lost in understanding how the engineering boat day was going to be implemented.

As Kim explains, “We received a paper that said, ‘This is what you’re going to do Friday’’. At this point, Mackenzie spoke up and explained how the EETPD that she had received the day before was very helpful:

> Mackenzie: And I went yesterday, which I wish everybody could have gotten to go because, unfortunately, I would not be here tomorrow for boat day. But had I been able to be here, it’s really a lot of fun. It’s great. After watching that video, I would love it. We watched that video of the kids doing like they did the windmill and the boat, I can show it to you all today.
>
> Kim: No way.
>
> Mackenzie: It was like, “Oh, I don’t feel nearly as stressed about it.” Even if I was going to be here, I’m still stressing cause I’m going to have a sub and Linda will be in my room. After watching that video, I was like, “Oh, even if I was here, I could do that.” And you could see the kids interacting. It’ll really calm me down. I’ll show it to you. It helped.

This part of the conversation brought to light a discussion about who was receiving EETPD while others were not. Mackenzie explained that, “It’s all first and second year teachers” at School B, while Candace hypothesized, “Well, I think she [Kitty] did it because she knows we’re retiring and not going to be here next year”. Although this is all speculation, the conversation illustrated lack of communication and perceptions of inequity from the principal. Two of teachers advised that they were planning on retiring soon, and so it seems that School B’s transition is not over.

However, the teachers desire training that focused on learning how to integrate the EETPD into their curriculum, rather than yearning for the INSPIRE training, which is perceived as project oriented. Mackenzie openly expresses her desire to become knowledgeable in engineering:

> No - teach me. Teach me how to do it. I mean for me, I'll try anything once with anything, so with being a first year, I was like, "Just teach me now, because for now, I'm not set in my ways, and for now I take constructive criticism rather well, I think. I'm like, "Just tell me, it's not going to hurt my feelings. It's my first year, I'm bound to do something differently than you do it and people make mistakes."

As Mackenzie points out, a reason why the new teachers are more open could be because they are at the beginning of their teaching careers. Kacey, however, has been teaching for eight years but is starting her second year at this school, and indicates that she is open to learning more:

> I think learning to be able to use the depth and complexity of the EDP with every level thinker. Because they can all do it, it just may look different. And I think finding a way to have each child be successful and be able to get through that whole process successfully is probably the biggest consideration. So all that differentiation, leaving things very open ended but still very guided.

Therefore, perhaps the openness to EETPD could be more attributed to being new at the school rather than new to teaching. Despite these positive attitudes, Peggy, due to her positive experience, discloses that she wishes her peers could attend INSPIRE, as engineering in the elementary setting was something she had not heard of previously:

> I would love to see as many people as possible be able to you know, go through something like INSPIRE. I know you've told me in the past that it's not available any more. But I thought that was the greatest thing ever. You know, to be able to get a holistic idea, because here in east State, in going to school, you know, locally for my college degree. It was never even an idea. I never even knew anything about engineering education in elementary schools. And even graduating high school, I personally didn't know anything about engineering, because I went to a small, very, very small school. So I feel like the work you are doing is fabulous for the state.

Therefore, there seems to be a strategic method of distributing the EETPD at the school by the administration, which is not transparent to the teachers. It appears to be based on investing in teachers who will continue to stay at the school long-term, but this is not confirmed. Also, teachers did not necessarily seek the INSPIRE training, but just continued follow-ups focused on integrating engineering into the curriculum.

4.1.6.2.3 Positive working relationships

As far as teachers working together, all of the teachers were complimentary about their teamwork mentality throughout the school. Stephanie shared that they "all work together well", to which Sabrina also added that they "collaborate very well". Despite the large differences in years of teaching experience, teacher seemed to be open to each other's suggestions. Because the teachers realize "that we're all in the same boat" (Daisy) in terms of the EETPD, this helps the teachers rely on each other for brainstorming of new ideas and clarification of concepts. Andrea relates that “work climate is, it’s very team oriented, we do a lot of things, well everything, together. We really stay together with each other so we can get ideas off of each other. So, team oriented”. Kim comments, “Oh my gosh, yes. We depend on each other to help because I was totally lost at the end of this little paper. I didn’t even know what to do”.

Candace mentioned how difficult EETPD could be if it weren’t for an INSPIRE teacher to help them: “And it’s hard on the teachers who don’t have somebody that went to Purdue working with them. That makes it, you know, really hard”. Emily supports Candace’s statement: “And also, we can learn from each other. Peggy has a lot more experience with this, so we can learn from each other too, and have that support”. Having a seasoned teacher serve as a mentor was valuable to the teachers in the discussion at School B, and leaning on peers and colleagues for new ideas and implementation strategies was widespread.

Also, the teachers seemed to share the drive to fulfill mutual goals together, and see the benefits for the students, such as narrowing the divide between PACE and PACK students. Teachers mentioned experimenting with groupings of students this year, something they had not tried before:

> We’ve really worked hard at grouping our students, with a variety of abilities and leadership skills, and it worked out really well Friday and so, I saw that they fed off of each other, everyone brought great ideas, and it was a good experience. But I do feel like it took, I mean it helped having the GT kids along with the PACK

> kids because I felt like they were able to pick up on some ideas. And then retaught, what they thought, you know? So, it worked well. (Peggy)

Despite divided feelings about the leadership, working relationships at School B were positive, as indicated in the results. During the engineering boat day, I observed that teachers worked well together, even though teachers had reported that there was hardly sufficient instructional support to allow teachers to feel prepared for the event. I also observed the teachers interact during a lunch break, and the conversations that transpired were similar to Ballet and Kelchertman's (2009) observations at the Lily campus, where teachers spoke about discipline issues and personal stories. As teachers enjoyed the student engagement and excitement with engineering, and observed success with ability groupings, teachers were motivated to continue the EETPD.

4.1.6.2.4 Management of a heavy curriculum

School B teachers' challenges in managing the workload are unique, mostly due to the structure of the school. Grades 3 and 4 teachers are grouped by subject matter, and teach both the PACK and the PACE students. Daisy, a new teacher, explains how teaching two ability groups throughout the day is challenging, as "we have to really bring it to a high level with our PACE and that's right up their alley, this engineering", while with the PACK students, "it kind of becomes a struggle, especially with them doing it on their own". Peggy, an experienced teacher, also shares the same burden, commenting that her greatest challenge is:

> Definitely the split. You know, going from one side that you're enriching, you're going way above basic skills, and then switching your mindset half your day, and

> going back to how do I get this child to read? Not, how do you get the high level thinking skills? You have to do the high level thinking skills with them, too, so that is a challenge, so it's a balancing in both, and feeling accomplished at both, because it takes quite a bit of energy and planning to do, to do each side.

The mid-day switching of gears seems difficult for every teacher, regardless of whether they are new or seasoned. In addition, Sabrina shares that "they have gaps; some of them have gaps in learning. And that's a very difficult thing to do, plus keep up with the curriculum, to fill the gaps and keep up with the curriculum". As Emily summarizes, "There are varying levels of, how can I say, of skill; skill levels and experiences and in all the grade levels", and differentiating for all of the students' needs is overwhelming.

Although the split was a challenge for the both sets of teachers, the new teachers, however, expressed support from the principal and the implementation of engineering, due to being given more training on integrating into the curriculum, and a day of planning time with colleagues in the same grade and content area. This is in alignment to findings by Torff & Sessions (2008), which determined that the first two years of teaching were when teacher attitudes towards professional development were positive.

The 5th grade teachers do not have to struggle with the ability differences because they only teach one ability group. The state standardized test is administered from the 3rd grade. However, since 5th grade is the last elementary year in this district, it is a factor in placing students in different tracks of education, depending on the score. The state standardized test measures the progress, which stresses teachers. Sabrina reveals, "We are so concerned about the new state standardized test, I am sure you have heard about that.

And it's more rigorous and it's more in depth, and the kids just aren't where they need to be yet" (Sabrina, Sabrina). Because of the state standardized test, standards are mentioned more than ever throughout conversations, beginning with Candace opining that the "fifth grade science standards do not align with engineering at all", but then indicating that engineering "does align with that cause the one thing they [students] can't do on the state standardized test is think. And I think the engineering will help them to think. So, in that area, I think they align beautifully".

Furthermore, new initiatives in the curriculum are numerous. Sabrina spoke of, "a science CBA, curriculum based assessment" that was in place and how the teachers were stressed about "making sure we hit all those check points". Others agreed; Megan brought up that, "We have a lot of new things, RPI, I can't remember what those initials are. They're underneath that thing [pointing to a heavy book], AY". Peggy generalized that "there is so much more in our curriculum, that we have to get to", including Destination Imagination, another piece of the science curriculum.

Lastly, those that are supposed to be experienced in EETPD lack consistency. First, there seems to be some disagreement on how to implement engineering. Candace speaks about her frustrations:

> They need to make up their mind are they going to let us do it like we've done it this week on a Friday, or are they going to, do they want to just integrate it throughout the year in the classroom? I'm not real optimistic that integrating it throughout the year will ever happen.

She expounds further on the difficulties of integrating engineering into language arts:

> We looked hard for books that we might read that would have engineering ties. We asked Heidi to, if she knew anything. There's just very little literature that has any kind of engineering connection. Maybe Sally Ride and, you know the first astronaut. But that's really a… first woman astronaut, that's really a stretch.

This is a puzzling finding, as the EiE units in the INSPIRE training are intended to extend the existing curriculum (LaChappelle et al., 2011), and evidence of integration and transfer is present with School A teachers. Peggy, another language arts and reading teacher, explains that although she feels comfortable in repeating the events that she learned at INSPIRE, she is hesitant in trying new activities because she feels inadequate and lacks confidence:

> And so the activities that I've had hands on experience with, those that we did at Purdue and those that we replicated here during development with each other - I do feel very confident in those, but when you're getting into, like new stuff, like the boat thing, I was a little hesitant there because I mean I had to do my research, I had to do my homework and study up on it because it, because I'm not naturally inclined towards the science curriculum.

Peggy's lack of confidence is in line with Sabrina's earlier statement that engineering is still unfamiliar. Sabrina disagrees with the engineering days that Candace seeks, and declares that rather than "shut down everything", she desires "chunks" of engineering:

> I would like to be like not spend the whole time doing one project, [but] like, this is what we are doing for this amount of time in science, we could implement this engineering and still teach these science skills, that type of… practical.

Peggy and Sabrina seem most focused on learning how to integrate and gaining practical strategies that will help her complete tasks that are required from the curriculum, as is Stephanie, who does not comment on the correct way to implement engineering, but rather, that "we haven't done nearly enough". There is a lack of consistency with the teachers that attended INSPIRE, but this might be because Candace does not have the challenge of teaching two abilities, while Peggy, Sabrina, and Stephanie do.

The new teachers have similar issues as well. While teachers understood the value of engineering and multi-disciplinary connections, many of the teachers had prioritized concerns that needed to be addressed:

> Jocelyn: I think implementing the engineering needs help, because we're still tying it in our curriculum and stuff. It helps you see that you can't be tied into your content area, because where we first started, it sounds like – uuhhh, but now it makes more sense. We're actually going through it.
>
> Desiree: Even though it makes more sense, it is difficult. You know, with the population of children that we deal with, trying to get them to do, you know, what the basic things let alone . . .
>
> Kate: And then, we're working with kids that really have a hard time reading even, in third grade.

All: Yes.

The packed curriculum mixed with the split of teaching two abilities are major hurdles to overcome, and although the majority of teachers are making efforts to “incorporate with the curriculum that required already” (Kaila), it appears that the teachers are struggling, especially those in the humanities. Kim describes her worries about lacking engineering knowledge:

> I guess maybe, my confidence is lacking because I really don’t have… on the things I’m familiar with, I know the words to use to kind of guide them in the right direction. And I guess maybe that’s my lack of confidence tomorrow.

Daisy, another language arts teacher, shares about the difficulty of integrating engineering into her content area:

> I feel like I have a good understanding and now my struggle is just how to implement it with reading, language, art and social studies. Where we can justify having it. It's just hard to, we have so much crammed in our curriculum it's hard to bring that over so we have to really do a good job at integrating it, with our math and science too.

In Daisy’s case, lack of engineering knowledge was not the issue, but finding appropriate times to integrate into her language arts curriculum, as well as finding the time to work with the math and science teachers. However, the newer teachers seem to have a more a positive attitude and willingness to try. Therefore, the majority of the teachers desire further training to integrate engineering into their curriculum despite the difficult workload, but note that the curriculum plays a large role in their work climate.

4.1.6.3 Discussion

The teachers of this study identified four factors that contribute to an ideal work climate for a successful implementation of EETPD. These factors were (1) strong leadership by the principal, (2) equal access to training, (3) positive working relationships with peers, and (4) management of a packed curriculum. However, the literature casts a different view on these factors. Although the significance of teachers' work environments were highlighted by recent research, the literature reveals that the leadership of the principal and positive working relationships of among teachers influences factors such as access to training or managing a packed curriculum. To begin, the impact of leadership is a key factor in work climate, as found in the work of Boyd and colleagues (2011). Their study revealed that administrative support was the strongest predictor of retention, while dissatisfaction with administrative support lead as the most influential reason for leaving of first-year teachers. Ladd (2011) conducted similar research, confirming Boyd et al.'s conclusions that "among the working condition factors, the dominant factor, by far, is the quality of school leadership" (p. 256). The next predictor for working conditions was time for planning and collaboration, which was also confirmed by the teachers in this study. Ladd connects the two with "evidence that leadership works in part through providing opportunities for professional development, giving teachers more roles and providing time for collaboration and planning" (p. 256). Therefore, the literature suggests that inequity in training is connected to the leadership of the principal. Johnson (2006) presents principals and leadership as the "brokers of the workplace conditions… who hold formal authority in the school, supervises the work of teachers, and serves as a link between the school and the community as well as the district office" (p. 16).

Johnson, Kraft, and Papay (2011) also discovered that working conditions matter to teachers, and most relevant were the three elements of school culture, leadership of the principal, and the relationship with their colleagues, which align to the findings of this study. However, Johnson et al.'s study differs from the above research by alleging that although the principal is one of three key elements that contribute to the work environment, "school culture is developed, enacted, and supported by both the principal and the teachers" (p. 30). This indicates that although the principal has a major role in school culture, teachers also work with the principal to build a culture of collaboration. This is more obvious in School A's work climate, but in School B's climate, it was apparent that the experienced group of teachers were suspicious of the principal, which contributed to their "tense" work climate. Both buildings did not have INSPIRE training for their whole campus, but School A teachers did not demonstrate negative feelings toward their principal, unlike School B, where some of the teachers were divided in their respect towards the principal.

The need for a more flexible curriculum is also a factor in the work climate, as the current one is rigid and limits the teachers' creativity. Johnson's (2006) NEA report titled, "The Workplace Matters" indicated that teachers are in need of a "comprehensive but flexible curriculum that allows for meaningful accountability" (p.18). Teachers mention the minute-by-minute breakdown of script, and that they struggle to fit everything into the school day. This aligns to research literature that identified time pressures and workload as one of the main sources of teacher stress (Kyriacou, 1987, Kyriacou 2001). However, Ballet and Kelchterman's (2009) qualitative case studies on elementary teachers' experiences with an increasing workload reveal that working conditions can alleviate increasing intensification, a concept by Apple (1986) that explains that the teaching profession is intensifying due to external pressure of accountability and performing tasks without ample time or resources. Teachers from four Belgian primary schools were chosen as participants for interviews. Findings revealed that working conditions could either reinforce intensification of workload or act as a buffer to increasing demands. For example, at the Lily campus, lunch breaks were often a time where teachers could share about issues and provide emotional support for each other, building mutual trust and a sense of unity. In the case at Rosetree, however, a teacher expressed dissatisfaction with the principal's leadership style, which negatively affected her ability to deal with other changes in the workplace. Ballet and Keltcherman's findings suggest that despite the packed curriculum that exists in the schools of the their study, if the work climate consists of quality leadership and positive working relationships with peers, feelings of intensification in the workload can be ameliorated. Previous literature suggested that good working conditions are important to teachers, and was confirmed by the findings of this study.

To conclude, the two factors that played a key role in a nurturing an environment for professional grwoth were strong leadership of the principal and positive working relationships with other teachers. These two factors can ameliorate circumstances such as unequal access to training or a heavy workload. Because School A's work climate was notably more stable and positive than School B, this could potentially explain why School A had a stronger implementation of EETPD, although this merits further study. Strong support from local engineers also drove the EETPD implementation, which I examine next.

4.1.7 Engineers in the Community

A unique factor that contributed to a successful implementation of EETPD was the development of strong partnerships with engineers. Teachers welcomed and exerted effort in building solid relationships with the engineers in the area, as both parties viewed their involvement with each other as mutually beneficial. Various sources of engineers were part of School A and B's network, but the relationships initially began with the media. According to Kyra, when the superintendent made the announcement of engineering initiatives in School A and B, "The daily news ran an article about it, and then the guy from [local engineering firm] saw the article and he contacted us". Brody, the engineer that contacted the school, spread the word in the large engineering firm in the city that specializes in the oilfield and power transmission segments. From Brody's advertisement within his company, a few engineers stepped up to volunteer their services during school events. One of the engineers within the firm, Steven, the president of the local Society of Professional Engineers and encouraged his members to attend school events and share their expertise when teachers were in need. In addition to outside engineers, the teachers also have a good number of internal connections. Mackenzie related that quite a few teachers' "husbands or fiancés are engineers. Like, we asked

Daisy, her fiancé. He's in engineering for textile. And Kayla's husband is a petroleum engineer" (Mackenzie). Lastly, many of the parents within the school were engineers and volunteered to participate in engineering activities, such as Candace, who was "lucky in that I had a father (in the class) that was an engineer", or Paula, who shared, "We are given so much. I know last week one of my parents is an engineer. He came in and assisted me". Emily also spoke about a student's father who was an electrical engineer: "Last year we had a parent who came in, one of our students, Mr. Hill, who came in and he works at Lockheed Martin, he came in and he did an excellent piece."

When the teachers were asked about why there was so much support from the engineers, Candace responded that the engineers "love to come and interact with the kids" and that the "dad that was here, just thought it was wonderful. He was so excited we were doing it". Sarah described how the engineers are "hands-on, you know, and they help, and interact with the kids, it's really good". Peggy revealed that Brody was "one of the actual grandparents" of a student at School B. Peggy mentioned "I've had a father of students that you know, actually a couple, we've had two different engineering fathers come and so… I mean it helps when it is directly related to their own children". Regardless, teachers valued the positive interaction that the engineers had with the students.

These strong partnerships with engineers were seen as "instrumental" to the EETPD movement at the schools (Kyra). The engineers fulfilled a variety of roles; they: (1) supported the teachers as engineering experts, (2) encouraged the students as influential members of the community, and (3) offered different professional perspectives to the teachers. Paula described that her student's parent "reinforced what I was saying with the kids", while Emily's parent served by having a Q&A session: "He had a slide show and a presentation, and the kids got to ask questions and that was really good". Sarah observed the engineers:

> Come in to the classrooms, and they just get right down on the level with kids, and do the projects with them… They model, and then they interact with the kids, they don't do it for them. They interact with them. Yes, they asked questions, and get kids to think.

Not only did they serve as experts to the students, but to the teachers. Daisy shared about how her fiancé taught her about engineering:

> Before I met him, I had no idea really what engineering was. I just thought it was a smart person thing and about math and science. But he is a civil engineer so just knowing him, I'm constantly asking questions. OK. What exactly is this? And so as far as I knew, the engineer was a designer, not the laborer or worker. So I did have a good understanding about it and that really helped me. I know a lot of things about civil engineering because that's what he's going into. So I did have a good, kind of some background on it.

Daisy's level of confidence in engineering was supplemented by conversations that she had with her fiancé, and Erin saw it as supplemental research: "It's just another bit of research in actually having experts coming help us".

Teachers also viewed the engineers as positive members of influence. Since the engineers were from their community and spoke of their occupations, students were more likely to entertain engineering as a possible career choice. Peggy admitted to influencing even her own child: “I’m encouraging my own 4th grader. ‘ You’d be really good at engineering, you know.’ I can encourage, especially girls who don’t feel comfortable, like I did, that you can do this! Candace emphasized the value of the praise students received from the engineers: “He was very, very encouraging to the kids. And so, you know I think it’s a really good thing. I think it’s really important”. They served as role models for the students, and aimed to give back to the community in whichever way they could, such as “nights at the hospital where they served hamburgers” and participated in the after school program to “provide whatever we need, to everybody” (Jasmine).

Engineers also served as different professional perspectives to the teachers, resulting in a mutual learning experience. Teachers began to understand the way that engineers think: “I think with them, they think on a different level than we do. I mean we think on teaching level, but they think on a . . . actually doing it and taking it, and you know”. Kacey and Jasmine share about learning from each other and seeking to expand opportunities:

> Kacey: We grew to understand better what they do, while they grew to understand that what we’re trying to do. It was a really neat thing to me, because we all come like, ohh. So that’s where they’re coming from. This is where we’re coming from. It’s two very different points of view. It’s the educator versus the real agony.

> Jasmine: They seem to truly enjoy when they come in talking to the kids, and try to really get a grasp of what we're teaching, in order to know how they can help, and then also try to grow that, at a high school, and then, I'm not sure about the middle school, what they've done there but, they are working towards that.

Gender differences also impacted the different professional perspectives, as Kate pointed that "they're all males, so they have that different kind of… perspective". Since all of the teachers at both schools are female, having the male perspective was different than the norm. Interacting with the engineers helped the teachers gain understanding from the engineers' perspective, and "came in and gave us ideas. They kind of brought it to a deeper level" (Daisy).

Efforts to sustain the partnerships with engineers occurred with the initiation of administration, teachers, and engineers alike. Peggy advised that Kitty "sent out an email to the engineers", while Jasmine spoke about a special science day that invited engineers and various members of the science community:

> We have a certain special day when we were invited our engineers to get in there school wide. So, we have science, different fields, we have science high school science teachers come in, we have people in the community that work behind the scenes, even at our Zoo, anything that had a connection with science, but our engineers also came in, and taught classes, and the kids rotate to different classes and hear about different things that retain to science.

School A seemed to Steven as “kind of our contact person when we need something, we just text or e-mail him and he can come” (Kyra), which implies a friendly relationship, while School B seemed to consider Brody as their main source of contact: “That’s Brody, he’s really into coming to schools” (Kate). This is in addition to Daisy and Kate’s internal connections, that Mackenzie counts as “two right there that have already said, ‘Yeah, I come to the school whenever it works with the project to talk to the kids’”.

Engineers also initiated training with the teachers. Jasmine recalls, “We’ve been invited to their meetings, we’ve even been invited to their industries, and starting training with engineers”. Peggy recounts being “invited to luncheons and… there have been a few times were there were opportunities to go”. Quarterly meetings were also held with both schools in attendance:

> We had, we also last year started, we had like quarterly meetings after school where, it was a little bit later than after school but we met with, they got food and provided food and we met with the engineers from [local engineering firm], those that could make it and the teachers and there were teachers from School A that came over and we all kind of talked about what we were doing, what we can do, that kind of stuff too. So that was good too.

Lego Robotics also played a role in building the relationships with engineers. Sarah explains that “during this [after school engineering] club last year, we made use of Lego robotics as part of it”. Kyra shared that “we had engineers from [the local engineering firm] come, when we were doing the LEGO’s”. Many participated in the after-school club at School A, and now ”are involved with our high school, with the robotics team” (Jasmine).

The findings of this study disclose that teachers value the support from engineers in the community, and that it is an influential factor to the success of EETPD. The literature on the impact of engineers working in the industry interacting with the teachers in local schools is slim, although working with engineering firms and businesses are often recommended as part of an outreach plan. An example of this is an ASEE Leadership Workshop (Douglas, Iversen, & Kalyandurg, 2004) that produced six key guidelines for improving K-12 engineering education, including hands-on learning, interdisciplinary approach, standards, use/improve K-12 teachers, making engineers “cool”, and finally, partnerships. This guideline defined the need for practical engineers to enter the K-12 arena to teach about their field, make engineering “cool”, and highlight the societal good that engineering produces (p. 13). Tate et al. (2010) also describes a nine year old partnership between State Tech University and a variety of other engineering education organizations. The researchers specify that this partnership served “as a key strategy in making initial overtures to schools and teachers nine years ago” (p. 388). In other words, the presence of engineers as a support can encourage teachers to invest in engineering.

The roles of engineers in the schools have been noted in the literature. Change the Equation (2012), an organization of businesses that seek to propel the STEM movement, promotes partnerships with STEM companies, advising such organizations could make up for deficiencies in knowledge and help in designing or implementing initiatives. This was evident with the relationships that teachers had with the engineers in the community, as they served as experts in engineering by both supporting and leading engineering activities, and also serving as subject matter experts when designing lesson plans.

An aim of the engineering movement was to increase the number of young people pursuing engineering careers, and the teachers of this study confirmed that students were becoming more open to engineering. Peggy specifically spoke about reaching out to girls, a target audience:

> I can encourage, especially girls who don't feel comfortable, like I did, that you can do this [engineering]! And so, I absolutely think that it changed things. I mean, I'm encouraging my own 4th grader. Yeah really, "You'd be really good at engineering, you know. Do you want to go to Purdue?

In addition, the makeup of the study's location consists of a large number of minorities, which was also a target of engineering outreach. However, there was no assessment of whether exposing engineering to these underserved populations made an impact in the career tracks of students in this city. Although the teachers feltthat interacting with engineers was "very encouraging" to the students, this anecdotal evidence must be rooted in empirical evidence, a point that Bogue, Cady and Shanahan (2012) make in their research, and therefore, should be explored in further studies.

A benefit to both teachers and engineers as a result of collaboration was providing mutually beneficial expertise from different professional perspectives (Swift & Watkins, 2004). Rushton et al. (2002) illustrated this point in his study comparing EETPD programs. As described earlier, the Tufts University GK-12 project consisted of graduate research fellows being paired with teachers to integrate engineering concepts into the classroom. Fellows were expected to spend two full days in the classroom a week, and also spend time with the teacher outside of school hours to collaborate on ideas and prepare for activities. As a result, teachers reported learning basic or upper-level engineering principles, while engineering fellows gained knowledge about pedagogy from engaging with experienced teachers in developing engineering curricula, and observing teachers while participating in classroom events. Although this study illustrated gains from the perspective of engineering graduate students, teachers reported similar results with their interaction with the engineers. Daisy shared about the ideas the engineers provided, and that engineering is “brought to a deeper level”, while Kate elaborated that “we think on a teaching level, but they think on an actually doing it and taking it”. A newfound respect was gained by both parties expanding their professional perspective, as Kacey explains, “It was a really neat thing to me… so that’s where they’re coming from. This is where we’re coming from”, which Jocelyn adding that, “In the future, that will help him to give us feedback”. NSF fellows participating in the Tufts’ study acknowledged that skills central in “breaking down complex concepts to present material in an understandable manner” developed throughout the partnerships. Fellows also found the experience useful in addressing someone who had little or no engineering background (p. 24), which the engineers experienced as well by gaining the experience interacting with teachers with little engineering knowledge.

One unique factor about the participating schools in this study was the prominence of engineers who desire to be involved in the outreach opportunities. Few EETPD programs work with engineers active in the industry to develop curricula for EETPD or participating as engineering expert on a regular basis, unlike the schools in this study. As described in the results, engineers in the city initiated contact with the schools first, seeking opportunities to be involved in the local schools. This is not the norm, where previous literature encourages schools to reach out to create partnerships (Douglas et al., 2004; Change the Equation, 2012). Engineers attended an all-day planning session to meet with teachers to clarify engineering principles and brainstorm ways to implement engineering into the curriculum, as illustrated in previous research (Rushon et al., 2004, Fontenot & Chandler, 2005). On special engineering events, engineers supported teachers by sharing their expertise in a supportive role, and also lead engineering activities themselves, allowing the teacher to observe and deepen their knowledge of engineering, as suggested by Swift and Watkins (2004). Teachers also mentioned that gender played a role in perspectives as well, since all of the engineers were male, while the teachers were female. Engineers also strove to become positive role models in the community by volunteering at the local hospital, or building LEGOs at the after-school engineering club (Rogers & Portsmore, 2004; Brophy et al., 2008), which allowed students to interact with positive male role models.

The high involvement with engineers is due to the various reasons. First, teachers had bigger breadth of parents to choose from, since both buildings are magnet schools for gifted students. Teachers reported that many of the parents were professionals who were willing to come in and present for the school. Second, the city of the buildings is home to a large engineering firm, as well as several smaller engineering businesses. Engineers from this business also belong to a state engineering society, which has a large focus on outreach to the community, so engineers were encouraged and excused from work to participate in community outreach events. Lastly, the teachers have spouses that are engineers and can garner support from their departments, so the network of active engineers at their disposal is large.

Although the teachers were insistent on how the support from engineers contributed to the implementation of EETPD, recent research suggests caution and planning in maximizing these efforts. Bogue, Cady, and Shanahan (2012) contend that in comparison to the large amount of money invested in engineering outreach, reported to be estimated to be around 400 million dollars, outreach efforts have marginal impact. Emphasis was placed towards reaching the underserved population of girls and minorities, and therefore, changing the students' idea of who can be an engineer (Bogue et al., 2012, Bogue, Shanahan, Marra, & Cady, 2012). The findings of this study confirmed that of the engineers that volunteered, all were male, and the majority is Caucasian (one is Hispanic). Although means to implement this would be valuable, this does not mean that the presence of engineers on campus was misleading, as teachers spoke of encouraging their students to become engineers, regardless of race or gender. Teachers overwhelmingly mentioned how the support of engineers in the community motivated and aided the teachers in their implementation of EETPD.

The strong support from local engineers in the community was perceived as instrumental to the EETPD effort, and was considered a key factor in a successful implementation of EETPD. Although the literature suggests being careful about choosing volunteers in order to present the right message, teachers in this study perceived engineers to be a contributing factor to the students' career aspirations. Exploring the possibility of training engineers, as suggested by Bogue et al., is a valuable suggestion, as the engineers could act as an extension of intensive workshops such as INSPIRE, by meeting with the teachers on a regular basis to discuss integration of engineering. This possibility also extends to reaching out to retired engineers that would be more amenable to substantial outreach efforts.

A key finding of this study is that strong partnerships with local engineers can be a contributing factor for a successful implementation of EETPD as demonstrated by the teachers' perspectives in this study. Engineers serve as subject matter experts, positive role models, and provide an opportunity to experience different professional perspectives. Next, I evaluated teachers' perspectives on measures of EETPD success.

4.1.8 Measures of Success

The last set of questions in the NSDC survey revealed changes in teacher attitudes and beliefs as a result of the EETPD. Teachers revealed that their top motivation for change was the student engagement in their learning, followed by the learning of practical instructional strategies, and enjoyment of the EETPD experience. Efficiency in teaching, a meaningful EETPD experience, positive impact in student achievement, and improved teaching were also indicated as changes that occurred as a result of EETPD. A positive impact on student behavior, pride over accomplishments, empowerment in new ways, and being able to meet the needs of all students were also changes that were noted.

Table 4-7 Changes in attitudes and beliefs of teachers

As a result of EETPD, my attitudes and beliefs about teaching and learning change when:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree	Mean
My students become more actively engaged in learning	16	15	4	0	0	4.34
I learned practical instructional strategies	15	16	4	0	0	4.31
I've enjoyed the experience	18	11	5	1	0	4.31
I am more efficient or productive as a teacher	15	14	6	0	0	4.26
The experience was meaningful to me	15	14	6	0	0	4.26
I can see a positive impact on student achievement	15	13	7	0	0	4.23
My teaching becomes more effective	14	14	7	0	0	4.20
It has a positive impact on student behavior	13	15	7	0	0	4.17
I feel proud of my accomplishments	12	16	7	0	0	4.14
I become empowered in new ways	14	12	9	0	0	4.14
I have learned to meet the various needs of all of my students	13	13	9	0	0	4.11
It connects to district needs and overall school improvement	11	15	8	1	0	4.03
I receive positive feedback from my supervisor	12	14	8	0	1	4.03
It impacts my annual performance evaluations positively	10	14	10	1	0	3.94
My efforts are recognized	11	12	11	0	1	3.91

Teachers also reported that the EETPD connected district needs and overall school improvement and lead to receiving positive feedback from supervisors. Teachers also perceived positive impact on annual performance evaluations, and that their efforts were being recognized.

In the qualitative data, ways to measure a successful implementation of EETPD included student engagement, evidence of student success, and high incorporation into instructional practice. When teachers experience their students' engagement in their learning, it spoke to the draw of engineering. Paige's reaction toward engineering was that, "I get really excited seeing them involved in things. And going, 'Wow'. They think [engineering], even in simplest of lessons, are super cool" (Paige). Candace described the students during the campus-wide engineering boat day:

> All the kids were involved. They were excited about it. Our kids loved making the sails. There was a lot of discussion, a lot of… I mean just a lot of thinking. I could really see their little wheels moving. They loved sailing their boats. They got a lot of satisfaction out when they improved their design. (Candace)

Citing student engagement in their learning as a measure of EETPD success was not surprising. Skinner and Belmont (1993) argue that student engagement influences teacher behavior, in that "positive student engagement elicits positive teacher behaviors" (p. 578). With the struggles that the teachers faced in both buildings with the PACK students, it made sense that when students showed interest in learning, that it was a motivating factor for teachers to continue the implementation, as shared by the teachers of this study.

Evidence of student success was also a way to measure the success of engineering. As Emily states, "You would see improvement in the student products, I mean, if we compare to, you know, what we did two months ago". Stephanie affirmed that teachers believe solid evidence of effective EETPD would result in "data showing student growth because of the professional development".

Archibald and colleagues (2011) mentioned that a "worthwhile" TPD goal "may be to increase student engagement or improve student behavior, which may or may not result in improved academic achievement" (p. 3), echoing earlier sentiments of the teachers of this study. It is unknown whether district priorities and goals focused on improving student behavior or engagement in learning, but teachers in this study found that to be a substantial reward from their perspective.

Another measure of a successful EETPD was that it would be highly incorporated into the teacher's instructional strategies. An example of this is Kim's classroom, where she claims, "If you walked into my classroom, it would scream fundamentals… It was very powerful. I love it, so it's successful". In Kim's situation, it was not only apparent in her teaching, but visually in her classroom as well. Camilla extended this idea of persistence when teachers were passionate about EETPD: "If it's really something you really want to implement, it's something that was really well-received, you're going to keep doing, or find different ways to tweak it and make it your own".

EETPD was successful when students are engaged in their own learning, when there was evidence of student success, and teachers utilized engineering frequently throughout their teaching. However, when measuring the success of engineering, a rise in standardized assessments was the weakest measurement. Teachers acknowledged that "it may or may not" (Kacey) cause a rise in student achievement, while some felt that it promoted "thinking skills" (Candace) that would help in raising student achievement. EETPD does promote student engagement in their own learning, which many teachers note as a motivating factor: "It is engaging for the kids, its hands on, the discipline, what we're doing on the engineering lesson, is almost null, zero problems, because they are so engaged, and so into what we're doing" (Jasmine). High integration was dependent on further training, but the more teachers developed a deeper understanding of engineering, teachers advised that it became a way of thinking, "I think the more you get used to it, it's kinda like a way of thinking, and so just to actually pull it into a lessons cause you're thinking like it" (Camila).

Findings regarding measures of EETPD success correspond with previous literature stating that effective TPD should cause a rise in student achievement (NSDC, 2009; Garet et al., 2001; Darling-Hammond, 1999). Teachers acknowledged that there was no evidence to prove that engineering had a positive effect on student achievement, but the belief that it improved the student's analytical skills was prevalent through the data. Although research has shown that engineering improves scores in math and science (Lachapelle et al., 2011), there is no assessment in place to indicate whether students are improving. Teachers acknowledged that students were gaining in their engineering content knowledge, as Patricia mentions encountering a kindergartner whose older brother had taught him the concept of technology:

> I started giving some examples and one little friend, the nurse's grandson, he said the exact words, what did he, we were talking about it this morning, something that's man made, that it helps us to get what we need, or helps us get something. I

> was like: “Where did you hear that?” he said: “My brother told me.” His brother is here, he came last year and went here to School B. (Patricia)

Following this progression, School B teachers should receive more students that have a base of engineering knowledge. Sabrina reported this as true, but somewhat inconsistent:

> Well it’s strange, because I did in some and in some I didn’t, like the beginning assessment, you know, used to be everyone say: “What’s an engineer?” and all of them think it’s someone who drove a train. But this year I only had, now I didn’t go through and look really carefully, but I only had two or three that said: “I don’t know what engineer is.

Teachers were able to identify growth in engineering knowledge as both schools begin to integrate it into their classrooms. Whether students achieved gains in standardized tests remains as a basis for further study.

Finally, success of EETPD can be measured when it is highly evident in the teacher’s instructional strategies. The teachers that most exhibited high integration of engineering were the PACE teachers at School A, who also seem the most knowledgeable in engineering content and practice. Archibald et al. argue for stronger assessment of TPD by suggesting job-embedded TPD that builds in continuous feedback. This suggestion seems like a worthwhile endeavor in the context of this study, although it is unknown how teachers would respond. However, in the context where state engineering standards exist, the inclusion of job-embedded EETPD and continuous feedback is a possibility. This method would ensure that there is indeed a high integration of EETPD in the classroom. *Therefore, the findings of this study identified measures of EETPD success as student achievement, student engagement, and high integration into instructional practices.*

CHAPTER 5. CONCLUSION

Recent attention towards increasing the STEM workforce (Jobs For the Future, 2007) has caused a wave of educational reform by integrating STEM subjects into the curriculum. The ultimate hope is to influence young people to veer towards STEM career paths (Van Meeteren & Zan, 2010). One movement that is gaining traction is engineering (NAE, 2009), stimulated by research that an introduction to engineering in the formative elementary years can be an influential period to plant the seed towards has the potential to grow the number of young people aspiring for STEM careers (Rogers & Portsmore, 2004; Brophy, Klein, Portsmore, & Rogers, 2008). With the growing adoption of the Next Generation Science Standards, in which engineering plays a large in role, the need to prepare elementary teachers with basic engineering content knowledge is increasing. Since content knowledge and situated practice are necessary to teach a subject well (Bruner, 2004; Lave & Wenger, 1991), teachers must experience engineering in context. Although engineering is gradually included in more pre-service teaching programs, in-service teachers must rely on teacher professional development as a way to properly equip themselves. Therefore, the need to examine the teachers' perspectives on an implementation of elementary engineering teacher professional development is necessary to identify factors necessary for success. In the specific context of the elementary setting, the research questions were:

1. From the teachers' perspective, what is a successful implementation of TPD? What does it look like? How can it be measured?

2. From the teachers' perspective, what work climate or environment is necessary for implementation of EETPD? How are relationships with administration and community members' participation initiated and sustained? What role(s) have they played in the EETPD?

3. From the teachers' perspective, how much value is placed on each of the four characteristics of effective TPD, as defined by the NSDC (2009)? Are there any additional factors that are crucial for EETPD?

The research framework used for this study was a qualitative multiple case study, in order to produce an "intensive, holistic description and analysis of a bounded phenomenon" (Merriam, 2009), which is the implementation of EETPD in the two schools. A case study was appropriate for the research questions, as there were the teachers' multiple realities, knower and respondent co-created knowledge through the focus groups and individual interviews, and the researcher collected this data within their buildings, their natural setting (Denzin & Lincoln, 2011). Through conventional qualitative analysis (Glaser & Strauss, 1967), themes arose from the data that were presented in the form of assertions and descriptions. Inquiry of this dissertation explored teachers' ideas on a successful implementation of TPD, and how to measure the success of the EETPD.

5.1 Main findings

The first research question centered around teachers' notions of a successful implementation of EETPD, and ways to measure it. When teachers defined a successful implementation of TPD, they revealed three additional crucial factors in addition to the four characteristics of effective teacher professional development: opportunities for teacher buy-in, a nurturing environment for professional growth, and strong partnerships with engineers. The first research question focused on teacher buy-in and measures of success, since work climate, partnerships with engineers, and the four characteristics of effective professional development were examined in closer detail in the remaining two research questions.

Teacher buy-in was generated when multiple levels of relevance were demonstrated to the teachers. When teachers saw the value of implementing engineering in the classroom, teachers were more willing to invest the level of commitment necessary to learn, plan, and implement engineering on a classroom and a schoolwide level. When teachers were (1) excited about EETPD, (2) participated in active learning activities, (3) had a firm understanding of the rationale behind the EETPD, (4) viewed evidence of student success, and (5) were more efficient through the use of EETPD to achieve existing goals, teacher buy-in was generated. Generating teacher buy-in also included working actively with those resistant or not present at the time of implementation.

Teachers identified measures of EETPD success with evidence of student achievement, student engagement, and high incorporation of engineering in practice. Teachers acknowledged that observing formal and informal rises in student achievement should measure the success of engineering. Teachers shared about witnessing growth in the informal classroom assessments, but were hesitant to declare an impact in standardized assessments. Students engaged in learning and took ownership of their products, which was also considered a measure of success. The last measure of EETPD success was when there was a high incorporation of engineering in everyday teaching.

The second research question focused on an ideal climate for an implementation of EETPD, and description of how their implementation of EETPD was established. Teachers identified the leadership of the principal, equal access to training, positive relationships with their peers, and management of a heavy curriculum as key factors. However, upon further examination with the literature, circumstances such as unequal training opportunities or a heavy curriculum improved by strong leadership from the principal and teacher relationships. Therefore, the two factors that had greatest impact in nurturing an environment of professional growth consisted of strong leadership of the principal and positive working relationships with other teachers.

Strong partnerships with engineers were also explored as part of the second research question. Engineers played a key role in the implementation of EETPD. Teachers expressed a high sense of satisfaction with the amount of support they have received from the engineers. Initiation began with an engineer reading about the EETPD in the local newspaper, which then spread among co-workers in the same company. Both schools had a contact person, who gathered engineers to participate in their events, while some at School B had personal connections. Engineers served as experts, role models, and offered different professional perspectives. Efforts to sustain the partnerships were made by all parties with invitations to special events and meetings.

The third research question involved teachers evaluating the EETPD according to the characteristics of effective TPD and any additional factors necessary to the successful implementation of EETPD. Evidence that the EETPD was intensive, ongoing, and connected to practice was present, but varied greatly, depending on whether the teacher had attended INSPIRE or not. Although results on the NSDC survey indicated that teachers gave high marks for participant satisfaction and learning from the EETPD, the qualitative data revealed that teachers who had not attended INSPIRE felt that their training was not intensive enough, and expressed the need for *a solid foundation of engineering knowledge*. Teachers expressed *the necessity of a practice-run through of engineering activities beforehand to cement engineering concepts*, and that the current schedule of *training every semester was ideal*.

Engineering was a success in regards to student learning. When the teacher had a deep understanding of the EDP, it applied to a variety of subject matter, engaged students in problem solving, and nurtured teamwork skills. The NSDC survey results corroborated the evidence of student learning from an observational standpoint, as it did not necessarily reflect on classroom or standardized assessments. However, despite the flexibility of the EDP, teachers continued to struggle to integrate engineering into their current curriculum and subject matter. Teachers sought *specific training on integration, and materials that were appropriate to their grade and subject matter, such as kindergarten and reading, writing, and social studies*. Although teachers have expressed interest in INSPIRE training, teachers overwhelmingly sought help in integration and practical strategies over daylong projects. Even those teachers who had attended INSPIRE events sought training on integration.

The NSDC survey results on organizational support and change indicated that teachers were aware of campus improvement priorities and goals, which focused on meeting state standards and raising student performance on the state standardized test. Since engineering standards did not exist on a district or state level, teachers expressed frustrations with the challenge of integrating engineering into their already heavy curriculum. Teachers were required to focus on creatively incorporating engineering to meet their state standards, which advanced teachers felt more comfortable to do than beginners. Teachers viewed engineering to be a way to help students think deeply, and therefore perceived it to be a tool in raising student performance, although it has not been proven as of yet.

The EETPD served as a wonderful way for teachers to collaborate and learn from each other. Through the EETPD initiative, PACE teachers shared the common experience of attending INSPIRE, and stayed committed to bring engineering onto their campuses. After engineering spread to the rest of the campus, these teachers served as mentors to less experienced teachers, and requested more planning time with their grade levels and content areas. Much of the engineering success in these schools emphasized the strong working relationships among teachers.

5.2 Implications

This study contributes to the body of knowledge of engineering education research and teacher professional development. Implications are divided below for the audience intended.

5.2.1 Administrators

For administrators, this study served to highlight what teachers valued and expected from a high quality EETPD, and that social work relationships played a central role in balancing the heavy workload and time pressure that teaching entails. Implications for administrators consist of the following:

1. Administrators should consider influencing the district officials to integrate the EETPD into the curriculum to avoid intensifying the workload of teachers. Obtaining the support of the district will help teachers connect the EETPD to the school improvement goals, and present engineering as part of a comprehensive improvement plan.

2. The administration may also consider the means to supply teachers with the same quality of training and consistent follow-up to support teachers in the EETPD adequately. This involves incorporating days for EETPD into the school schedule before the year begins to collaborate on setting a plan in place before teachers begin classes.

3. Administrators will benefit by allowing teachers opportunities to buy-in before beginning a program. Demonstrating multiple levels of relevance to the teachers'

goals will more likely result in a strong commitment to implement the engineering in the long term. In addition, this act of partnership between the administration and teachers will improve the flow of communication and trust.

4. Finally, administrators can act as mediators for the teachers by establishing partnerships with professionals in the community. Bringing engineers from the community to collaborate with teachers can be an influential motivator and support system for teachers, encouraging the implementation of engineering as well as building a sense of community.

5.2.2 Developers

For developers and researchers of EETPD, this study provides implications that highlight the current needs for the primary level. Implications for developers and researchers consist of the following:

1. Developers of EETPD should always consult with a teacher advisory board to discuss and design towards the affective aspect of teachers. Since teachers must often attend TPD that is unrealistic or irrelevant to their individual realistic practical classrooms, developers should begin by demonstrating multiple levels of relevance in their initial presentation. Exciting teachers' passion by providing a positive learning experience for teachers is an important goal for EETPD.

2. Developers should highlight the need for a practice run through as part of the EETPD curriculum. Unlike other topics where teachers do not have to complete the same activity as the students, since teachers are not familiar with engineering

concepts themselves, participating in the engineering activities before student implementation often helps teachers develop a deeper understanding of engineering concepts.

3. Developers must consider the difficulty for teachers to embrace engineering when engineering is not incorporated into the school improvement goals or district and state standards. For states where engineering is not incorporated into the standards, developers will benefit from customizing the EETPD to cover current state standards. As the findings of this study showed, when engineering helps teachers cover what is already required in a way that engages students, teachers will be more willing to invest the time to learn about engineering.

4. Developers need to create engineering curriculum that are grade and subject appropriate. Findings of this study revealed large gaps in early childhood and reading, writing, and social studies. Developers should seek to fill this void by collaborating with early childhood and humanities teachers, university researchers, and professional engineers to create literature, lesson plans, and appropriate connections in the engineering curriculum.

5. Developers should consider presenting past student work and artifacts from successful engineering implementations as tangible evidence for teachers. When teachers can view how students have grown from exercises in the past, and see how this should transfer to their own students, benefits from engineering become more concrete.

6. Developers should also consider creating a TPD for administrators on best practices for integrating engineering in the primary levels. Administrators need training on how to generate teacher buy-in for engineering, and also how to handle resistors by establishing good lines of communication. In addition, training on establishing a life-cycle of EETPD at their building is also recommended, as teacher turnover results in an influx of new teachers. Developers can help administrators set up mentoring relationships among teachers and leverage the excitement of teachers to serve as evangelists among the resistors and new teachers.

7. Developers can also integrate participation from professional engineers in the community into the EETPD. Although it does not need to be required for the engineering curriculum to function, recommending the input of engineers in the community by incorporating engineers' expertise in certain activities fosters teachers' motivation to reach out and develop relationships. Engineers in this study were highly motivated to contribute to the engineering movement in their community, and developers can give recommendations to teachers by leveraging the engineers' knowledge in certain contexts when appropriate.

5.2.3 Facilitators

EETPD facilitators can have the greatest implications from the findings of this study, as it facilitators have much impact in presenting engineering to the teachers. Implications for EETPD facilitators consist of the following:

1. EETPD facilitators have the unique position to customize the EETPD even further by studying the various curriculums that exists at the district and building level, and work with a teacher advisory board to tie the different subjects together to create a comprehensive program. When facilitators begin a new relationship with a district or school, effort to learn as much as possible about the district or building's unique curriculum structure and school improvement goals is recommended, so that teachers will see engineering align with the requirements that the teachers have to fulfill.

2. Facilitators should always consider various methods of disseminating engineering pedagogical content knowledge, and offer options before implementing a particular EETPD structure. Options can include a weeklong intensive training session before school starts, developing staggered phases of training rather than an intensive week, all depending on the needs of the teachers. This allows teachers time to learn, plan, implement, and meet again to reinforce and correct any misconceptions. Teachers can then build upon that knowledge, experiment, and then reconvene again to reinforce and so forth.

3. Facilitators must work to embed follow-ups as part of the EETPD process, although this does not need to be in a face-to-face context necessarily. The idea of online teacher professional development was proposed by Liu and colleagues (2009) as a potential "way to deliver highly effective just-in-time and individualized support to in-service teachers" (p. 110), something that could be explored with the schools in the future. Monthly hour-long webinars could easily

fit into a conference period or afterschool session, and this would allow facilitators to check up on the progress and offer just-in-time expertise to struggling teachers.

4. Additionally, EETPD facilitators can prepare to act as a mediator between professionals in the community and teachers by inviting local engineer societies or firms to attend EETPD sessions to foster mentor relationships, plan activities, and encourage participation in scholarly activities such as engineering education conferences. Facilitators can help with the legwork of establishing relationships along with the administration, which make the connections that the EETPD curriculum calls for more of a reality.

5. Facilitators could also train engineers to interact with teachers to maximize their expertise in elementary pedagogy. Since both teachers and engineers come from different professional perspectives, it is important to train engineers on the obstacles that teachers might have. Since there are many engineers in the area, a program could be designed to have weekly visits with the teachers to collaborate on lesson plans and deepen engineering content knowledge. Though training engineers to become better providers of EETPD to teachers could be difficult to implement, as it is a voluntary act, networking with retired engineers in the community could be an interesting concept.

5.3 Limitations and suggestions for future research

When considering the findings, a few limitations need to be considered to understand that whole picture.

5.3.1 Sampling

First, purposive sampling must be kept in mind. Though the sample size of twelve (12) teachers for the individual interviews qualifies for the concept of saturation as described by Guest, Bunce, and Johnson (2006), it is still dependent on the quality of thematic analysis.

5.3.2 Perspectives of administrators and engineers

The themes and opinions in this study strictly represent the teachers that participated in the study. This is not to be taken as a true representation of any other persons mentioned in the study, as the researcher did not consult the administrators or engineers for verification of facts. However, because a deeper look into teachers' perspectives provided useful implications for EETPD, to conduct similar subsequent research studies from:

1. The administrators' perspectives while implementing EETPD and engineering activities. Little research has been completed on the struggles that administrators experience when implementing engineering, especially in a state where no engineering standards exist. Further insight on the difficulties of handling turnover, "selling" engineering to their already stressed teachers, finding financial funding support from the district, as well as working with resistors would be an extremely beneficial endeavor. This would allow TPD developers could create best practices for administrators beginning to implement engineering in their buildings.

2. Administrators' perspectives on the changing needs of teachers as engineering becomes an established practice in their building. Findings of this study

suggested that teachers' needs changed from the beginning of EETPD towards when teachers became more advanced in their knowledge. Gathering data from various administrators' experiences on the changing needs, as well as how this affected their responsibilities could prove to be beneficial in developing long term support for both administrators and teachers.

3. The engineers' perspectives while participating in the implementation of engineering. Engineers, in turn, could offer the same type of knowledge – understanding their expectations while volunteering for engineering implementation in the schools, how engineers feel the engineering could be improved in the schools, as well as how to best utilize engineers as part of a comprehensive EETPD program. Much is unclear of how to best use engineers' time and expertise, and understanding the perspective of how engineers would prefer to help could help developers in creating natural connections in the curriculum.

5.3.3 Researcher as EETPD facilitator

While conducting the data collection, the researcher also served as an EETPD facilitator. It is possible that some of the opinions towards evaluating the EETPD in both the qualitative and quantitative data collection were affected because of this connection. However, the researcher feels that it was not to a disadvantage, as she was able to build trust with the participants and gain knowledge about the setting through informal, personal communication. Subsequent similar qualitative studies where the researcher does not serve as an EETPD facilitator could shed light on whether the results of this study were biased or not.

5.3.4 NSDC Survey Results

As noted in Chapter 3, the NSDC survey was disseminated before the researcher arrived onto campus. However, some teachers participated in the survey after the researcher facilitated EETPD training, which could have influenced the scores of the survey. Because of this limitation, not much weight was placed on the quantitative results of the survey. Administering the survey again without the researcher facilitating EETPD could be a useful way of measuring true feelings towards the EETPD experienced by the teachers.

5.3.5 Transferability

Lastly, a limitation of this study, common with qualitative research methods, is that the degree of transferability of findings to similar contexts. The results of this study cannot be considered conclusive. Future research in similar contexts could confirm and expand the foundation of knowledge that was provided by this study.

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APPENDICES

Appendix A Recruitment Email

Dear ______,

Good afternoon and thank you for taking the time to look over my email! My name is Nikki Boots, and I am a doctoral student in the Learning Design and Technology program at Purdue University. I am contacting you in regards to a research study I am conducting in Lufkin. Because you, as a teacher, administrator, or community member, played a significant role in the engineering teacher professional development at School B and Lufkin, it would be great to have your perspective to achieve a comprehensive outlook. My dissertation research topic is titled, “Examining the Teachers’ Perspective on an Implementation of Elementary Engineering Teacher Professional Development”, is focused in understanding all of the elements that were necessary for to make an implementation of teacher professional development flourish, as the engineering program has in Lufkin.

I am attaching a document with more information about the study (Informed Consent Form). If you are willing to participate, I would like to set-up a time for a short interview (approximately 30 minutes - 1 hour) for my visit to Lufkin, if possible. Please note that your participation is voluntary and your responses will be kept confidential. I look forward to hearing from you!

Best,
Nikki Boots, PhD Candidate
nboots@purdue.edu

Appendix B NSDC Survey Consent Form

Thank you for your interest in participating in our research study. Please take a few minutes to read the information sheet below before you start to fill out the survey. At the bottom of the page, you may choose to continue by clicking the appropriate buttons.

Information Sheet

Examining Teachers' Perspectives on an Implementation of Elementary Engineering Teacher Professional Development

Principal Investigator: Dr. Johannes Strobel
Co-Investigators: Nikki Boots & Dr. Heidi Diefes-Dux
Purdue University
Learning, Design & Technology

Purpose of Research: The primary goal of this research project is to examine the teachers' perspective on successful implementations of teacher professional development, as viewed from the framework of the four characteristics of effective teacher professional development (TPD; National Staff Development Council, 2009). We seek to learn what elements teachers find crucial in creating an environment that is conducive to fostering a successful implementation of teacher professional development. This includes 1) the climate and environment that the teachers work in, 2) their relationships with the administration and the community, 3) the process of how administration and community support was initiated, and 4) determining the motivations of the administration and community in supporting a particular TPD program.

Specific Procedures: You are being asked to participate in a web-based survey, where you will be asked to provide demographic and evaluation information related to your teaching career and teacher professional development training. The data collected will be used in the research and dissemination process. The survey is adapted from the National Staff Development Council's Professional Development Survey, written by Christine Lowden (2005).

Duration of Participation: This survey will take approximately 10 – 15 minutes. This is the total duration of your participation in this study.

Risks: The risks to you are minimal. The standard for minimal risk is that which is found in everyday life.

Benefits: There are no direct benefits implied or offered. You may not benefit at all if you are part of the study.

Compensation: There is no compensation implied or offered.

Extra Costs to Participate: There are no extra costs for the purpose of participation in this study.

Confidentiality: The project's research records may be reviewed by departments at Purdue University responsible for regulatory and research oversight. You understand the researcher will do everything possible to maintain your confidentially and privacy. All data will be either stored in a secure drawer or cabinet in the office of the lead researcher at Purdue University or on a designated computer server with login and password protection. All names and identifiers will be removed from data prior to any data analysis. Unauthorized personnel will not have access to the data. Interviews will be digitally recorded, and transcribed, then stored on a Purdue server until the study has concluded, at which point, it will be deleted. Material from this research will be used by the researchers in presentations at professional conferences, published research articles, and teacher professional development.

Voluntary Nature of Participation: You do not have to participate in this research project. If you agree to participate, you can withdraw your participation at any time without penalty.

Contact Information: If you have any questions about this research project, you can contact Nikki Boots at nboots@purdue.edu or (714)222-3233 (first contact), or Dr. Johannes Strobel at jstrobel@purdue.edu or (765)494-3887. If you have concerns about the treatment of research participants, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is (765) 494-5942. The email address is irb@purdue.edu.

Documentation of Informed Consent: By clicking the continue button, I am indicating that I have read the information sheet and I am choosing to consent to participation in this research study.

Appendix C Professional Development Survey

Please begin by taking a few minutes to complete this questionnaire. Please be assured that your answers will be kept strictly confidential.

SECTION 1 - Please tell me about yourself:

Name:

Email address:

Grade level currently teaching: (check all that apply)
Kindergarten
- 1st
- 2nd
- 3rd
- 4th
- 5th

Building
- School A
- School B

Subject or Content Area

Teacher Professional Development Process (General) - This section concerns ALL teacher professional development.

I am aware of the goals of my district's Professional Development Plan.
- Yes
- No

My district's Professional Development Plan is linked to overall school improvement and increased student achievement.
- Yes
- No
- Not sure

My district's professional development plan is related to the teacher evaluation process.
- Yes
- No
- Not sure

Professional development in my district is offered: (check all that apply)

- o During the school day
- o Before and/or after school
- o On conference days
- o At the end of the school year (the week after school closes)
- o At the beginning of the school year (end of August/early Sept.)
- o During the summer
- o On my lunch hour
- o On weekends
- o In the evenings
- o Online
- o Other ____________________

Who decides the content of teacher professional development in your district?

- o District Level Administrators (1)
- o Building/School Level Administrators (2)
- o Grade Level or Department Chairperson (3)
- o Professional Development Committee (4)
- o Teachers (5)
- o Combination (6)
- o Other (7) ____________________

Please list the topics of the last 3 teacher professional development opportunities offered to you by your school district in which you participated: (e.g. technology, learning styles, brain research, differentiation)

Elementary Engineering Teacher Professional Development (EETPD) - This section concerns only elementary engineering teacher professional development.

In which types of engineering teacher professional development activities have you participated? (check all that apply)

- o INSPIRE Summer Academies (Purdue Campus)
- o Workshops or seminars with University Researcher (1/2 day or 1 day)
- o Working with a mentor teacher/team teaching
- o None

List any other types of engineering teacher professional development experiences you have had that are not mentioned in the previous question.

How many years have you participated in INSPIRE's Elementary Engineering Teacher Professional Development?

- o 0 - 1 years
- o 1 - 2 years
- o - 3 years

How many hours total have you spent working with INSPIRE's Elementary Engineering Teacher Professional Development?

Section TWO - About Elementary Engineering Teacher Professional Development (EETPD)

Statement: EETPD in my school district:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Meets my needs					
Is nonthreatening					
Is offered at a time convenient for me					
Is time well-spent					
Is offered by instructors who are knowledgeable and effective					
Is generally a positive experience					

Statement: Because of EETPD, I have learned:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Practical instructional strategies					
New knowledge and skills					
The theory behind the practice					
New concepts connected to prior knowledge					

Statement: EETPD in my school district:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Has a positive impact on the organization as a whole					
Has a positive impact on the culture and climate in my school					
Is often conducted during the school day					
Leads to in-service credit or a stipend					

Statement: EETPD in my school district is recognized as being extremely important by the following	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Board of Education					
District Administrators					
Building Administrators					
My Colleagues					
Myself					
Parents					

Statement: After I have participated in an EETPD experience, I usually:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Go back and experiment or practice with new instructional strategies					
Implement/apply new instructional practices					
Become committed to new teaching strategies					
Note positive changes in my teaching					
Make long-lasting changes in my teaching					

Statement: Generally, EETPD impacts my students in the following ways:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
It makes a positive impact on my students' learning					
Student achievement increases					
Students are more engaged in learning					
Students are involved in their own learning					
Classroom management has improved					
Student achievement has risen on state or district assessments					
Student achievement has risen on teacher or classroom					

assessments					
Students' confidence as learners has improved					

Statement: As a result of EETPD, my attitudes and beliefs about teaching and learning change when:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
The experience was meaningful to me					
I learned practical instructional strategies					
My teaching becomes more effective					
I am more efficient or productive as a teacher					
I've enjoyed the experience					
I become empowered in new ways					
I have learned to meet the various needs of all of my students					
It has a positive impact on student behavior					
My students become more actively engaged in learning					
I can see a positive impact on student achievement					
It impacts my annual performance evaluations positively					
I receive positive feedback from my supervisor					
My efforts are recognized					
I feel proud of my accomplishments					
It connects to district needs and overall school improvement					

Appendix D Teacher Participant Consent Form

TEACHER PARTICIPANT CONSENT FORM
Examining the Teachers' Perspective on an Implementation of Elementary Engineering Teacher Professional Development
Principal Investigator: Dr. Johannes Strobel
Co-Investigators: Nikki Boots & Dr. Heidi Diefes-Dux
Purdue University
Learning, Design & Technology

Purpose of Research: The primary goal of this research project is to examine the teachers' perspective on an implementations of teacher professional development, as viewed from the framework of the four characteristics of effective teacher professional development (TPD; National Staff Development Council, 2009). We seek to learn what elements teachers find crucial in creating an environment that is conducive to fostering an implementation of elementary engineering teacher professional development. This includes 1) the climate and environment that the teachers work in, 2) their relationships with the administration and the community, 3) the process of how administration and community support was initiated, and 4) determining the motivations of the administration and community in supporting a particular TPD program.
Specific Procedures: You will engage in the following activities: an online demographics survey and a semi-structured focus group interview (~60 minutes in length). If selected, an additional semi-structured interview (~60 minutes each in length). The focus group interviews will be audio-recorded and transcribed by researchers. The data collected will be used in the research and dissemination process.

Duration of Participation: The duration of participation will be from August 1st, 2012 to June 18th, 2013.

Risks: The risks to you are minimal. The standard for minimal risk is that which is found in everyday life. There is risk of breach of confidentiality. However, safeguards are in place to minimize the risk of breach of confidentiality, as outlined in the Confidentiality section.

Benefits: There are no direct benefits implied or offered. You may not benefit at all if you are part of the study.

Compensation: There is no compensation implied or offered.

Confidentiality: The project's research records may be reviewed by departments at Purdue University responsible for regulatory and research oversight. You understand the researcher will do everything possible to maintain your confidentially and privacy. You are aware that, due to the nature of focus groups, the researchers cannot control what focus group members might share outside of the research environment. All data will be either stored in a secure drawer or cabinet in the office of the lead researcher at Purdue University or on a designated computer server with login and password protection. All names and identifiers will be removed from data prior to any data analysis. Unauthorized personnel will not have access to the data. Interviews will be digitally recorded, and transcribed, then stored on a Purdue server until the study has concluded, at which point, it will be deleted. Material from this research will be used by the researchers in presentations at professional conferences, published research articles, and teacher professional development.

Voluntary Nature of Participation

You do not have to participate in this research project. If you agree to participate you can withdraw your participation at any time without penalty.

Contact Information:
If you have any questions about this research project, you can contact Nikki Boots at nboots@purdue.edu or (714)222-3233 (first contact), or Dr. Johannes Strobel at jstrobel@purdue.edu or (765)494-3887. If you have concerns about the treatment of research participants, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is (765) 494-5942. The email address is irb@purdue.edu.

Documentation of Informed Consent
I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research project and my questions have been answered. I am prepared to participate in the research project described above. I will receive a copy of this consent form after I sign it.

_______________________________________ _______________________
Participant's Signature Date

____
Participant's Name

_______________________________________ _______________________
Researcher's Signature Date

Appendix E Focus Group Interview Protocol

Defining Success

1. How would you define a successful implementation of teacher professional development?
    a. What does that look like?
    b. How is it measured?

Understanding the Process

1. How would you describe your work climate and environment?
    a. Are there any unique factors or changes in your climate or environment?
2. How would you describe the role that your administration played in the EETPD?
    a. Who are they?
    b. How was initial contact made to support this EETPD?
3. How would you describe your relationship with the community?
    a. Who are they? (List members involved in EETPD)
    b. How was initial contact made to support this EETPD?
    c. What role have they played in your TPD?

Insight on the four characteristics of effective teacher professional development

1. From the teacher's perspective, how much value is placed on whether EETPD is intensive, ongoing, and connected to practice, as in
    a. where new knowledge and skills are gained?
    b. where the EETPD is implemented for a sustained period? How long of a period would you say is necessary?
    c. where learned knowledge is applied to teachers' planning and instruction?
2. From the teacher's perspective, how much value is placed on whether EETPD focuses on student learning and address the teaching of specific curriculum content, such as
    a. focusing on how students learn and understand the content?
    b. learning how to teach the content effectively?
3. From the teacher's perspective, how much value is placed on whether EETPD aligns with school improvement priorities and goals, as in
    a. where the EETPD aids in building improvement priorities?
    b. where the EETPD aids in meeting district goals?
4. From the teacher's perspective, how much value is placed on whether EETPD builds strong working relationships among teachers, as in
    a. promoting collaboration with peers?
5. Are there any factors that were not discussed that you feel are crucial to a successful implementation of TPD? If so, what are they, and why?

Concluding the focus group

1. Using those measures of success as defined earlier, how would you rate the EETPD experienced? Why?

VITA

VITA

Nikki Kim Boots

Learning, Design and Technology, Purdue University

Education

Ph.D., Learning, Design and Technology 2013

Purdue University, West Lafayette, Indiana

M.A., Digital Teaching and Learning 2009

Azusa Pacific University, Orange, California

B.A., Sociology with minor in Education 2003

University of California Riverside, Riverside, California

Professional/Work Experience

Instructional Designer, Dartmouth College 2013 – present

Working closely with faculty to incorporate best practices in instructional design while maximizing educational technology tools and interactive media.

Information Technology at Purdue (ITAP) 2012

Assisting in the transition of online courses from Blackboard Vista to Blackboard Learn. Includes individual faculty consulting to workshop training, with the revision of instruction utilizing ID principles and interactive media.

Institute for P-12 Engineering Research and Learning 2010 – 2012

Research and development of a teacher engineering adoption model and teacher professional development for engineering in elementary settings.

Metallurgy Internship, Fairfield Manufacturing 2011

Developed instructional training modules with the use of Articulate ’09 Software. The focus of the heat treatment of steel and the general carburization process.

Gifted Education Resource Institute (GERI) 2010 - 2012

Funded through a JAVITS grant (’09-14), developing and perfecting engaging online teacher professional development modules for K-6 teachers in underserved areas. Graphic design of promotional materials for youth programs, and development of websites for Project Hope, Native American Research Initiative, and Total School Cluster Grouping.

Teaching Assistant, EDCI 270 2009

Introducing pre-service teachers to a basic foundation of educational technology. Includes the use of web 2.0 applications, creating elective learning modules, utilizing behaviorism, cognitivism, and constructivist learning theories, and digital storytelling

PUBLICATIONS

Boots, N., & Strobel, J. (accepted). Equipping the Designers of the Future: Best Practices of Epistemic Video Game Design. *Games and Culture.*

Boots, N., Tafur, M., Carr, R.L., Strobel, J., et al. (2012). Design Fixation and Cooperative Learning Strategies in Elementary Engineering Education. Paper presented in Paper Session: Exploring Processes, Philosophies, Impediments and Connections in Design and Technology at 2012 Annual Meeting of the American Educational Research Association (AERA). Vancouver.

Sun, Y., Boots, N. & Strobel, J. (2012). EEE (Elementary Engineering Education) Adoption and Expertise Development Model: Conceptualizing, Assessing, and Tracking Elementary Teacherse EEE Adoption and EEE Expertise Development. American Society for Engineering Education (ASEE) National conference 2012, San Antonio, TX.

PRESENTATIONS

AECT Presentation, “K-12 Administrators and Web 2.0 technologies – An Exploration of Possibilities”, November 2, 2012, Louisville, KY.

STEM Goes Rural Presentation, “Online Teaching and Learning Management Systems”, July 11th, 2012, Purdue University, West Lafayette, IN.

ASEE Presentation, “EEE (Elementary Engineering Education) Adoption and Expertise Development Model: Conceptualizing, Assessing, and Tracking Elementary

Teachers' EEE Adoption and EEE Expertise Development", June 10th – 13th, 2012, San Antonio, TX.

AERA Presentation, Design Fixation and Cooperative Learning Strategies in Elementary Engineering Education, April 2012, Vancouver, Canada.

Native American Research Summit Presentation, Digital Storytelling, Ganado, Arizona, 2012.

Gifted Education Resource Institute Advisory Board Presentation, "Progression of TSCG Online Learning Modules", October 12, 2011, Purdue University, West Lafayette, IN.

Teaching Institute for Excellence in STEM (TIES), STEM Learn and Earn Summit, INSPIRE Representative, October 2nd, 2011, JW Marriott, Indianapolis, IN.

NAGC Presentation, "The Instructional Design Process of Creating E-ective and Engaging Online Learning Modules", November 4th, 2011, New Orleans, LA.

AECT Presentation, "Using PBL as a Framework for Implementing Educational Video Games in the K-12 Classroom", October 28th, 2010, Anaheim, CA.

AWARDS

• Purdue Doctoral Fellowship, Purdue University, West Lafayette, IN, August 2009 – May 2013

• 3rd Prize Winner at the Experience Accelerator Game Competition, Stevens Institute of Technology, July 2010, Hoboken, NJ

• Editor of Gifted Children, an electronic journal of the AERA Special Interest Group (SIG) for Research on Giftedness, Creativity, and Talent