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CONVERSATION ANALYSIS OF ENGINEERING PARENTS' OCCUPATIONAL KNOWLEDGE, ATTITUDES AND BELIEFS

A Dissertation

Submitted to the Faculty

of

Purdue University

by

Brianna L. Dorie Brinkman

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For my family near and far (and two who are even farther).

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ABSTRACT

Dorie Brinkman, Brianna L. Ph.D., Purdue University, August, 2015. Conversation Analysis of Engineering Parents' Occupational Knowledge, Attitudes and Beliefs. Major Professor: Monica Cardella.

Broadening participation from a diverse set of individuals is one of the central tenets of engineering education research. Interest in a potential occupation is influenced by knowledge and familiarity as a child reaches adolescence. However, studies have shown that most children have limited information regarding engineers, and this lack of knowledge can often persist into adulthood. Parents are the predominant source of occupational information for young children, and researchers hypothesize that parents socialize their children to be predisposed to their own occupation through informal interactions such as conversations. This is highly evident in the phenomena of occupational inheritance that is prevalent within engineering families.

This exploratory qualitative study investigated the strategies in which engineering parents engage when reading a story about engineering to their young children. Twenty-four parents that self-identified as engineers (through a degree conferred or a job association or other) video-recorded themselves in their own home, reading a provided storybook to their children aged 3 to 5 years. Conversation analysis was used to identify the knowledge, attitudes and beliefs that were shared during the interaction. It was found that engineering parents provide both general and specific knowledge about engineering that

is informed by their own background. However, while engineering parents display positive attitudes regarding engineering, they may not correct inconsistencies that the child may have. The findings from this study will be used to develop materials to inform parents and educators of how to engage in conversations about engineering with young children.

CHAPTER 1. INTRODUCTION

Conversation is an essential feature of human existence, empowering us to interact with others, participate in the exchange of knowledge and information, and even reprogram our brains to work in new ways (Deacon, 1998; Kuhl, 2010). The way we converse impacts not only what we say, but also what we learn, believe, and eventually become (Piaget, 1953; Vygotsky, 1978). Its formative power is perhaps most apparent in the dialogue between parent and child, wherein even the youngest brain is highly bound in the analysis of the exchange (Kuhl, 2010). In a field like engineering education, where recruiting new diverse minds is a foundational objective, there is a profound prerogative to investigate how and under what circumstances conversations about engineering are occurring with our youth -- and what tools may be provided to further enhance their understanding and interest in becoming engineers themselves.

1.1 Changing the Conversation

For the past decade, there has been national concern in increasing and broadening participation in engineering. A more competitive economic market has placed a high demand upon engineering institutions to create professionals that are prepared to enter the workforce (National Science Board, 2010; Council on Competitiveness, 2004). However, there is concern that the United States may not be able to meet this demand due to lagging student enrollment in fields with highly sought technical skills, such as engineering and science (National Science Board, 2010). Part of the shortage is presumed to be due to lack of interest on the part of college-bound students. But also underlying this critical issue is the fact that the general public does not understand what engineering is, or what engineers do, implying that the problem is as much about lack of exposure and misinformation as it is about lack of interest (NAE, 2002).

In 1998, a nationwide poll conducted by Harris Interactive, was commissioned by the American Association of Engineering Societies (AAES) to gauge public awareness of engineering within the United States (NAE, 2002). Results from this evaluation showed that the public had limited understanding of engineering, did not credit engineers with contributions to their quality of life, and had only moderate levels of goodwill towards engineers (NAE, 2008). Thus emerged a major concern that the public perception of engineering could potentially be a limiting factor in the amount of undergraduates studying engineering and eventually entering the field.

Ten years after the Harris poll, the National Academy of Engineers (NAE) published a report, "Changing the Conversation" (CtC) that looked at research-based communicable messages for use in informing the general public about engineering (NAE, 2008). This was a concerted effort to define the status of engineering within the general public, as well as to develop marketing strategies for use by the engineering community and others to promote interest in the field. The new messages focused on the humanistic side of engineering, such as concern with human welfare and creativity. It was hoped that these messages would create a more accurate and positive perception of engineering, as well as resonate more with underrepresented groups (NAE, 2008).

However, to make a persistent change in the perception of the public understanding of engineering, a coordinated and consistent effort to communicate the same ideas to a wide audience is required. The CtC report outlined three different artifacts to use when talking about engineering in any outreach capacity: a position statement emphasizing the engineer's ability to make the world a better place, four market-tested messages, and preliminary taglines. The four messages that tested well were associated with the humanistic side of engineering, and were recommended for use with the associated demographic groups outlined in the report (NAE, 2008):

- Engineers make a world of difference
- Engineers are creative problem solvers
- Engineers help shape the future
- Engineering is essential to our health, happiness and safety

The tagline that engineers "turn ideas into reality" scored highest across gender, age and ethnicity, followed by "because dreams need doing" (NAE, 2008). However, there were differences in teenager's response by gender – girls gravitated to messages that aligned with people, whereas boys were more "thing" oriented (Graziano et al., 2012). A secondary report "Messaging for Engineering" encouraged the engineering community to spread these messages through diverse and innovative ways (NAE, 2013). The main thrust of these reports was to increase the public's knowledge and familiarity with engineering in order to bolster the fields' reputation – and hopefully popularity.

1.2 Case for Early Exposure to Engineering

Knowledge and familiarity with careers can translate into interest as a potential occupation as a child reaches adolescence (Trice & Rush, 1995; Howard & Walsh, 2010). While much attention regarding occupational pathways has been focused predominantly on high school students, there is some recent evidence that highlights the need to intervene at a much younger age. Augur et al. (2005) found that “occupational aspirations and expectations of children undergo dramatic development changes during the elementary years, as well as resisting change in other respects”. At four years of age, children have already formulated firm beliefs about occupations such as doctors, nurses and police officers (Lutz & Keil, 2002; Wright et al., 1995). This means that at a very young age, children have already formed their perception of occupations and that stereotypical attributes have already been firmly established. It is therefore important to introduce engineering at young ages (< 5 years) as to provide a sense of familiarity for future career consideration.

Despite the invaluable opportunity the young mind presents for being positively exposed to engineering, studies have shown that most children have limited information regarding engineers, and the lack of knowledge can often perpetuate into adulthood (NAE, 2002; NAE, 2008; Pearson & Young, 2002). In addition, the field of engineering has fallen prey to stereotypes that are prevalent in both adults and children alike. For example, many young students have associated engineering with someone who operates a train, auto mechanics or construction workers, which are also common associations of adults as well (Pearson & Young, 2002; Cunningham et al., 2005; Knight & Cunningham, 2004). These stereotypes lack the humanistic allure found by the CtC study to be most appealing. If these are some of the prevailing perceptions of children and the adults they glean occupational information from, it is entirely plausible that this misinformation could potentially be impeding children's desire to pursue engineering.

1.3 Parental Role in Occupational Development

It is within the family environment that children are first exposed to the world of work by observing family members and even overhearing conversations between adults recounting their day (Galambos & Sears, 1998). From this informal exposure, young people can construct ideas regarding work and how it applies to them even before they enter formal education (Augur et. al, 2005; Bryant et al., 2006; Savickas, et al., 2009).

Several empirical studies have shown that parents play a significant role in the occupational aspiration and career goal development of their young children (Augur et al., 2005; Bandura et al., 2001; Bryant et al., 2006). Magnuson and Starr (2000) asserted that preschoolers' knowledge about occupations and perceptions about the world of work are shaped by the degree to which their parents expose or teach them about different occupations. In addition, Bandura et al. (2001) found that parents' own beliefs and aspirations were important factors in children's career aspirations. In reviews regarding children's career development (e.g., Hartung et al., 2005; Watson & McMahon, 2005), parents were highlighted as crucial and important figures in developing occupational awareness in their children.

Research in both science and engineering education literature has shown a child's interest is significantly impacted by the parent's viewpoint (George & Kaplan, 1998; Szechter & Carey, 2009). Particular knowledge about a subject, such as science or engineering, can affect the parent's strategies for educating their children (Yun et al., 2010). Parents can also play a variety of roles that can promote engineering learning such as: 1) engineering career motivator, 2) engineering attitudes builder, 3) student achievement stimulus, and 4) engineering thinking guide (Yun et al., 2010). Of specific interest to this thesis is the parental role of engineering career motivator, though the other roles also have a hand in the development of occupational interest. The profound impact of the parent on a child's possible interest in engineering as a career presents an opportunity for early educational intervention. It is even more crucial owing to its potential to have long-lasting effects: retrospective studies involving undergraduate engineering students corroborate the idea that parents are the strongest initiators for engineering career development (Alpay et al, 2008; Trenor et al., 2008). This is especially relevant for low socio-economic students whom enter into engineering (Strutz, 2012).

1.4 Occupational Inheritance

Several studies have found that engineering students often have family members, who are engineers, a correlation that is stronger with females (Seymour & Hewitt, 1997; Mannon & Schreuders, 2007). This occupational inheritance phenomenon, in which offspring follow in their parent's career footsteps, has also been observed in the medical community (Lentz & Laband, 1989; Pinchot, et al., 2008), with lawyer families (Lentz & Leband, 1992), politicians (Kurtz, 1989) and even in NASCAR (Groothuis & Groothuis, 2008). These studies suggest that parent's own deeply held beliefs from their own personal experience are transmitted to their children through parenting action (Bryant, et al., 2006; Caspi et al, 1998). This transmission, whether conscious or not, gradually promotes a pathway for an interested child to learn about, be open to, and possibly mimic a parent's occupational interests. This is not necessarily a formal process, but rather one that occurs in everyday familial interactions. For example, an electrical engineering father might introduce circuits to his daughter at a young age, which may lead to a science fair project on electricity and an advanced course on circuitry during high school. Through interviews with engineer parents, Zhang and Cardella (2010) identified play with particular toys, reading books, participating in around-the-house projects, and engaging in everyday conversations as ways that parents help their children learn about engineering. In other words, these typical parent-child interactions are a mechanism by which parents socialize their children to recognize and develop traits that ensure success in the same occupation to which the parent belongs (Kohn, 1969).

1.5 Occupational Socialization

Socialization, broadly defined, is the process by which a child develops into a member of a certain social group through the learning of social roles (Clausen, 1968). In terms of occupational socialization this means that a child will develop a certain set knowledge, attitudes and beliefs regarding a certain career path that allows them to associate with a given profession. Well before entering the workforce, children process the information around them to form aspirations and define expectations regarding their place in the world in a process called "anticipatory socialization" (Jablin & Putnam, 2001). By learning about different occupations, children identify what types of occupations do and do not identify with their personal views, and the process is an integral part of adolescent maturation into working adults (Jablin & Putnam, 2001).

Parents have been identified as the key-socializing agent in this process by introducing a child to roles within different situations (Brim & Wheeler, 1966; Clausen, 1968). For example, the parent takes a child for a check-up and explains that the doctor will give a shot to make him or her feel better. Or when passing a construction site a young child might curiously ask what the people are doing, at which point the parent will explain that they are using materials to make the road better or to build a tall building. However, though parents have been identified as an important source of occupational knowledge in transactions such as these, the process of *how* they transmit their knowledge, attitudes and behaviors about occupations has received little attention (Wahl & Blackhurst, 2000). Thus the identification of parental socialization strategies concerning occupational knowledge is key to understanding the occupational inheritance phenomena.

1.6 Vocational Development

Over the past decade there has been an increasing shift towards addressing the role of social relationships in a child's career development (Soresi et al., 2014; Blustein, 2001; Schultheiss, 2003). Several models and theoretical approaches recognize the role that the family context, especially parents, have in the process, such as contextual action theory, social cognitive model(s) and the life design approach. These models highlight the co-construction process of career development in which the family is a social system influenced by many factors (e.g., cultural beliefs, ethnicity, lifestyle, etc.).

Contextual action theory places career development in the domain of family and personal goals (Young et al., 2001). In this, the parents and children identify specific goals and actions to favor career development. For example, there are several out-of school activities that children can participate in such as afterschool programs, summer camps and internships that can relate to the engineering profession, such as Project Lead the Way and robotics clubs. There are several reasons why a child may choose to initiate in these activities' such as self-interest, peer pressure, resource availability, time constraints and parental influence. However, the activities that adolescents participate in are not independent of their career development, but rather are immersed in a complex integration of family projects and goals (Young et. al., 2001).

Social-cognitive model centers on self-efficacy and the role that it has in career choice (Bandura, 1986). Depending on an individual's interests and abilities they will tend to focus on activities they believe they will excel at (self-efficacy) and avoid those that will make them feel incompetent. Parents can influence the self-efficacy of their children through favoring certain experiences, providing or creating barriers and providing encouragement for the acquisition of new abilities and/or knowledge (Bandura, 1997, 2012; Lent, Brown & Hackett, 1994).

The life design approach (Savickas et. al., 2009) focuses upon the family context and the way that environments can shape how an adolescent forms their occupational identity. It relies heavily upon social constructionism and the idea that an individual's knowledge and identity are resultant of social interactions and that meaning is co-constructed through discourse.

However, it is noted that the aforementioned models are geared toward adolescents actively considering career paths and do not focus on development at a younger age where several researchers have noted that career development starts to take place (Auger et al, 2005; Hartung et al., 2005; Vondracek, 2001).

Conducting an extensive review of literature pertaining to the relationship of parenting to vocational development, Bryant et al. (2006) developed a model of parental factors that are central to vocational development (Figure 1.1). The model takes into account how a child's development interacts with family contextual factors during the formation of early career construction as well as adolescence. Specifically, the model integrates parenting variables (e.g., accessibility, self-efficacy, responsiveness, etc.) with developmental foundations that lead to vocational outcomes (e.g., informed work choices, work self-efficacy) within the family context (e.g., SES, social capital, family structure etc.). Three developmental foundations are core to the model (a) the development of occupational knowledge, attitudes and beliefs; (b) the development of exploratory processes in relation to interest development; and (c) the development of academic and vocational aspirations, self-efficacy, expectations, plus academic attainment (Bryant et al., 2006).

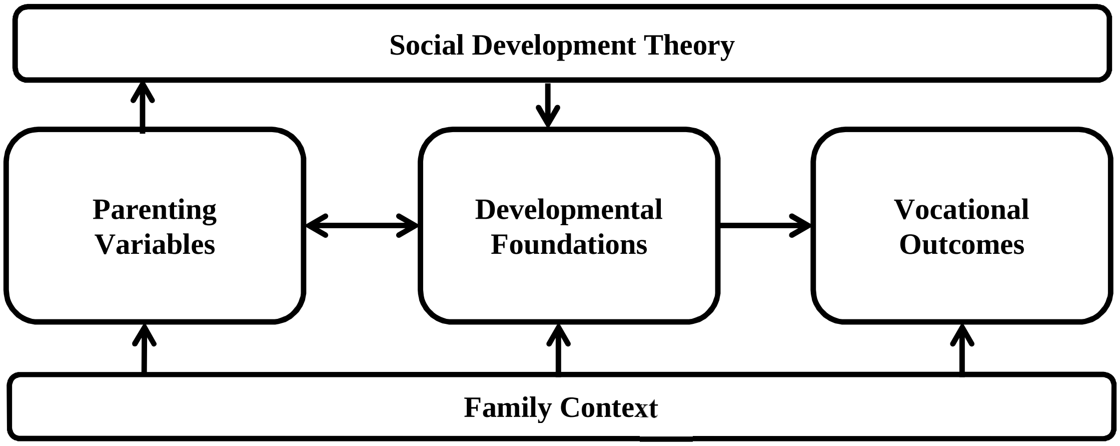

Figure 1.1 Parenting in relation to child and adolescent vocational development model (adapted from Bryant et al., 2006).

1.7 Purpose

The way that parents socialize their children regarding occupations can have profound impacts on the way that the children perceive the occupation and how it can relate to their own self-interests and abilities (Bryant et al., 2006). In terms of the more knowledgeable other, parents with engineering expertise should be able to guide their children about engineering as an occupation, whereas parents with limited knowledge might not be able to assist their child.

Determining the socialization process by which engineering parents engage with their own child, can lend to insights not only about how to discuss engineering with young children, but can also define strategies to assist others with less knowledge about the profession of engineering. This dissertation aims to look at the socialization process through parental interaction using a storybook as a means for generating discussion between engineering parents and a young child. Specifically, the types of discursive strategies that parents use to discuss engineering will be observed through an exploratory qualitative methodology.

Storybooks were chosen as the main catalyst for this investigation due to the direct interaction between a parent and a child in an intimate, informal environment. Storybooks also provide an interactive process where the child interacts not only with the words and pictures on the page, but with the reader in an inquisitive manner (Allor & McCathren, 2003). Thus storybooks allow for observation of dyadic talk focused on the story itself, which in this case is on the occupation of engineering as told through two young protagonists.

The engineering storybook, which development is outlined in Chapter 3, will be used a platform to observe how engineering parents engage with their children when talking about their own occupation. The main research question for this study is: What **strategies** do engineering parents use to facilitate occupational knowledge about engineering to their child when reading an engineering-themed storybook? More specifically:

i. What engineering *knowledge* do parents bring into the reading experience?

ii. What engineering *attitudes* and/or *beliefs* do parents impart into the reading experience?

1.8 Personal Motivation

While it is extremely important to find ways to increase interest in engineering, there is also a more personal impetus for the development of this thesis. My own engineering tale started from a newspaper clipping regarding the top paying and in-demand jobs for the next 25 years (circa 1990). My father wanted financial security for his daughters, so he ~~told~~ encouraged me to become an electrical engineer since it was at the top of the list. I remember that I found this immediately distasteful (since I wanted to set my own path) yet engineering seemed intriguing even though I had no idea what an engineer did. I told him that I would become an environmental engineer instead (to fix the hole in the ozone layer) and thus my journey started!

While my story is not the focus of this investigation, it goes to show the importance of parent-child conversations - just a single conversation with my father at the age of 8 was impactful enough to encourage my entire career path. It is my hope that the findings of this study can help mothers, fathers, educators and caregivers have that type of impactful conversation with young children in the hope that they too will consider engineering as a potential career.

CHAPTER 2. BACKGROUND

Parents have a large role in their children's learning experiences as children typically spend more than 80% of their waking time in outside-of-school settings (LIFE Center, 2005). Additionally research suggests that children develop critical and lasting attitudes towards science at young ages (Pell & Jarvis, 2001), highlighting the necessity of understanding parent-child interactions at this influential stage. This literature review will illuminate the different aspects of how parents introduce occupational interest through the sharing of knowledge, attitudes and beliefs about engineering to young children.

2.1 Occupational Interest

What exactly do parents want their children to learn about occupations, such as engineering, and when do they want this learning to occur? A recent mixed-method study on parental attitudes toward preschoolers' career education found that parents agreed that young children should learn about careers, but that the process should unfold slowly and that children should be sheltered from the complexities of "real work" (Cinamon & Dan, 2010). Common careers such as firefighter, nurse, and teacher are prevalent because they are readily recognizable and have job description that have been simplified for children.

Engineering on the other hand lacks a simplistic explanation due to its complexity and diversity of foci.

Social-cognitive career theory (SCCT) emphasizes that social and cognitive factors play important roles in early career development process, and that it is important to expose children to a variety of activities that relate to occupational behavior (Lent, et al., 1994). Children could potentially be influenced from an array of different contexts such as society (e.g., gender role socialization, socioeconomic status), ethnic background, media, school, home environment and family (Bryant et al., 2006; Lent et al., 1994)). However, through interactions with significant people, children are more likely to gradually develop skills, adopt personal standards, and be capable of estimating their abilities and the outcomes of their efforts (Lent et al., 1994).

As mentioned previously, parents are a significant influence on the occupational interest of their children (Augur et al., 2005; Bandura et al., 2001; Bryant et al., 2006), especially in engineering where the phenomena of occupational inheritance is evidenced (Mannon & Schreuders, 2007). It is therefore of major interest to understand how engineering parents, whom are expected to have intimate knowledge of the field, interact with their children regarding their chosen occupation. Specifically, what **strategies** do engineering parents use to facilitate occupational knowledge about engineering to their child when reading an engineering-themed storybook (RQ)? Additionally, from the Bryant et al., (2006) framework (Figure 1.1) parental factors that relate to developmental foundation focus on the knowledge, attitudes and beliefs that are shared. Thus in addition to the parental strategies outline in RQ there are two additional sub-questions that look at engineering occupational knowledge (RQa) and engineering attitudes/beliefs (RQb), that these engineering parents express during conversations while reading an engineering storybook.

2.2 Occupational Knowledge

Occupational knowledge is the practical knowledge and understanding centered on a job or occupation. It creates both boundaries and expectations regarding professions. For example, in general we as a society would not ask a nurse to design a wastewater treatment plant, nor would we ask an engineer to administer an IV. The specific knowledge of an occupation can be widespread, based on imagery, stereotypes and popular held beliefs to name a few.

Occupational knowledge is influenced by the experience and perceptions of the individual. In particular, a child's understanding of work is influenced by their parents' occupation (Dickinson & Emler, 1992). Between the ages of 4 and 11, children's understanding of the world of work steadily increases and gendered notion are firmly established (Auger et al., 2005).

In years past it was common practice for children to observe their parents at work, however in modern times this has become less common (Galinsky, 1999). Instead most children abstract information about adult work through indirect or even incidentally listening into to conversations about work (Galinsky, 1999). In an exploratory study looking at what engineering parents "do" with their children, a majority of the participants stated that the didn't explicitly talk about engineering as a career, but rather worked on developing key skills such as problem solving (Dorie & Cardella, 2013). While some of the 24 participants mentioned that they took work home with them in some form, several mentioned that their children didn't recognize the parents' occupation as an engineer. So what is the engineering knowledge that these engineering parents share with their children (RQa) and by which means is it shared (RQ)?

2.3 Occupational Attitudes and Beliefs

Occupational attitudes and beliefs are cognitive or affective evaluative dispositions that can be either positive or negative. Occupational attitudes include ability for job advancement, freedom on the job, pay, and social aspects and are often influenced by gender-socialized norms. For example, in a national survey children perceived their parent's attitudes toward work more negatively than the parents do (Galinsky, 1999).

Occupational beliefs are cognitive content held to be true. It includes the types of traits that are necessary for a certain occupation (i.e., engineers need to be good at math and science) as well as prevailing stereotypes that might not be true (i.e., train engineers).

However, there is considerable overlap in semantics between the ideas of beliefs, attitudes, and values. Oftentimes, they are used interchangeably (sometimes in the same study) and have different connotations depending on the context, and research discipline. For the purposes of this study they are assumed to be intertwined and not considered as separate ideas due to their overlapping references.

2.4 Importance of Storybooks

Few studies have looked at the influence of media on the career development of children, though it has been implied as the primary source of occupational learning (Watson & McMahon, 2005). Literature is just one of the compelling mediums used for introducing concepts to children at a young age. However, while the notions of doctor, teacher and firefighter are ubiquitous in young literature, there is a lack of engagement about engineering (Dorie & Cardella, 2011a; Holbrook et al., 2008). In recent years several professions have looked towards storybooks as a way of communicating occupational knowledge. For example, a shortage of nurses in the United States resulted in innovative strategies to encourage more people to enter nursing careers such as the development of storybooks to engage a younger audience (Thomas, 2010).

According to Vygotsky (1978), book reading is an intensely social activity, where social guidance allows children to participate beyond their own abilities (zone of proximal development). Book reading is a very common form of interaction between young children and parents, with young children spending on average 44-52 minutes a day reading books (Rideout & Hamel, 2006). For young children (ages 3-6) the most common use is storybooks, a combination of mostly pictures with minimal text and plot. Storybooks have the ability to present new information, increase stimulation of the imagination, and deliver messages both moral and social through engaging imagery and storytelling (Simcock & DeLoache, 2006). In a school setting, storybooks have been shown to impact kindergartener's mathematical achievement when produced in tandem with a mathematics unit (Keat & Wilburne, 2009). Additionally, storybooks have been shown to facilitate discussion between diverse populations, especially when the characters are appealing to a broad audience (Marshall, 1998). A short exposure to books supporting women in non-traditional roles affected kindergarten children's perceptions of women's career roles, especially for young girls (Barclay, 1974).

2.4.1 Strategies for Reading

When reading a storybook parents structure children's developing narrative skills by posing questions to organize children' s stories or accounts (Eisenberg, 1985). Within reading activities, parents function within a child's zone of proximal development in order to stretch what the child can do with a little assistance from a more knowledgeable other (e.g., Vygotsky, 1978). For more advanced children the level of collaboration is also advanced, as the parent shapes the experience so that the child will take a larger role.

With very young children, parents play several different roles when reading a storybook to their child. They often take on the role of "labeler" when reading books by connecting pictures or representation to the appropriate term (Szechter & Liben, 2004). This allows the child to develop a lexicon of familiar words. As a child grows, both the parental interactions and the books themselves become more complex. For example, parents might start to emphasize relationships between items (Gelman et al., 1998) or inquire about spatial relationships (Szechter & Liben, 2004) rather than just point out labels for a specific object on a page. Crowley & Jacobs (2002) also identified the use of "explanatoids", or short explanatory talk during parental conversations to develop "islands of expertise" about a particular subject.

2.4.2 Conversation around Storybooks

Parental conversations may have an important role in developing occupational awareness of engineering for young children. However, what happens when the parent does not feel confident talking about certain occupations? According to Bandura et al. (2001) parental self-appraisal of capabilities determines what occupational goal aspirations they set for their progeny. So the stronger that parents perceive their own self-efficacy, the higher the goal aspirations they adopt for their children and firmer is their commitment to them (Bandura, 1991; Locke & Latham, 1990).

One potential method of parental transmission of occupational knowledge is through conversations and other verbal interactions (i.e., children listening to parents talk to others) as language is an important part of the socialization process. Other sources include observation, identification and imitation (Clausen, 1968). A recent study found that parents who used more spatial language (e.g.. dimensions – *big, little, tall, fat*; shape terms – *circle, rectangle, square*; and spatial feature terms – *bent, curvy, flat*) in everyday talk, had children that performed better on non-verbal spatial tasks (Pruden, Levine & Huttenlocher, 2011). Lutz & Keil (2002) found that young children have intuitive notions about occupations based upon generalizations that they abstract from real world phenomena. Even preschool age children can distinguish between the kinds of knowledge that certain occupations have. They are able to "cluster" groups of information together to form rudimentary divisions of labor. However, with the youngest children (3 years) they found that even though they could distinguish between what a doctor and a mechanic does, they couldn't extrapolate to broader areas of expertise (i.e., a mechanic might have more knowledge to fix a broken lawnmower than a doctor). A proposed mechanism was that the 3 year olds recognized key words that were more likely to be associated with a certain profession (Lutz & Keil, 2002).

There are few studies that look at the dialogue between parent-child dyads during storybook reading. Webb (2006) focused upon examining the relationship of a father and his sons while reading of different types storybooks over a six-week period. Webb found that certain patterns emerged when reading specific genres of books, e.g., more dialogue and time with narrative books rather than concept books. Thus a narrative was chosen for this study. Additionally Webb (2007) found that conversations flowed from talk about the book to other topics and were often not bound by the text.

2.5 Summary of Key Points

- Career aspirations form at an early age, thus it is important to expose younger children (< 5 years) to occupations
- Parents are important factors in career development of their children
- Engineering parents have specialized socialization practices that are enacted through their own knowledge, attitudes and beliefs.

CHAPTER 3. STORYBOOK DEVELOPMENT

To understand how engineering is represented in children's storybooks a thorough review of existing books was conducted. Due to limited selection of occupational themed engineering storybooks, it was decided that a storybook be developed. This was imperative as the storybook is the central piece in this study as a stimulus for parent-child interactions. However, it is pertinent to note that since the time this study was conceived there has been an increase in the amount and quality of engineering related books available (e.g., "Engibear's Bridge, Goldiblox, etc).

3.1 Review of Engineering Storybooks

In 2011, a search of children's literature was completed using several different online sources using the keyword "engineer" within the confines of fictional storybooks intended for ages 3 to 6 years (Dorie & Cardella, 2011b). To eliminate misrepresentations within the database, each entry was individually examined and coded for age level and application to engineering. Books were not included in the analysis if the content did not contain references to engineers or engineering in the subject headings as designated by Library of Congress. Multiple databases were used to cover a broad expanse of written material and to assess availability of books to the general public (Table 3.1).

The WorldCat database is the most comprehensive online source for catalogued literature for the entire world. Since the keyword "engineer" is more specific than a broad category such as "science", online searches were sufficient to delineate books of this nature. Additional databases were used to include independent published materials that are not included in the WorldCat database.

Table 3.1 Databases for search of engineering books

Type	Locations
Bookstores	Amazon.com, Barnes and Noble, Powell's, Borders
Libraries	Tippecanoe County, Chicago Public Library,
Databases	WorldCat, Worlds of Words

The review of storybooks focused primarily upon works of fiction that incorporate real world lessons. Storybooks are often detailed as a mixture of illustrations with minimal text (< 1 page compiled), for those in young childhood (aged 3-6 years). It was expected that this type of book would be the most widely read for this age group due to limited time commitment and engaging stories. Also since the storybooks are fictional, they help to illuminate certain inherent misconceptions about an occupation, especially if the author is not an engineer. Biographies and non-fiction books were excluded from the study as they are often beyond the reading comprehension of this age level. The Engineering is Elementary books (n=18) are not included as they are primarily intended for in-class use and aren't intended for the specified age range in this study (Cunningham, 2009). The books were analyzed for (1) common misconceptions in engineering, (2) thematic analysis of messages, and (3) implications for learning in and out of classroom. Additionally, the top ten children's picture books (based on record sales) were analyzed for potential application to engineering.

In the Worldcat database using engineer as a keyword, a total of 605 books were identified. A majority of the books were non-fiction (n= 386) and biographical (n = 115) books. Popular historical engineering figures included Herbert Hoover, Thomas Edison, and Henry Ford. Of these, only 41 books had the word engineer in the title, though some were mislabeled due to inconsistencies in the database (Figure 3.1). Particularly, audio and paper engineers associated with production of sound and pop-up books slightly inflated the numbers (n =4). Over half of the books were linked to trains (n =22), showing a potential link as to why young children associate engineers with railways. Of the eleven stories pertaining to engineers, only three were suited within the parameters of the study for the younger age group. The books for older children were delineated by length (> 50 pages), lack of illustrations and complexity of storylines. Additional searches used a combination of the parameters and variation of keywords to exhaust the database. Cross validation of the database occurred through online bookstores and local libraries (Table 3.1).

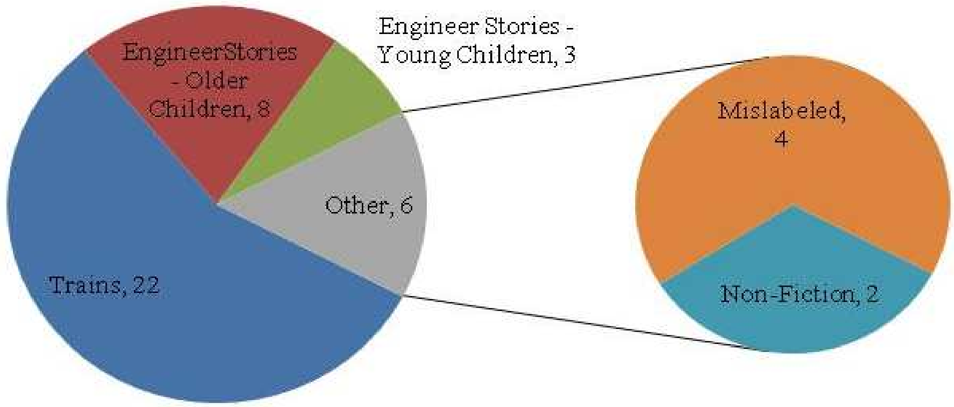

Figure 3.1 Distribution of books with engineer in the title showing a majority of books associated with trains. Only three books were within study parameters.

In total, six fictional storybooks pertaining to engineers were found that ahered with the study boundaries (Dorie & Cardella, 2011a). Of those six, only one touched upon occupational information regarding engineers ("Rock, Jeans and Busy Machines" by Alane & Ramundo Riveria, 2009) but also did not focus on occupational aspects such as where engineers work or what they did. Several of the books didn't even have any engineering imagery that wasn't construction or train related. As none of the existing books at that time focused on the occupation of engineering, a storybook was developed using the messaging recommended by the national report "Changing the Conversation" (NAE, 2008). The development of this storybook is described further in the next section.

3.2 Storybook Requirements

In creating the original engineering storybook for use in the study, several objectives were identified to ensure that it would be an effective and appropriate research tool. The intended focus was to be on the engineer's world of "work" in such a way as to be able to present occupational knowledge, as well as insight into occupational attitudes and beliefs. The plot line needed integrated devices to allow the reader(s) to become an active participant in the story (Shepard, 2000); thus the chosen format was a quest to find the “engineer”. The benefit of this format was that through searching for the engineer, a reader would encounter several artifacts and locations that illuminate aspects of the engineering occupation. The primary objective was to expose readers to information about what the engineer can be, who can be considered an engineer, where engineers work, and what they do. Additional messages included were that engineers work in teams, incorporate elements of design and that they make the world a better place – all messages supported by the “Changing the Conversation” (NAE, 2008).

Several different considerations were taken into effect during the development of the storybook, including plot, text and illustrations.

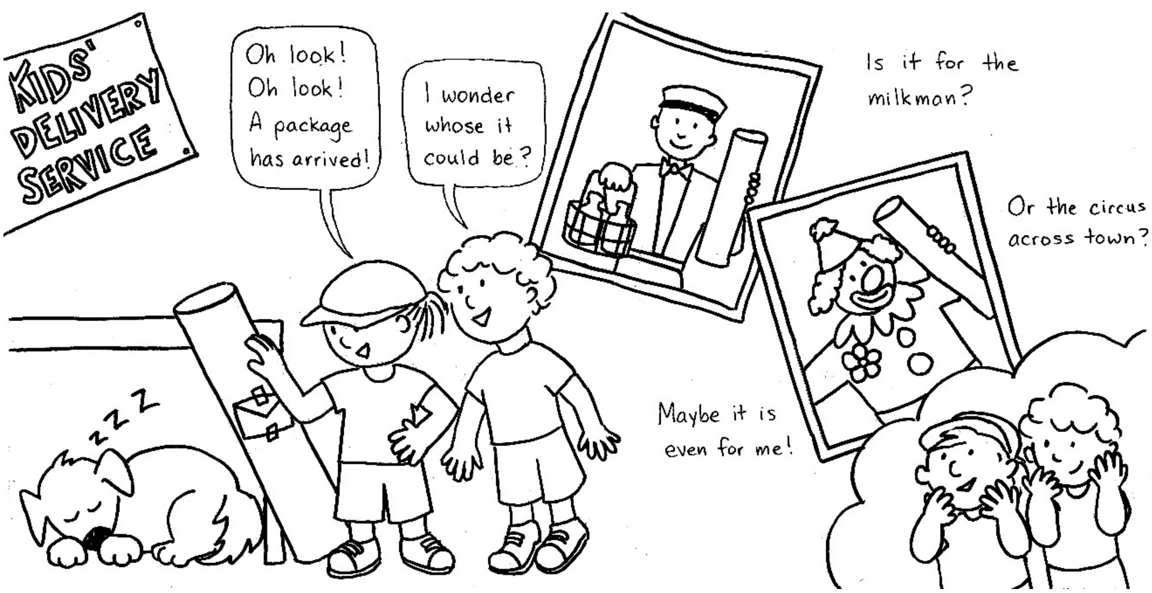

Figure 3.2 Example illustration of the engineering storybook.

3.2.1 Plot

Several different iterations for storylines were brainstormed for the storybook ranging from inanimate crayons working on an engineer's sketch of a playground, to a classroom of kids attempting to build a fort under the watchful supervision of a local engineer. Decisions were made with respect to how relatable the plot was to the intended audience, how the engineering world of work was included and simplicity. Several ideas were abandoned if they were too similar to current books or were unable to share occupational knowledge about engineering.

After much consideration and input from parents, a storyline following two protagonists, an unnamed boy and girl, on a journey to deliver a package to an engineer was settled upon. They are joined by their dog, whose mischievous ways provide for some light humor. Through conversation the children ponder what an engineer is, who engineers can be and where they work – allowing for the text and illustrations to build upon the engineering world of work to expose occupational knowledge, attitudes and beliefs. During the process of the book, the children come into contact with other people, some of which belong to the engineering team that they deliver the package to. The package itself contains blueprints for building a ramp to get ducklings out of a pond that has an eroded bank.

3.2.2 Text

The text of the storybook was developed with several aspects in mind, such as focus on specific keywords, rhyming mechanisms and readability (Shepard, 2000). The storybook purposefully repeated the word "engineer" multiple times (n=8 in text, plus twice in title pages), as research has shown that repetition is important for children to absorb new words (Wixson, 1984; Schwartz, 1985). The mnemonic device of the story was closely related to the old German folk song of “Oh Where, Oh Where has my little dog gone” by Septimus Winner (1864) and had rhyming structures.

Readability was assessed through several different measures: the Flesch Reading Ease, Flesch-Kincaid Grade Level, and Gunning Fog Score. The Flesch Reading Ease score looks at the overall comprehension difficulty through weighted factors such as word and sentence length (it does not take into consideration the difficulty of the concepts). Readability of the storybook was intended to be for 1st graders to allow for easy reading as well as for the dyad to focus on the content and not learning new words (with the exception of the word engineer). The final version of the storybook had a Flesch Reading Ease of 99.6% with a Flesch-Kincaid Grade Level of 1.6 placing that the book is between a first and second grade reading level. The Gunning Fog Score looks at the ratio of the length of sentences compared to the words used, as well as takes into consideration the amount of complex words compared to more familiar words. In the case of this storybook the word “engineer” is considered to be complex (9 out of the 13 complex words presented in the book).

3.2.3 Adaptive Text

Adaptive text that allows for separate passages for children and parents was also used to include more parent-child interactions (Clarke-Stewart, 1998). Two prompts were provided independent of the storyline. The first prompt occurs when the protagonists asked who an engineer could be, with the illustration and text providing several responses: a) the man fixing the car, b) the child jumping rope, or c) the lady who winked. The simple query "What do you think?" was intended to allow the dyad to discuss if the illustrated characters on the page were potential engineers, but also had the potential to inspire further conversation beyond the boundary of the storybook, such as additional qualifiers like education, gender, age, ethnicity, race, etc.

The second prompt was introduced when the main characters asked who the engineers were. In posing the question: "Do you know any engineers?" it was to determine the child's recall of their parent's occupation, and at the same time to see how the parent reacted to the child's answer. Additionally, it allowed for additional engineering connections within the family network.

Several sections of the book were left intentionally vague to facilitate conversation. For example, a blueprint of the bridge was provided but was not mentioned in the text, as were pictures of the airplane turbine.

3.2.4 Illustrations

In addition to parents, depictions of work-related activities of fictional characters in media are an important source of occupational information for youth (Levine & Hoffner, 2006). The fictional characters on TV, books and online act as role models, influencing wishful identification, which is the child's projection into the role, of the occupation of their favorite character (Levine & Hoffner, 2006; Signorielli & Kahlenberg, 2001). It is therefore important that the illustrations of the protagonists are familiar to young children.

After a preliminary version of the text was in place, storyboards were created in which the intended imagery was developed to tie in with the existing text. Both children were purposefully drawn so that no specific cultural or ethnic identity was predominant, allowing a broad audience to identify (Shepard, 2000). The characters in the book were intentionally left uncolored for this reason as well, however the book will be published in full color in the future.

Inclusion of the train and the man working on the car were included to address misconceptions that have been found to be common with young children (Cunningham et al, 2005). Reasoning for the development and inclusion of certain images will be discussed further in Chapter 4.

3.3 Review & Dissemination

An advisory panel consisting of a parent, an illustrator and two engineers assisted with the evaluation of the storybook. Their informal reviews through in-person conversation, as well as exchanges over email, allowed for refinement of the storyline and resultant imagery. Several words were changed to make the text more streamlined and congruent with the rhyming mechanisms.

The book was also piloted with four different dyads (two fathers, two mothers) to evaluate the flow and to determine if the storybook prompted enough conversation for analysis. Additionally, the pilot group read an additional storybook, *Rocks, Jeans and Busy Machines* (Rivera et al., 2009) for comparison of reading styles. The pilot testing also refined the data collection procedure which included how the storybook reading was recorded. The book was printed and bound (via an online company for picture books) in order to lend the book a more authentic representation.

CHAPTER 4. METHODS

The purpose of this study is to investigate parent-child interactions during reading of an engineering storybook to discern strategies for disseminating occupational knowledge of engineering. As this study observes personal interactions between a parent and a child, an exploratory qualitative methodology was chosen to allow for "rich" data to review the issue in the depth and detail required (Patton, 2001). This study therefore does not focus on what the child learns or if the storybook is effective, but rather the way that the parent and child interact vis-à-vis their conversation. The engineering storybook was developed and intended as an impetus for the informal conversation, but is not the main focus of this study.

4.1 Data Collection

Recruitment of participants was achieved through an online (email) communication strategy. Recruitment materials called for parents with children aged 3-5 years (pre-school) who had engineering experience as defined by 1) completion of a degree in an engineering discipline, 2) current or previous employment in an engineering field, or 3) other. Social networks consisting of known contacts were also used to recruit in areas that may not have been associated with Purdue University, and assisted in the facilitation of snowballing. Those in the social network who did or did not qualify for the study passed on the information to other parties that fit within the parameters of the study. This allowed for reaching potential subjects that might not otherwise be notified.

Interested parties were emailed a letter detailing the study along with the IRB-approved consent form to review. After answering any questions, the participants were asked for their address as confirmation of participation in the study. Within a week, the study materials were sent out (depending on availability) and the participants were given two weeks to complete the task.

Participants were then asked to video record while they read the given storybook to their young child in a location and time of their choosing. This allowed for a more naturalistic approach, where the researcher is not a distraction, and has been used in previous studies to gauge emerging literacy through storybook readings (Webb, 2007). The participants then returned the video recording through a format of their choosing (via Google Drive, compact disk, YouTube, Picassa, Dropbox, email or thumb drive) as well as sent back the signed consent form and study storybook to the researcher for data analysis.

4.1.1 Parental Engineering Awareness Survey (PEAS)

In addition to the video data, participants were asked to fill out a short survey on their engineering awareness. The Parental Engineering Awareness Survey (PEAS) assesses an individual's engineering knowledge, attitudes and behaviors through a series of Likert scale items ranging from strongly disagree (1), neutral (3) to strongly agree (5) (Yun et al., 2010). It is based on a knowledge, attitudes, and behavior framework developed by Shrader & Lawless (2004) (Yun et. al., 2010). The survey also included individual demographics (gender, age, salary, ethnicity, race, exposure to engineers, etc.), as well as several questions regarding reading frequency and exposure (Bus et al., 1995). The information from PEAS was used to evaluate the parents' own occupational knowledge and what they wish their child to know. Therefore if a participant strongly indicates that they favor engineering learning at a young age, their strategies employed with their child should reflect this.

4.1.2 Adult-Child Interactive Reading Inventory (ACIRI)

One of the measures that affects the story-telling process, is the ability of the parent to actively engage the child in the book through different literary strategies. Designed to evaluate joint reading in the home environment under natural conditions, the Adult-Child Interactive Reading Inventory (ACIRI) is an observational measure of interactive behaviors of both the adult and their child (DeBruin-Pareki, 1999) (Appendix B). The ACIRI consists of 3 key categories: 1) enhancing attention to text, 2) promoting interactive reading and supporting comprehension and 3) using literacy strategies (DeBruin-Pareki, 1999). Each category has four literacy behaviors that are ranked based upon the amount of times observed ranging from 0 (no evidence), 1 (infrequently – 1 time), 2 (some of the time – 2-3) to 3 (most of the time - 4 +). The tallies of each of the 12 behaviors are then combined to get the overall score (max of 36). The overall score was a measure of how interactive the parent-child dyad was during the storybook reading session. Oftentimes parents that tend to be more comfortable reading have a high score, and those that aren't as comfortable a lower score (DeBruin-Pareki, 1999).

4.2 Conversation Analysis

Talk is a social enterprise by which one engages others in daily lives. Humans entertain through stories and jokes, woo through poetry, commiserate over a cup of coffee, and even explain what “talk” is. Conversation Analysis (CA) is a qualitative method established in the 1960’s by social scientists Harvey Sacks, Emanuel Schegloff and Gail Jefferson as a means to describe, analyze and understand talk as a basic feature of human life (Sidnell, 2011).

CA is derived from ethnomethodology and discourse analysis, and focuses on social interaction during discourse. The main premise of Conversation Analysis is that there is an organized set of practices or “organizations” during talk that allow a researcher to understand what happens during an interaction (Sidnell, 2011). Oftentimes the transcript is united by turns-at-talk often linked together in an adjacency pair that help to delineate conditional relevance (e.g., first turn-at-talk of adjacency pair makes the later turn relevant). Common organization of talk include: taking and constructing turns, building sequence of actions, repairing troubles, speaking in ways fitted to occasion, and selection of particular words.

The decentralized tendency of CA is one in which an individual’s internal thinking processes or their external attributes (race, gender, etc.) are not emphasized as much as the structure of the activity of talk itself (Sidnell, 2011; Sacks, 1995). While talk may be correlated with external attributes of persons involved, it does not shed any light on the way that talk is organized. In other words, the structure of the conversation do not necessarily rely heavily on who is talking, but rather are fairly universal. For example, when asked a question ("how are you doing?") conversational rules prompt a related response ("I'm fine").

CA is an empirical approach to social interaction that requires record of conversations (either video or audio) that are then translated into a very detailed observation based transcript for analysis. In this way CA acts as a naturalistic record of real world events. The level of detail in CA exceeds those in a "normal" transcript as it includes pauses, unintelligible grunts and hand gestures (if possible).

CA also requires the researcher to be "removed" from the conversation so as not to influence the progression of the discourse (Sacks et al., 1974). It is noted that different analysts will notice different things, so the recording and the subsequent transcript are required to be as data rich as possible.

Why does conversation analysis work for this study? CA is about close observation of the way that patterns develop across instances of informal talk. It is used to find out what exactly is being accomplished via interactions by speaking in a particular way. As parents often differentiate their language patterns based upon their child's perceived ability, conversation analysis in this study allows us to determine the different strategies that parents provide while talking about an engineering storybook. CA is particularly useful for being able to discern the intended meaning behind what the parent is saying, as they often say one thing but mean another. For example, a parent might agree that a purple monkey would be a great pet, but by the tone of voice or inflections, one could infer the undertone of sarcasm. This type of empowerment to denote subtext is often not available via traditional transcript techniques.

CA in this study (1) involved the identification of conversational structures between parent and child, (2) operated under the restraint that the meaning of the conversation was in a storybook reading context, (3) was examined with the assumption that each conversational element was purposeful (functionally intended); and (4) occurred in the setting of natural and unscripted speech.

CA has previously been used to analyze a single case study of a father-son dyad reading a storybook while looking at how gender, genre of book, repeated reading and adult power were related to communication patterns (Webb, 2007). CA will be used in this study to look at the interactions between parent and child during their discourse while reading a storybook.

4.3 Data Analysis

Video data was transcribed and segmented using the CA coding system developed by Gail Jefferson that illuminates turns-at-talk and phonetic variations (Sacks et al., 1974) (see Appendix A). It takes approximately 1 hour to transcribe one minute of conversation (Roberts, 2004). The original transcripts for this research include allegro spelling, used to convey conventions for verbalizations. An example would be the use of the phrase "gonna" for "going to". Also phonemically transcribing verbalizations or utterances that are unintelligible, while subject to subjective interpretation, may contribute to the conversations in the context of the situation to provide a sense of their meaning.

The data came from the close examination of the transcript and formed the basis for theorizing about the parental strategies by investigating adjacency pairing. To do this the transcripts were intricately analyzed for initial observations using different "keys" to sequester data into manageable phenomenon (Sidnell, 2011). Focus was placed on the sections of talk that deviated from the reading of the story, that is, in which the parent or child interjected talk.

As this was an exploratory study, the transcripts were openly coded in their entirety. This consisted of two "reads" of each transcript, followed by review of the entire collection. Codes then were applied to the section of extraneous talk (i.e., not using storyline text unless it deviated) to determine themes.

There were five constructs that were intentionally developed for the book to elicit talk during the reading based upon illustrations, prompts and in-line text (see Table 4.1).

Table 4.1 Construct identification

Construct	**Focus**
1	The word "Engineer"
2	Engineering Imagery (includes train, turbine, and blueprints)
3	Who can be an Engineer
4	Engineer's Workplace
5	Recognition of Engineers

Additionally, there was an a priori coding scheme that focused upon shared engineering occupational knowledge, attitudes and beliefs per the study framework (Bryant, et al., 2004) which aligned with RQa and RQb. Combination of different data sources allowed for a more detailed analysis (Table 4.2).

Table 4.2 Data relating to source and focus area.

	Source(s)	**Focus**
Parental Strategies	CA – adjacency pairing, ACIRI	Constructs
Engineering Knowledge	Open coding, PEAS	Constructs
Engineering Attitudes + Beliefs	Open coding, PEAS	Whole document
“Other”	CA, open coding, PEAS, ACIRI	Whole document

4.4 Role of Researcher

For the purposes of the study methodology, the author remained removed from the data collection process. As such, the participants were in complete control of their own recording – including location, timing, and set-up.

The design of the research questions, storybook and analysis was centered on the development of occupational knowledge, attitudes and beliefs framework outlined by Bryant et al, (2006) and was influenced by the engineering messages presented in the Changing the Conversation report (NAE, 2008). Having such a narrow analysis, with a socio-cognitive lens, could have unintentionally left out other potential perspectives (Zeldin, 2000).

In addition, my role as an engineering parent increased my perceptivity of parental engagement strategies. For example, when I am reading a story and it is close to bedtime (or I am on my 10th book for the night), I tend to ask fewer questions and give more token acknowledgments so that we can progress through the story at a faster pace. This acknowledgement that the participants make certain allowances to meet the demands of their situation has an effect on the quality and interaction that occurs during the storybook reading. However, as this study is exploratory in nature I did not look at the structure of the activity, but rather what was occurring in this natural state.

Also as a mother, I may have a subconscious bias toward other mothers. To minimize this, the genders of the participants were removed during initial coding.

4.5 Validity & Reliability

To ensure that validity and reliability are achieved in qualitative research, there are several considerations that need to be addressed such as sampling, representativeness, and generalizability (Zeldin, 2000). Validity in this case means that the findings represent the knowledge, attitudes and beliefs that were intended to be investigated.

Reliability is ensured by the detailed process of the interpretive steps that are inherent in the methodology of CA. The researcher practiced transcribing source material and comparing to published transcriptions to get used to the detailed transcription notation required for CA. Additionally, the process of transcribing with notation required multiple observations of the source data, and the recording was also played in concert with the transcript to get the entire "feeling" of the session.

Transferability is how the findings from a qualitative study can be transferred or generalized to other context or settings. As these findings are coming from a small, homogenous sample it would be expected that the findings are not generalizable. However, due to the type of research methodology, the findings will be used to inform those not familiar with engineering rather than generalize to other populations (e.g. nursing or accounting).

CHAPTER 5. FINDINGS

While the exploratory qualitative study was the main thrust of this document, additional information pertaining to participant demographics, reading correlates (number of books read per week, rating of interactive reading ability) and engineering awareness was analyzed. Conversation Analysis (CA) was then used to determine parental strategies and engineering knowledge, attitudes and beliefs shared during the storybook reading based upon five constructs.

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5.1 Participants

Constructed on a purposeful sample design, 32 participants and their children were sent the study materials: 8 father-son, 8 father-daughter, 8 mother-son, and 8 mother-daughter dyads, which provided a balanced proportion of gender distribution with respect to dyad composition. In total, 27 parent-child dyads completed the study in its entirety. However, three of the dyads were removed from analysis as they read the honorarium book “Rocks, Jeans, and Busy Machines: An Engineering Kids Storybook” by Alane & Raymundo Rivera instead of the intended study book (modifications to the methodology are discussed in CH 6). Two participants also recorded the honorarium book being read, but as it was after the study book was completed it did not unduly influence the data collection. The final distribution of the study participants is outlined in Table 5.1.

Table 5.1 Parent-child dyad distribution of study participants.

	Sons	Daughters	Total
Fathers	6	5	11
Mothers	7	6	13
Total	13	11	**24**

At the time of data collection, all of the participants (aged 25 to 44) were married with children living at home, with six individuals residing with a spouse that was also an engineer. Based on the survey demographics, 20 participants identified as Caucasian with two acknowledged of Latino/a ethnicity. There also was one individual of Asian descent, one Native American and two participants that claimed “other”. They hailed from 17 different states, demonstrating the diverse geographical areas reached through social networking online (Figure 5.1).

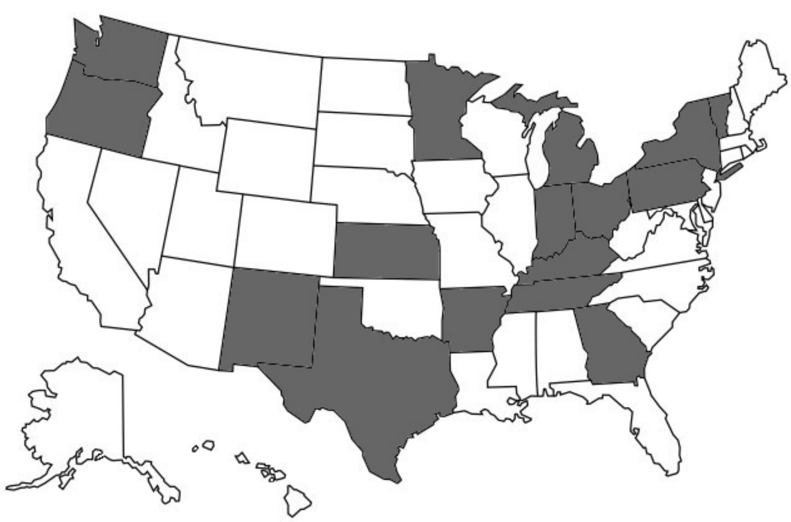

Figure 5.1 Geographical distribution of study participants.

All participants stated that they had at least one engineering degree, with ten individuals that had earned advanced degrees (4 M.S. and 6 Ph.D.). In terms of occupations, the majority were working as engineers (n =16) with representation from academia (n=3) and engineering management (n =2). In addition, there was one person who was unemployed, another whom started their own business, and a third individual that was a farmer, stay-at-home mother, and tele-commuting engineer (Figure 5.2). In terms of engineering disciplines there was representation from mechanical (n=9), electrical/computer (n=5), environmental (n=2), civil (n=2), chemical (n=1), industrial (n=1) and biomedical (n=1) engineering (Table 5.2).

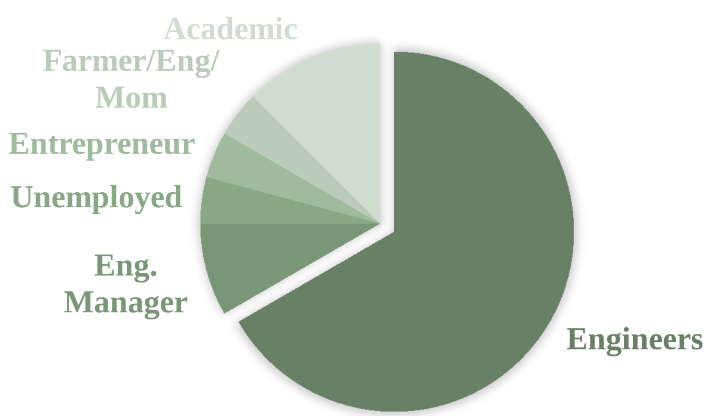

Figure 5.2 Participants current job focus

Participants were assigned pseudonyms to keep their information private. Females in the study were assigned with the first half of the alphabet (A to M), and males the remainder with the exception of letters U and Y which were unassigned.

Table 5.2 Participant discipline and child gender

Female	Discipline*	Child	Male	Discipline	Child
Anna	ENV	Son	Ned	ECE	Son
Beth	CE	Daughter	Oliver	ME	Daughter
Cara	ENV	Son	Pete	ECE	Daughter
Diane	CE	Daughter	Quincy	ECE	Son
Evelyn	BME	Daughter	Robert	ME	Son
Fran	ME	Son	Steve	ME	Son
Gemma	ME	Daughter	Tom	ECE	Daughter
Heather	IE	Daughter	Victor	ME	Son
Ingrid	IE	Son	Wade	ECE	Daughter
Jess	IE	Son	Xavier	ME	Daughter
Kamie	ME	Son	Zane	ME	Son
Liz	ChE	Son			
Maddie	IE	Daughter			

* ENV = Environmental, CE = Civil, BME = Biomedical, ME = Mechanical, IE = Industrial, ChE = Chemical, ECE = Electrical / Computer Engineering

5.2 Parental Engineering Assessment Survey (PEAS)

The Parental Engineering Awareness Survey (PEAS) was completed by each of the participants. While the survey was administered in its entirety, six items that specifically related to children were investigated. The items were categorically divided into two different thematic areas for the purpose of analysis. Three items pertained to the participant's knowledge of how to teach, explain and help with engineering-related idea/skills/concepts to their children. The remaining three focused on engineering attitudes and beliefs such as wanting their children to understand engineering, necessity for early exposure, and child's pursuit of a career in engineering. The table below outlines the items, with designation by first initial of the participant's pseudonym. Mothers are bolded and those who read to their daughter are underlined to delineate the different dyad combinations, a designation that is kept through the majority of the analysis (Table 5.3).

Table 5.3 PEAS items relating to engineering knowledge, beliefs and attitudes. Letters in bold denotes adult female participant with underlined are those with a daughter.

Area	Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Engineering Knowledge	I know how to **teach** engineering skills to my child(ren).		**J**	***A*** **K** O S V Z	**B C D F G H** N T W X	**E I L M** P Q R
	I know how to **explain** engineering-related concepts to my child(ren).			S Z	**A D F G H I K M** N O T W X	**B C E J L** P Q R V
	I know how to **help** my child(ren) with his/her engineering ideas and skills.			**J** O S	**A B D F G H K M** N T W X Z	**C E I L** P Q R V
Engineering Attitudes & Beliefs	I want my child(ren) to **understand** what engineers do.			N W X Z	**A B** O S	**C D E F G H I J K L M** P Q R T V
	I think it is necessary to learn engineering as **early** as possible.	V	N O	**A B C F** R S W X Z	**G K** P Q	**D E H I J L M** T
	I want my children to pursue a **career** in engineering.			**B C F K** N R S V W X	**A E G H I M** O P Q T Z	**D L J**

There was general agreement across all six items, especially those pertaining to engineering knowledge. While the majority of parents wanted their child to understand what engineers do, they were neutral regarding the necessity of early learning. Fathers were particularly divided on necessity of early learning, whereas mothers were more strongly in agreement. Additionally, fathers tended to be more neutral in responses overall than mothers.

For example, Victor did not rate his ability to teach, even though he felt like he could help develop skills and explain concepts – key characteristics of teaching. While he held that his children should understand engineering, he disagreed that early learning is a necessity (which may be a semantic issue with the survey itself). In comparison, Jess had strong agreement with the three engineering attitudes and belief items, but was found to be more comfortable explaining concepts than teaching/helping engineering skills.

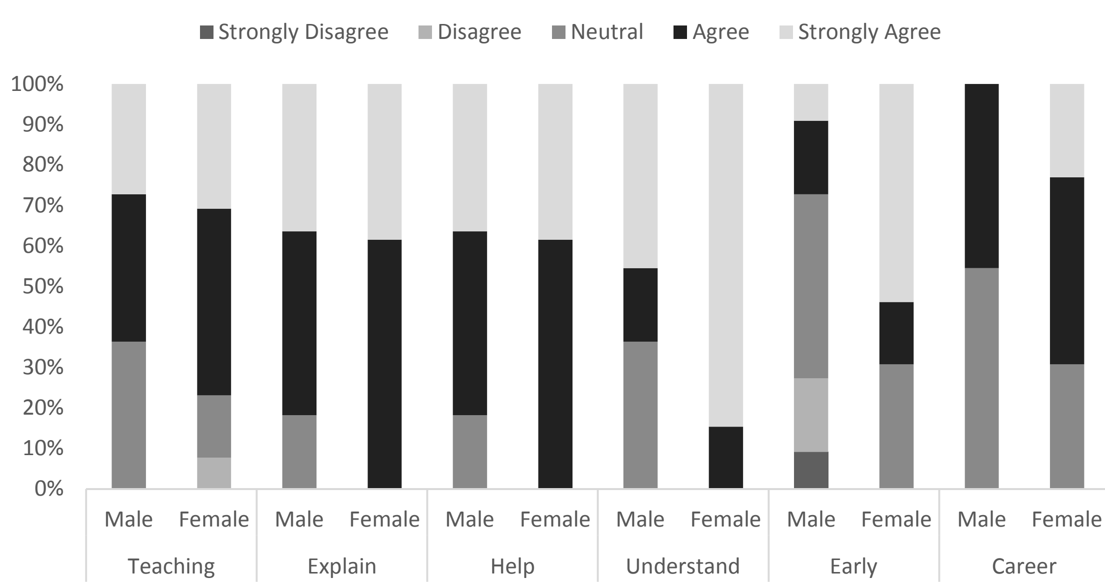

Figure 5.3 Percent response for six PEAS items by gender.

5.3 Adult Child Interactive Reading Inventory

The ACIRI scores ranged from 6 to 28 (out of 36) with an average of 16.5 (SD = 7.5). Two participants (Liz and Maddie) were not evaluated as only audio recordings were provided. Mothers had a higher average score (M = 18.5, SD = 6.1) than fathers (M = 14.5, SD = 7.8), but the difference wasn't significant (t(20) = -1.32, p <.01).

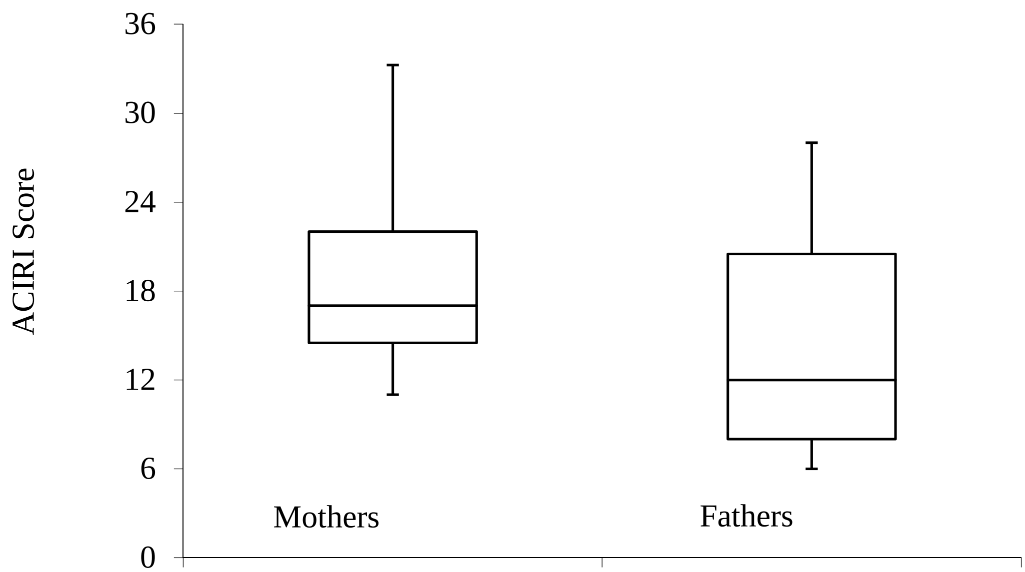

Figure 5.4 Box blot of ACIRI scores based on gender.

Parents were also coordinated into grouping based upon ± one standard deviation of the average (Figure 5.4). Five fathers (Pete, Steve, Tom, Xavier and Zane) scored the lowest of the population, whereas two fathers (Quincy and Ned) and two mothers (Gemma and Jess) scored the highest.

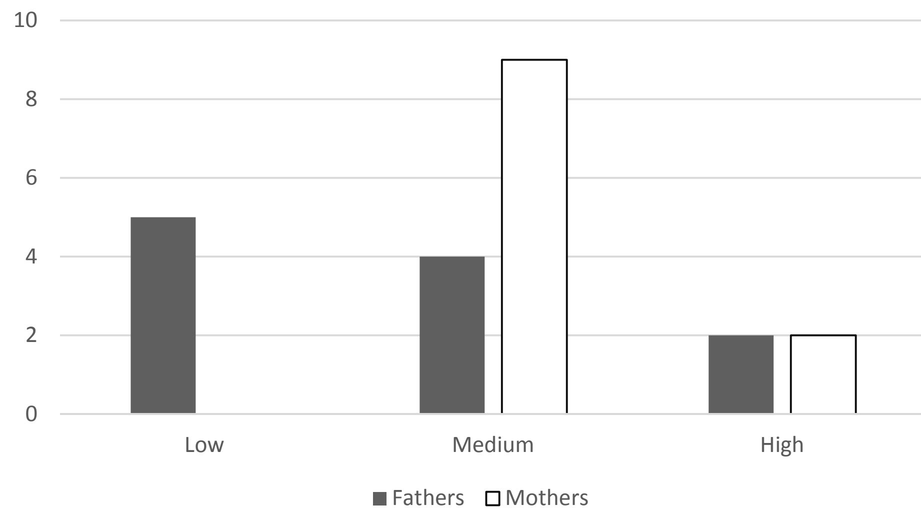

Figure 5.5 Distribution of parents' categorical ACIRI score.

5.4 Exploratory Qualitative Findings

Through the development of the engineering storybook there were five constructs that were purposefully integrated as to elicit conversation between the parent and child. The intention of these constructs was to encourage talk between the engineering parent and their child around 1) use of the word "engineer", 2) engineering imagery, 3) who can be an engineer, 4) where an engineer works and 5) if they know any engineers. Means to facilitate these conversations included illustrations, question embedded within the text and two separate prompts that specifically posed the question to the listener (in this case the child).

5.4.1 Construct 1: The Word "Engineer"

From cover to cover the word "engineer" is used within the text seven times, once in a prompt, with two separate uses on the outer and inner covers for a total of 11 times. An additional use of the word engineer can be seen in the name for the engineering firm on the blueprint (Figure 5.9). All of the parents read the intended passages of the book – including the prompt and note left on the package (Figure 5.7). Two of the parents did not read the inner cover or mention the title (Tom and Xavier).

The number of times the word "engineer" (including the plural engineers) was mentioned by the engineering parents ranged from 8 times to 30 times during the process of the storybook reading. On average mothers mentioned engineer/ing ($M = 18.5$, $SD = 6.1$) more than fathers ($M = 14.6$, $SD = 7.7$). While there was a difference in the means by gender, it was not significant ($t(19) = -1.21$, $p < .01$). Additionally, a modest correlation ($\tau_{kendall} = 0.57$) was found between number of times engineer was mentioned and the ACIRI score, showing that the word was used more often by those who had a more interactive reading style.

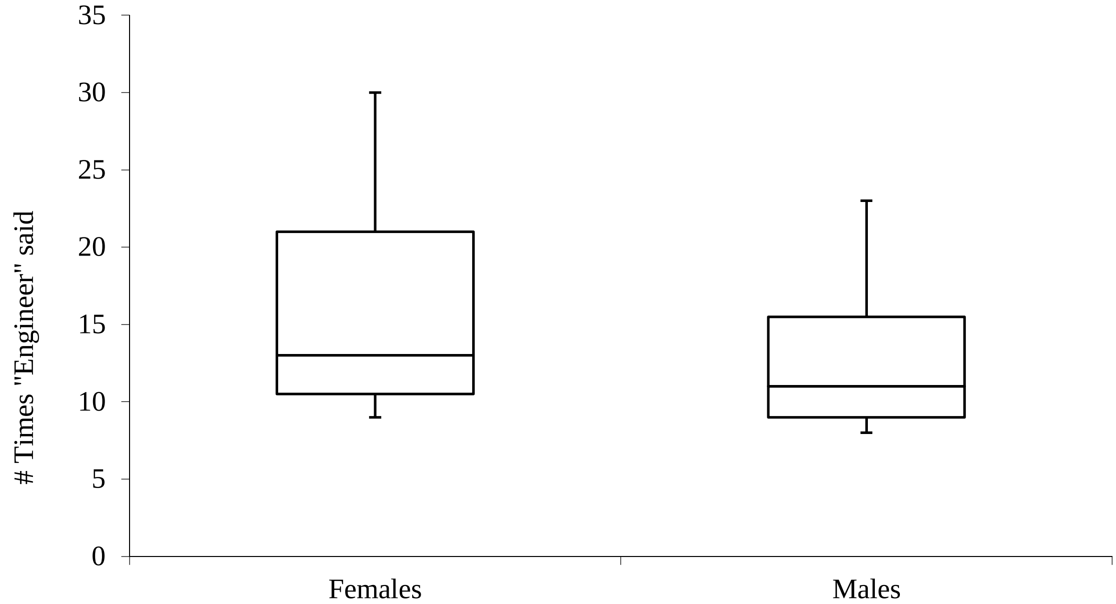

Figure 5.6 Box plot for enumeration of word “engineer”.

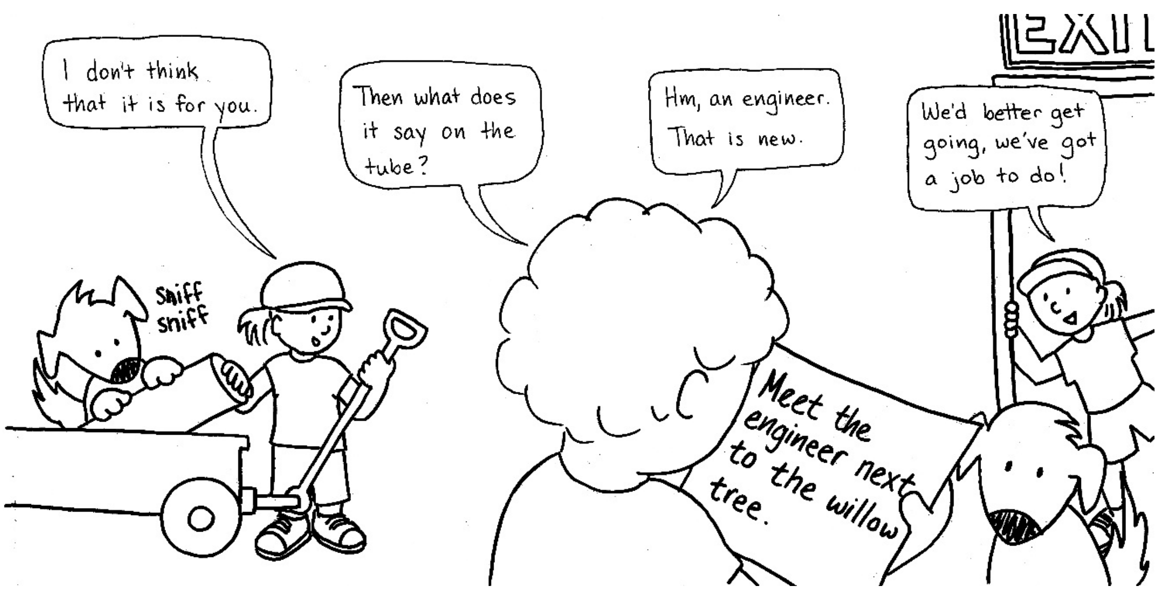

Figure 5.7 Storybook page showing use of the word engineer.

Table 5.4 Number of times "engineer" was said by parents and children.

Name	*#Adult*	*#Child*	*Name*	*#Adult*	*#Child*
Anna	18	0	Ned	23	1
Beth	9	4	Oliver	16	3
Cara	24	5	Pete	9	0
Diane	12	0	Quincy	14	4
Evelyn	13	0	Robert	16	5
Fran	10	0	Steve	11	2
Gemma	11	0	Tom	9	2
Heather	26	1	Victor	9	0
Ingrid	9	0	Wade	15	2
Jess	13	2	Xavier	8	0
Kamie	30	3	Zane	10	0
Liz	18	0			
Maddie	12	1			

5.4.2 Construct 2: Engineering Imagery

The idea of engineering imagery was represented on two different pages. The first set of images (Figure 5.8) included representations of a train and a turbine. This was coupled with the text asking "what could an engineer be?" The image of the train was intended to get at the issue of the occupation of professional engineers being largely associated with trains. This is largely an issue of semantics as in other regions, a person who drives the train is called a combination of train/engine/locomotive-drivers or operators. For example in Great Britain they are referred to as Train Drivers, and in India as "Loco Pilots" only in the US and Canada are they known as locomotive engineers.

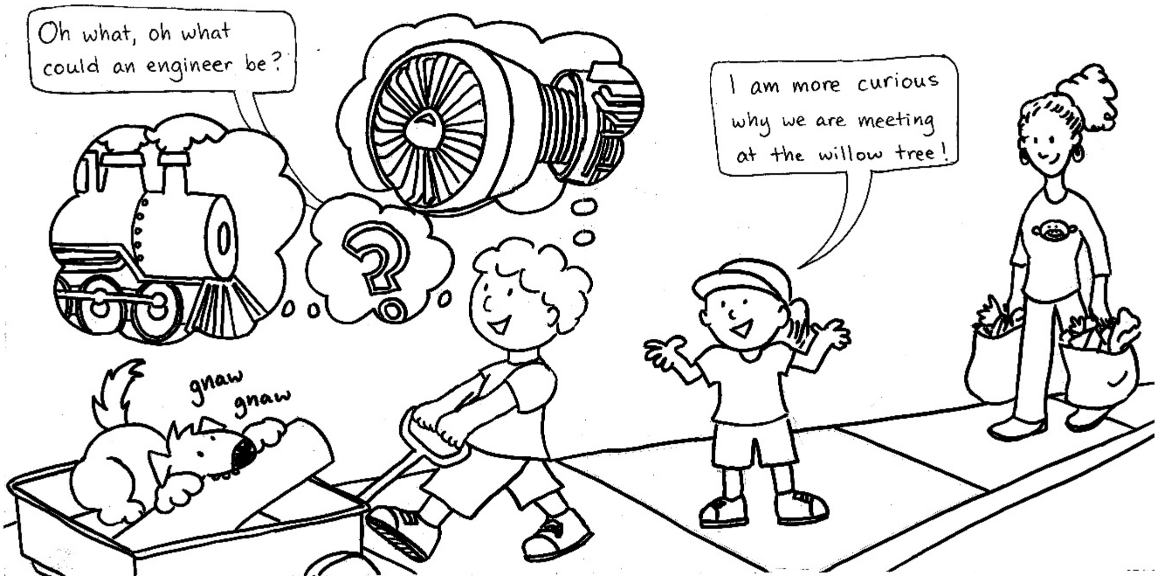

Figure 5.8 Storybook page for Construct 2: Engineering Imagery 1 (train & turbine)

The picture of the turbine was something that more closely related to professional engineering so it was included to see if: 1) parents recognized it as such, 2) what vocabulary terms they used and 3) to determine association to engineering. Additionally, the turbine also picked due to its association with "engines" a close linguistic leap to engineers that might cause some misidentification.

The second set of pages pertaining to engineering imagery included an illustrated version of blueprints (Figure 5.9). It was hoped that the engineering parents would go into more detail about the plans and explain personal connections.

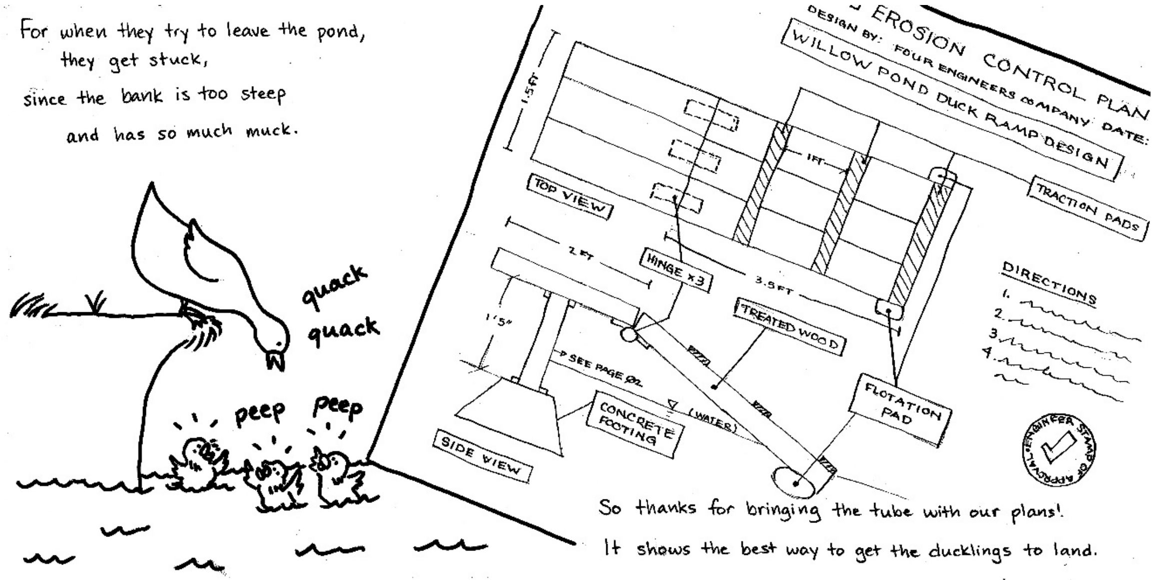

Figure 5.9 Storybook page for Construct 2: Engineering Imagery 2 (Blueprints)

Vocabulary use

The way that parents talked about the engineering imagery included engineer-related vocabulary such as turbine and blueprint, but also simplified language (Table 5.5). Anna explained how the ducklings used the ramp using child adjusted language to her four-year-old son. She referred to the turbine as “motor of plane” and the blueprints as “map of how to build the ramp”.

Table 5.5 Vocabulary used for engineering imagery

	Turbine Vocabulary	**Blueprint Vocabulary**
Engineering-related	Turbine (**H L M** N O) Jet Engine (**D** R)	Blueprint (O **M**)
Simplified	Plane (S W) Motor of Plane (**A**)	Drawing (**C**) Picture (**D** Q) Map (**A**)
Inconsistent	Fan (Q) Wheel (O)	N/A
From text	N/A	Plans (**B H** N R V W X Z)
No identification	**B C E F G I J K** P T V X Z	**E F G I J K L** P S T

Due to the lack of reference in the text, the images provide ambiguity for the parent-child to determine what they are. Oliver asks his daughter to identify the pictures, but the child thinks that the turbine is a wheel. He follows up with an affirmative statement ("okay") then states that it is a turbine, correcting the child's initial statement. The then child repeats the word "turbine" and then asks what the symbol for the question mark is. Quincy's son identifies the turbine as a fan when asked, and Quincy acknowledges with a token that it is correct. The use of simplified vocabulary might be indicative of the level to which the parent believes the child to be.

Dealing with Inconsistencies

Young children that are developing their views of the world may harbor inconsistencies that result from misinterpretation or lack of knowledge. Without appropriate feedback from a more knowledgeable other, they may accept the misinterpretation as truth. By accepting something as "true" it becomes part of their self-organizing structures and is often intractable to change without great concerted effort (e.g. Piaget, Vygotsky). One major misconception is that professional engineers are associated with the operation (primarily driving) of trains. While not all children have this misconception, it still persists (Knight & Cunningham, 2004; Fralick et al., Cunningham & Knight; Fralick et al., 2009).

Engineer as a thing

Two children associated the engineer as a thing and not a person. Anna's son initially thought that an engineer was a train (as depicted on the storybook page). However, Anna clarified through a series of questions – her tone of voice and inflection show that she was skeptical of his beliefs. However, the son held onto the idea that an engineer was a train. Anna then stated that she “don’t think so” which can be taken as an ambiguous statement instead of a concrete answer.

Cara’s son starts off with a limited understanding of what an engineer is. At first he points to the image of the train and asks Cara if it is an engineer – confusing a person with a thing. Cara then clarifies that the image is a train and that a type of engineer drives a train.

Son: I dunno wha a enjaneer. ((points to train)) is tha an enjaneer?

Cara: That’s a train. A type of engineer drives a train.

Son: .hOH yeah! An en-han-neer

On the opposite end of the spectrum, Beth’s daughter points to each illustration in the bubbles and states “that’s not an engineer” with each. Beth then points to the dog and asks if it is an engineer, which gets an amused “no” out of her daughter.

Engineer working on train/plane

There were several exchanges that related to how an engineer would be associated with either a train or a plane. Diane’s child exclaimed about the picture of the train engine. Diane then took that interest and turned it into a query about engineers “working” on a plane or a train, but did not discuss what type of work that engineers do with those things. Steve focused more on the specifics by asking if an engineer runs the train or flies a plane, and his son answered affirmative to both. In response, Steve gave a non-committal token “hmmmn” and moved on with the story. Robert prompted his son regarding the train image by starting a sentence and then leaving it hanging so that the son may finish the statement. He then goes on to ask him what a “person that drives a train is called” and the child has some difficulty saying the word engineer (he partly states engine).

Evelyn asked her daughter if is she knows what an engineer is, and she pointed to the train and explained that engineers ride trains. In contrast, Ned asks his son if engineer drives a train and the child responds “no”.

Focus on the familiar

In several instances, the train was the only picture that was mentioned. Jess and Gemma both pointed to the picture of the train and made reference to previous knowledge (e.g., Thomas the train, or trains that go “choo choo”) but did not call out the image of the turbine. Gemma however, does ask for a prediction of what is going to happen at the willow tree, though this garners no response.

Robert has his child focus on the duckling and how they can’t get up to the land. He mentions how the engineers have the plans. Additionally, both Tom and Ingrid focused on the ducks instead of talking about the plans. Wade acknowledges the struggle of the poor ducklings and has his daughter look at the plans.

Design Purpose

Several parents emphasized the purpose of the ramp and that the ducks were the intended user for what the engineers designed. Oliver points out that the mama duck is separate from the baby ducks and asks his daughter how they are supposed to get up on the bank. The daughter imitates flapping wings with her arms, but Oliver asks a secondary follow-up question about what the engineers are supposed to do (aka what they are building). She states that they have to build the ramp and points to the plans. Oliver asks her what it is, and she reiterates what the purpose of the ramp is ("to make ducks go up here"). Oliver then says that it is a blueprint and moves on with the story without any additional explanation. The daughter then misinterprets the amorphous squiggly lines that serve as directions as "the ocean" and dad corrects. She then points out the check mark, which is a representation of the engineer's stamp, but Oliver ignores this and continues with the story.

Beth reiterates that the ducklings can get up on the bank to the momma duck and shows how the ramp will help the ducklings. Her daughter goes on to show how the ramp "goes" and Beth mentions that the plans were in the tube that the children brought to the willow tree.

Quincy asks what is happening with the ramp and gets a response that the ducks are quacking (probably not what he intended). A follow-up question specifically asked about the little ducks and their ability to get up on the bank. He then points to the blueprint and ask what the engineers are planning to build.

Quincy: And their picture tells them how to build it doesn't it?

Son: Mhhmm hmm.

Quincy: Isn't it nice that the ducks can climb out now.

Jess explains what the muck is, and then goes on to explain the ramp and how it gets the ducks out of water.

Son: Whas the mo:ok?

Jess: The muck. Like mud.

Son: Who dues that?

Jess: The engineers, they're making a ramp. ((points)) See here is the ramp, so the ducks can go <u>up</u> the ramp (.) and they can go out of the water.

Son: Where's the water?

Jess: Right here ((points))

Design Explanation

Some parents also spent time going over how the individual parts of the ramp design worked. Evelyn used the blueprint illustration to talk about the ramp – specifically pointing out the floatation device. Victor gave an explanation of the "plans" and the purpose of each individual piece. He also made an evaluative comment regarding the actual design.

Victor: See here is their plan and they are using this piece of wood here to make a ramp for them. And they'll put concrete to keep it up and a floating pad there to keep it with the water. Good ideas huh?

Heather showed great enthusiasm for the plans. While the child referred to it as a picture, Heather corrected this to plans. The child then counted the steps on the plans, and the mom explained that they are directions for building the ramp. Heather then went on to show what part is the ramp and where the water is. She even mentioned that the ramp is made of wood, denotes the flotation pad and indicates where the hinges are. Heather also related the hinges on the map to the hinges that are commonly found on doors – something the child is more familiar with. She then pointed to the measuring bars that indicates "how high it's [the ramp] got to be". She then summarized that all those things are to help the engineers build a ramp for the ducks.

Gemma spent some time focused on the ducks, before connecting that the engineers "designed" a ramp for the ducks. Gemma explained where the water and ramp is on the plans. After the last page, she came back to the illustration of the plans to show that it matched the ramp that was built on the next page.

Zane brings attention to his son how the steep bank prevents the ducks from getting up. While visually scanning over the blueprint, Zane starts to talk about erosion control plan but then decides not to go into any more detail.

Fran's son initiated the exchange about the ramp by asking if the ducks will go up the ramp. He then gestured movement and Fran tied into the connection of the blueprint illustration. Fran then affirmed that it does go up and down as the son stated. She then talked about how the float helps the ramp go up and down with the water level.

Son	So they will go éup dat thing? ((points to ramp on page))
Fran	Mhmmhnn::
Son:	Dat a a (haa::nnd)
Fran:	Mhmmhnn::
Son:	So that ting can go ((Gestures on page)) can go can go to daté
Fran:	Yup. It can go up and down ((points on page)) I think it see it floats. This is to help it float. And it can go up and down as the water level goes up and down.

Interestingly, Steve paused on the page for 16 seconds without talk before turning to the next page. During this time his eyes were actively scanning the page, though he was not interacting with his son.

Role of Engineers in Design

Parents mentioned the interaction of the engineers with the plans as an artifact needed for the engineers to "build" the ramp. Ned talks about the purpose of the ramp and refers to the plans as the "directions the engineers will use". Cara reiterates that the engineers are going to "build a ramp for the ducks to go up". She also refers to the blueprints as the "drawing the engineer uses to build the ramp". Kamie asked her son what the engineers are doing and he positively identified that they are "making" a ramp for the ducks. Diane was the only one that mentioned the role that engineers had in the development of the plans (other than just build/making) in that the engineers “drew a picture” of the ramp so the ducklings can climb up.

5.4.3 Construct 3: Who Could Be an Engineer

The idea of “who” can be an engineer probed and challenged stereotypes that are common (i.e., that engineers are old white men) as well as provides a baseline for who can be included. The illustrations (e.g., Figure 5.10) and text for this construct presented several different options for who can be an engineer. The first deals with the common misconception that engineers work on car being a man fixing a car (Cunningham et al., 2005), but also is the only “male” other than the main character on the page (the dog is gender neutral). Other “potential” engineers include a young girl jumping rope (who could one day theoretically grow up to be an engineer) and a lady carrying some materials that is winking at the main characters (a foreshadowing of what is to come). The prompt “what do you think?” was intended to see if any of the three characters could potentially be deemed to be an engineer, as well as to determine what traits (e.g., old, young, female / male) they should have.

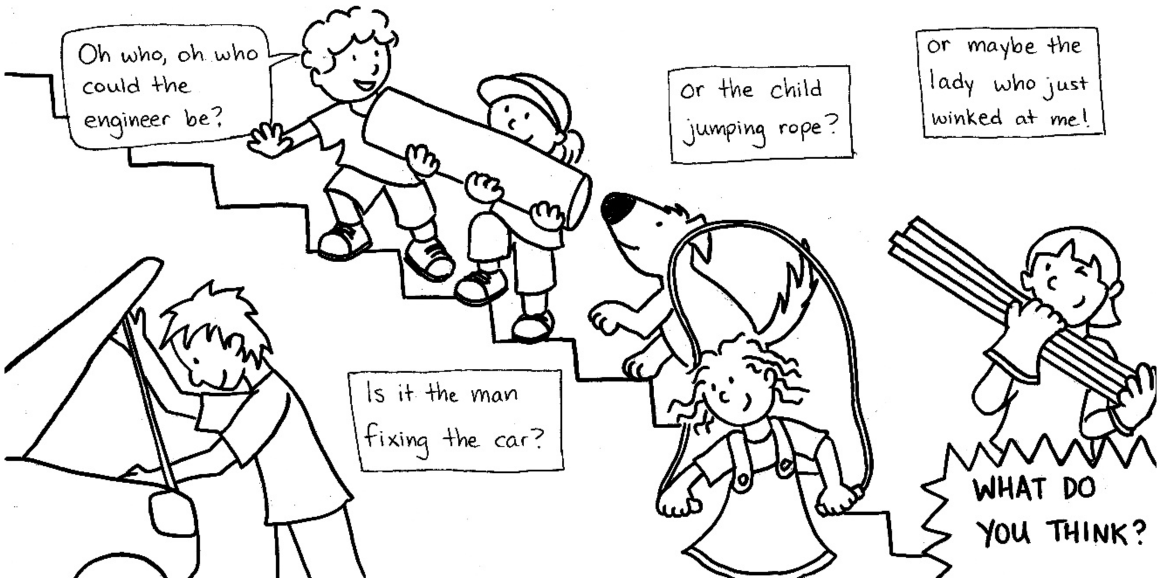

Figure 5.10 Storybook page for Construct 3: Who could be an engineer.

Eight children correctly identified the women carrying material (and winking) as an engineer (Table 5.6). The idea that the mechanic could be an engineer was chosen by three children, and no one identified the child alone as an engineer. However, three children thought that all of the characters provided were potential engineers and seven children did not respond or were uncertain. Additionally, two children continued on with the belief that an engineer was someone who drives a train and another joked that the dog could be an engineer.

Table 5.6 Identification of who could be an engineer by child.

Child's response	**Participant(s)**	**Parent Behavioral Response**
Man fixing car	**Kamie**	Repeats child's response, clarification, repeat's response, clarification, rephrase
	Diane	Token affirmation
	Zane	Repeats child's response
Child	N/A	
Women Winking	**Anna**	Restatement, Explanation, Token
	Oliver	Rephrase
	Jess	Repeat child's response → Affirm.
	Gemma	Repeats response, Request reasoning, Affirm
	Robert	Repeats child's response
	Fran	Repeats child's response
	Evelyn	Rephrase question
All three	Ned	Token affirmation
	Xavier	(None – continued w/ story)
	Heather	Rephrase / Restate question per character, Repeat child's response, Token
None/Don't know	**Beth**	Rephrase question x3, token acknowledgment
	Maddie	Restate question
	Quincy	Token
	Ingrid	(None – continued w/ story)
	Pete	No pause for child's response
	Tom	Rephrase / Restate question x2
	Steve	Laughter
	Cara	Rephrase / Restate question x2
	Victor	Laughter – continued w/ story
Other: Train Driver	Wade	Clarification, physical affirmation, token acknowledgment
	Liz	Clarification, Token acknowledgement

Engineering Identification

The action of the lady winking (Fig. 5.10) was intended to draw the readers to assume some sort of importance for that character, as to create a sense of foreshadowing. A third of the children picked up on this idea and identified the lady as a person who could be an engineer. Of these, Fran, Jess and Robert acknowledged and affirmed what the child chose by repeating what was said. Oliver asked an additional follow-up question and after much consideration (based on eye movement) she points to the lady. Oliver then confirmed her choice with a token acknowledgement, and the child shakes her head affirmatively.

Anna and Evelyn both repeated and rephrased the storybook prompt asked an additional follow-up question to the storybook prompt. Evelyn framed the question around whether or not the lady was an engineer, to which her child responded positively. Anna then acknowledged and then affirmed through repetition.

Gemma's daughter pointed to lady and she asked why she think that she is the engineer. The child responded that it was because the lady is going to the car – possibly the child connecting to the need to meet at willow tree. Gemma then clarified what "girl" is going to the car.

Gemma: What do you think?

Daughter: ((points to the lady))

Gemma: The lady?

Daughter: uh huh.

Gemma: Oh. Why do you think so?

Daughter: (4) No. I tink she is going to this car.

Gemma: Ooo::h. You think they are going to give it to this girl? ((points to lady)) All right. Let's see. ((turns page))

(Mis)identification

There were three children that decided that the guy working on the car, which was intended as a mechanic, was the potential engineer. Diane's son thinks "I think it fer the engine", and she acknowledges with a soft, quiet "oh:hh" before continuing on. Zane's son at first says that he does not know who the engineer is, but then points to the guy working on the car. Zane reiterates (possibly for the camera's benefit) that "he thinks it's the guy fixing the car." Kamie's son also choose the mechanic as the engineer, as he is a "big ol man" who is "closing a car". It is interesting to note that he is the only one who identified the illustrated engineering with any kind of traits. In response, Kamie nods affirmative and foreshadows that they might find out later in the book (but did not come back to this idea).

Two children made the connection that instead of the people on the page, that an engineer is associated with trains. When asked what he thinks about who could be the engineer, Wade's daughter states that she thinks "it's somebody who drives a train". In response, Wade shakes his head in agreement and repeats what his daughter had said. His daughter then clarifies with an acknowledgement token ("mmn hmmm") after which Wade also gives a token response ("okay"). Liz's daughter pauses after the prompt, then replies that an engineer could be "the people that drives train:nsss." Liz then asked her daughter if she thinks that is the engineer, to which she confirms.

All inclusive

Several (n=3) of the children identified that all three of the individuals presented were engineers. However, both Ned and Xavier did not expand upon their child's choices and continued readings. Heather's daughter identified all three characters as potential engineers, however in order to get a response she had to restate her question and individually asked about each person. In responding to her daughter's answers Heather rephrased her child's answer, though the laughter bubbling up within her response indicated that she may not agree with her child, though she did nothing to engage further.

Heather: What do you think? Do you think that the man fixing the car is an engineer?

Daughter: (.) Hesh fixin the cahr::wa

Heather: Do you think he's an engineer? ((points to mechanic))

Daughter: .hh mmmnahh yes.

Heather: Y(h)ou think he's an engineer↑?

Daughter: He is an en, en-gin…

Heather: What about the girl jumping rope, do you think she's an engineer?

Daughter: Yee:sssss↑ha

Heather: °Yeah you think s(h)hes an engineer.° What about her? ((points to monkey tee)) You think she might be an engineer?

Daughter: Yeesss↑ha

Heather: Hah, y(h)ou think sh(h)e's an engineer too. ((turns page))

Child's negative and non-response

When posed a non-committal (e.g., I dunno), negative or non-response response, several parents further engaged their children through questioning. Steve's child does not know who an engineer could be and this is funny to both of them as they start to laugh.

While Beth's daughter claims that none of the people on the page are engineers, Beth tries to provide some doubt by a repetitive line of further questioning. By pressing on with her queries, Beth provides a possibility for her child to consider the characters as engineers.

Beth:	Oh who oh who could the engineer be?
Daughter:	I don't knowahhhh.
Beth:	Is it the man fixing the car?
Daughter:	°No.
Beth:	How about the child jumping rope?
Daughter:	NO
Beth:	Or maybe the lady who just winked at me?
Daughter:	°No:oha
Beth:	You don't think?
Daughter:	No. (.) Yea:h?
Beth:	Maybe?
Daughter:	Maybe.
Beth:	Yah, what do ya think?
Daughter:	Yaa:hh ((Note: token))

Beth: ((mom chuckles, turns page))

Tom's child promptly replied "no" to all three being potential engineers. He then asked "what do you think?" and after a short pause followed up with a question clarifying that none of the characters were engineers to which the child still replied no.

Cara initiated a line of questioning in which she asked if the lady was an engineer, then the dog (inciting laughter) prior to the questions asked in the text. She paused after each question for her son to answer. She repeated asking him about the lady who winked three times – once in the text, restating it, then again after a negative response from the child. Several times during the course of the book, Cara asks if the doggie is an engineer. This makes the child laugh, but the child also give a logical response that the dogs can't drive anything as he stated previously that engineers drive trains. Cara repeated his words back at him, and moved on.

Victor changes his tone of voice when reading the prompt versus the text, however his son points to the dog in answer to his question, resulting in laughter from both of them. While his son was being silly, Victor did not ask the question again and went on with the rest of the book.

In two cases the child did not respond to the prompt. Quincy does not get a response from son about who the engineer could be, instead he draws notice to how the illustrated dog looks their own dog. Ingrid's child did not respond at all and she continued on with the story.

5.4.4 Construct 4: Engineer's Workplace

The engineer's workplace is often limited to office scenarios, which can limit occupational interest for those that prefer outdoors. Several children responded to the queries that the main characters articulated in the text (Fig. 5.11), but those ideas were not expanded on by their parents. Tom's daughter said "no" to each location (office/dock) and while this amused him he did nothing to affirm or deny the child's statements. Liz's daughter also thought that neither location worked. Heather's child did not think the engineer was in the office, but did not mention if she thought an engineer could be on the dock. Victor's child did not think an engineer was in the office, but did think that the engineer was on the dock.

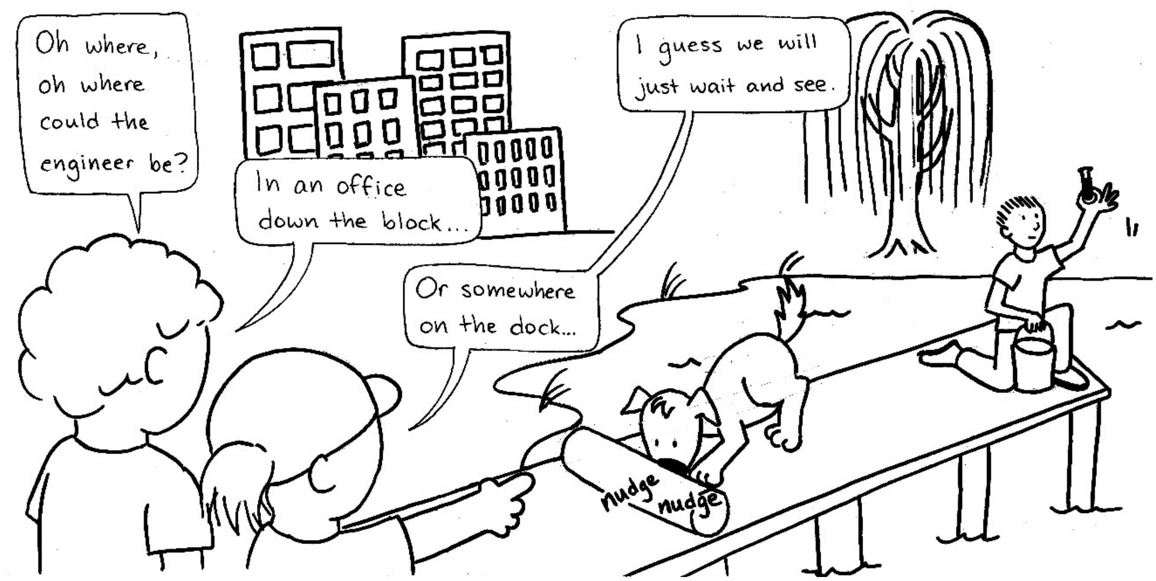

Figure 5.11 Storybook page for Construct 4: Engineering Workplace

Connections to Experience

Connecting to personal information is essential in developing emergent literacy as well as developing and building key interest and knowledge in certain subject (Crowley & Jacobs, 2008). While several connections (to fishing, boats and eating) were made regarding the man on the dock (Figure 5.12), none pertained to engineering. Jess clarified what a dock is, and her son asked about boats (connecting to his own personal experience).

Several parents questioned what the guy on the dock was doing. Quincy asked his son what the man on the dock is doing and he replies that the guy is fishing - “a fish in a little bucket right?” Gemma points out the water and the dock and asked her daughter what she think they are doing on the dock, to which she promptly answers eating! Gemma negates, then the child asked for clarification “wat they doin therah?” to which mom replies that she does not know and that they are “gonna hafta see”. Ned questioned what the guy is doing, and when child responds with “I dunno” he moves onto a secondary question about the item that the guy is holding (child says it is a toy).

The only person to go into any detail about what the man on the dock was doing was Anna, who specifically labeled it as “very interesting” denoting increased importance. Anna has a background as an environmental engineer.

Anna: So you see the dog is carrying the package, and there is someone – oh look this is very interesting. Do you see this man? <points to guy on dock> This man, is having, a little tube here, with probably water, and probably he is testing the water to see if the water is good to know. Hmmm interesting person.

Son: dee dee.

Cara asked if an engineer sits in the office and the child responds that they don't. When questioned further he states and points out the willow tree where the main characters are supposed to meet the engineer. Cara also posed a question to see if her son thought that the man on the dock is an engineer, he responds maybe which is followed up by an acknowledgement token (Maybe. Okay). Cara also points out that the guy on the dock has a "tool" in his hand, however she does not expand on this idea and instead asks her son if he thinks that the dog is an engineer. One limitation to this particular analysis is that the imagery points to the engineer on the dock.

5.4.5 Construct 5: Recognizing Engineers

This construct (Figure 5.12) was intended to evaluate how the children recalled their parent's occupation and conversely how the parent's reacted to the response of their child. This construct consisted of a call-out with the prompt "Do you know any engineers?" The positioning of this text was not in line with characters, and as such it was read either after the opening question from the main character or after all the text on the page was read (Figure 5.12).

Children's answers varied from recognition that the parent was an engineer to identification with common misconceptions, such as misrepresentation as a car mechanic (see Table 5.7). Additionally some children expressed that they did not know any engineers or were uncertain. Parent's response included affirmation, repetition, restatement and rephrasing of prompts, statements and no action.

Figure 5.12 Storybook page for Construct 5: Recognizing Engineers

Table 5.7 Child response and parental reaction for prompt about knowing an engineer. ( ) denotes child's subsequent answer when parents restate question

Child's Response	Participant(s)	Parental Interaction
Recognition of Parent	Victor (1) Xavier **Beth** Robert (2) **Liz**	Token Affirmation → restatement Token Affirmation Affirmation Repeated child's response w/ personal emphasis Token Affirmation
Book Character	**Anna** **Evelyn** (2) Victor (2) **Kamie** (1)	Token Affirmation w/ laughter Token Affirmation w/ laughter (None – continued w/ story) Restates question
Misconception	Oliver Steve **Diane**	Token Affirmation Token Affirmation Repeated child's response
Identification of other (incorrect)	**Kamie** (2)	Amusement → Restates question
Uncertainty	**Fran**	(None – continued w/ story)
Negative Response	**Gemma,** Quincy (1) Robert (1) Tom **Ingrid** **Cara** **Heather** Zane (1,2)	Affirmation w/ physical proximity Restatement w/ personal emphasis Restatement w/ personal emphasis Repeated child's response w/ laughter (None – continued w/ story) Statement as engineer Statement as engineer w/ physical proximity Restates question; Repeat child's response
Non-response	Pete **Kamie** (3) Wade (1,2) **Jess** Ned **Maddie** **Diane**	Did not allow time for response Prompt for hint Rephrases question; Statement teach engineering Restates question (Did not ask prompt) Restates question Token

* Ned skipped prompt

Identification of Parents as Engineers

Out of 24 participants, only four children readily stated (directly after the prompt) that the parent reading the book was an engineer. For example, when Beth gave her daughter the prompt, she pushes on her mother's faces and declares that "momma is an engineer". One other was able to recall that their parent was an engineer after some prompting.

Xavier's daughter was able to mention that her dad and an aunt were engineers and he followed up with non-committal affirmation (oh). Liz's daughter was also able to state that bother her mother and her father, as well as another individual were engineers. Victor focused his attention on his son when asking the question and his son was able to state that he was an engineer. When asked who else, Victor's son pointed to the guy from the dock, then continues reading the story.

Parents responded with some form of affirmation, be it a token (e.g. oh or okay) or repetition of the child's response. However, three of the parents – Victor, Xavier and Beth – made eye contact with their children during the prompt which may denote special importance of this question and potential extrapolation by the child.

Identification of Book Character as Engineers

In some cases when asked the prompt, the child responded by pointing to the characters on the page, showing comprehension of the story but not connecting to personal association as intended. This could potentially be attributed to predictive behaviors of the child, a skill encouraged within emergent literacy.

Anna’s son states that he does know an engineer, and when she questioned whom, he points to male character on the page. This is prior to her reading the text that states that the characters on the page are engineers. Anna then clarifies his choice by asking if he “think he’s an engineer?” and the child affirms with a shake of his head. Anna’s then acknowledges with the token “hmmm… okay”. Instead of redirecting his answers to specific real world example, she moves on with the storybook and does not connect that she is an engineer during the reading session.

Evelyn asked the prompt and the daughter responds with a “no”, she asked again, with emphasis on knowing “any” engineers. This time she responds that she does. When mom questioned about whom is an engineer, she points to the illustrated character in the book. Evelyn laughs and continues on with story without mentioning that she is an engineer herself.

Response to Misconceptions

While misconceptions about engineers abound with children and adults alike, it was not expected that this prompt would elicit a response in that manner. However, three children used general description of engineers when answering the prompt. There were two different misconceptions that were observed. The first dealt with the idea that engineers fix cars and the second was association with heavy machinery.

Oliver’s daughter turns the prompt on her father and he redirects it back to her. She answers that engineers are “guys whose fix cars” and Oliver repeats this statement and child shares affirmation. She then goes on to explain that engineers are “guys [that] build roads and make it nice“. Instead of confronting the misconception that engineers are mechanics and/or construction workers, Oliver moves on with the remainder of the story after a non-committal token. After the storybook is finished, he then puts the book aside and looking directly at his daughter (denotes importance) asks if she knows who else is an engineer. The daughter finds this slightly amusing (she laughs with intake of breath) and states that she does not know any engineers, corroborated by shaking head her head negative and leaning back. Oliver stresses (through inflection and body language) that he is an engineer and then the daughter asked about her mother (who is a nurse) and brother and Oliver reaffirms that he is indeed the engineer.

Oliver: Do you <u>know</u> any engineers? <looks directly at daughter>

Daughter: Do <u>you</u> know:: any engineer↑?

Oliver: That's a question for <u>you</u>. DO you know any engineers?

Daughter: Uhh….guys whose fix cars and…

Oliver: Guys who fix cars.

Daughter: <shakes head affirmative>

Oliver: Yea::h

Daughter: And guys (.) build roads and make the hang n make it nice like nice n perfect like a borehouse (dollhouse) inside

Oliver: <turns page> °hmm:: yeah° .pt

Diane's son mumbles several different before finally saying "car engine". Diane repeats his statement preceded with an acknowledgement token "oh" and the child affirms his answer. This type of exchange acknowledges the child's statement as correct, as it was not challenged. Diane then asks if she is an engineer after which a long pause, the child quietly asks her to turn the page, and she acquiesces with an acknowledgement token.

Steve looks directly at son while giving the prompt and his son shakes his head negative. He then repeats the prompt to which the son replies that he does know engineers. By prompting who those engineers were, the child then states “an engineer at a plane” to which Steve repeats “a plane”. The child then adds “and ah train”. When Steve asks yet again who those engineers are, after a pause the child responds with engineers. After another question about who the engineer is, the child does not answer and then Steve gave an affirmative token before moving on. There is a possibility that by stating that an engineer is at either at plane or a train that Steve’s son could have been influenced by the imagery presented earlier in the book.

While only a small sub-set (n = 3) of the participants’ children associated engineers with incorrect attributes such as “fixing cars” and “engines”, the parents did not address these inconsistences during the storybook reading.

Child’s negative and non-response

A majority of children expressed that they did not know any engineers or expressed uncertainty. In some cases the child would deflect away from the question through verbal or physical means. Parental responses ranged from surprise that the child did not recognize their own occupation (Quincy, Robert), to physical interaction (Gemma), rephrasing of question to include personal connection (Robert, Zane), stating that they are an engineer (Gemma) and doing nothing (Tom, Ingrid).

Quincy's son states that he does not know any engineers which surprised Quincy (through octave change). He asks if he is an engineer and his son replies with a querulous yes. Quincy then lists several members and his son replies in the affirmative. However, it could be that he was expected to say yes from Quincy's emphasis and the long list of people.

Robert's son replies that he does not know any engineers by shaking his head negative and Robert repeats the question with more emphasis (and a little disbelief) and gets another negative head nod. He then sets the book down to ask what he is, with emphasis on himself. The child then states that daddy is an engineer and Robert affirms this by reinforcing that he is an engineer, that he teaches engineers, and that the son knows the engineers that he teaches (personal connection).

Robert:	…Do you know any engine::ers?
Son	((shakes head negative))
Robert:	You don't know éany engineers? ((puts book down))
Son:	((empathetically shaking head negative with smile))
Robert:	é then what am what AM I::?
Son:	an engine-earé ((points to daddy's chin))
Robert:	An engineer. (.) I am an engineer! ê I teach other engineers. You know ALL the engineers in daddy's class!

After the end of the book, Robert restates that he is an engineer in an exaggerated tone of voice and then tickles his son, who squeals with laughter.

When given the prompt, Cara's son did not say anything, to which Cara restated the question again. The child responded with a querulous "no", showing that he wasn't able to recall. Cara then states that she is an engineer while looking directly at her son. After a slight token expressing acknowledgement, Cara asks her son if he knew that she was an engineer. The child deflected this answer by asking if his father is also an engineer – which he is not. He then expressed that he does not know who else is an engineer, though Cara asks him if he does know any more. After a slight pause, he offers up his papa in a questioning way, as if he was uncertain. Cara shakes her head and states that he isn't an engineer. Yet her son clarifies about who he intended to talk about (another grandparent), but again Cara says that he is not an engineer. She then goes on to state three individuals are engineers. With some exuberance Cara's son offers a name, but again is not an engineer. Cara then starts to read again.

When prompted, Zane's son stated "no" to the study prompt regarding knowing engineers. Zane then restructured the question into a more personal query: "who do you know who is an engineer? While his child also responded "no" to this question, Zane repaired his statement to "you don't know". He did not offer any information regarding his own occupation.

Gemma's daughter simply said "no" when asked if she knew any engineers. Gemma then used physical closeness and affirmation to engage with daughter. However, the daughter still insisted that she did not know any engineers, which caused Gemma to laugh before she continued on reading the story.

Gemma: Do <u>you</u> know any engineers?

Daughter: No.

Gemma: Yeeee::sssss ((puts face close to daughter))

Daughter: He::yyyy-ah I don't!

Gemma: ((leans back and chuckles)) ((turns page))

Tom's daughter reiterate through repeated language that she did not know any engineers, though she seemed to think of an engineer as a thing and not a person. He continued on with the story without acknowledgment.

Tom: Do you know any engineers?

Daughter: ((high voice)) No.

Tom: N(h)o. ((smiles))

Daughter: No habh a enghnhear. Don't have it. I don't have it. I don't have a en-jin-hHEAR.

After an exaggerated "no" from her son, Ingrid then continued with reading.

Deflection

Several children showed uncomfortableness when asked if they knew any engineers. Their responses, or lack thereof, included physical withdrawal and deflection of the question through both verbal and physical means.

When asked if he knew any engineers, Fran's son put his hand over his eyes and stated that he did not know. Fran then suggested that his papa was an engineer and asked if he know anybody else. He gave one suggestion but it wasn't correct. Fran quietly asked if she was an engineer and the child laughed and said that she is.

Wade poses the question to his daughter four times without answer, during which the child attempted to turn the page though he places his hand on it so she couldn't. He then asks what he teaches and after a pause qualifies that he teaches engineering. The child then pats the book and Wade continues on with the story.

Kamie repeats the prompt to her son after not getting a response and the son points to a character on the page. Kamie then restates the question with exclusion of the book illustrations. This caused the son to shrink back a little bit in the couch and he puts his fingers near his mouth. After a long pause he says some intelligible, which Kamie takes to be "President Jefferson" (she was amused at this answer). She then asks the question a third time, and after a long pause (with fingers in mouth) she ask if he needs a hint to which he shakes his head positive. Kamie asks "don't you know what mommy is?"), after a long pause, she asks about what she does at work. He enthusiastically states that "fix!" showing that he had some knowledge of her occupation. Kamie continues this on with her line of question by asking what her job is called, but her son replies with what she does – fixing telephone poles. Kamie reiterates this statements by repeating what he said and then states that she is an engineer for the telephone company. She then asks if his father is an engineer, to which the child shows a slight surprise (indicated by tonal differences). However, while both parents work at the same place, the child did not recognize this. Kamie also went on to explain and list other family members who are engineers, a total of six all together.

When Jess poses the prompt to her son, he tries to immediately turn to the next page. When the prompt was repeated the child physically places a sticker on mom's face, which she acknowledges with a polite thank you before turning the page.

Maddie asked her daughter if she knew any engineers twice in a row. Instead of a response, her daughter started going off about what was going on in a different location in the house. After the lengthy aside, Maddie asked the question again and received a "no" in response before moving on with the rest of the story.

General Observations

Parent identification as an engineer, either through child response (through prompt or follow-up questioning) or parental statement identifying themselves occurred in twelve out of the twenty four cases (Table 5.8). There was no discernable pattern with regard to child's response or age. Nor was there any pattern between a child's recognition of parent as an engineer and the types of engineers with whom they interact.

Table 5.8 Identification as engineer / Eye contact during prompt

Participant	Identification	Eye Contact	Participant	Identification	Eye Contact
Anna		X	Ned		
Beth	**X**	**X**	Oliver	X	
Cara	**X**	**X**	Pete		
Diane			Quincy	**X**	**X**
Evelyn			Robert	**X**	**X**
Fran	X		Steve		X
Gemma		X	Tom		
Heather	**X**	**X**	Victor	**X**	**X**
Ingrid			Wade	X	
Jess			Xavier	**X**	**X**
Kamie	**X**	**X**	Zane		
Liz	X				
Maddie					

5.5 Parental Strategies

The guiding research question for this exploratory study was to determine what **strategies** engineering parents use to facilitate occupational knowledge about engineering to their child when reading an engineering-themed storybook (RQ). To this end, adjacency pairing through the CA lens was investigated, coupled with additional information regarding reading levels and corresponding comfort levels as determined by the ACIRI. The parental strategies were openly coded and then themes emerged. Parental strategies were evidenced by their behavior in responding to child's talk as well as the ways in which they shared occupational knowledge, attitudes and beliefs. Four different themes regarding parental strategies were observed including: physical response, questioning, affirmation and clarification.

Physical responses played a role in the interactions between parent and child. When asked the prompt "do you know any engineers?" parents denoted emphasis by turning their body as to make eye contact with their child (Table 5.12). Almost half of the participants (n=11) made purposefully eye contact with their child when asking this prompt. This is of interest as only three participants made eye contact during the previous prompt (Construct 3, Figure 5.12) asking about who could be an engineer. However, out of those that made eye contact with their child all were able to get a response. Half of the children (n=5) responded that they did not know any engineers, and the remaining half recognized the parent right away (n=3), mentioned one of the book characters (n=2) or had a misidentification (n=1).

Parents used questioning and additional prompting as devices to elicit a child's response. This could be either educational ("what are those pictures of?") or entertaining ("can the dog be an engineer?"). On rare occasions, children would often solicit a question from their parents, for either clarification ("what's that?") or curiosity ("why you be an engineer?). Parents often repeated what a child said in question form to clarify their answer or in some cases restatement denoted an incorrect or incomplete answer.

Affirmation was a key parental strategy that was used throughout storybook reading and often preceded most of the interactions from the child. Key tokens such as "okay" and "yeah" was used to reinforce a child's response and also to keep the storybook progressing.

5.6 Engineering Knowledge

A subset of the research question was to observe the knowledge that engineering parents brought into the reading session as aligned with the Bryant et al. (2006) framework (Figure 1.1) that tied together parental strategies regarding occupational knowledge, attitudes and beliefs with the developmental foundations for occupational learning.

Engineering parents within this study shared both 1) general engineering knowledge as well as 2) specific engineering knowledge. When generalizing engineering, parents included information such as how the ramp works including basic floatation principles, the role of engineers in designing the plans, and how engineers work together.

In regards to specific knowledge, it was influenced by a parent's own background. For example, with the man on the dock Anna pointed out that the man (Fig. 5.11) was testing the water as her background in environmental engineering would have included this connection. Also instead of prompting a response, Robert points out that the turbine is a jet engine and that he teaches jet engines and how they work to his class. Thus the content in the book was able to bring about connections to personal knowledge about engineering.

5.7 Engineering Attitudes and Beliefs

Another focus of this study was to determine attitudes and beliefs that engineering parents share during the reading process (RQb). The belief that train drivers are also engineers is a misconception that is derived out of semantics within the English language, and which is only compounded by the title of “locomotive engineer” that is used predominately in the United States and Canada (though not elsewhere). Even engineers make this connection as 11 out of the 24 parents mentioned and/or affirmed association of engineers with trains.

When asking whom an engineer could be, several dyads discussed traits that engineers have such as age, gender, height and even species. For example, when listing possible friends and family who are engineers, Heather’s daughter suggests a young child. Heather then stated that she did not think the child could be an engineer since “he’s just a baby” though she did mention that the baby had the possibility of becoming an engineer, thus implying that it could happen when the baby grows up. Kamie and her son were also listing potential engineers when he suggested a person. Kamie explained that he couldn’t be an engineer because he was still in school – suggesting that to be an engineer one need to finish school.

Oliver’s daughter posed a question asking why he was an engineer. While Oliver may have provided an answer for her question it was largely practical as it focused on the process of being an engineer rather than the motivation (i.e. showing positive affect). His emphasis on the quantity of schooling reflects his advanced degree level (Ph.D.) and displays the belief that to be an engineer it takes a lot of effort. However, his explanation that engineers solve problems is congruent with the message on the last page of the storybook (i.e., Engineers solve problems).

Daughter: Why you an engineer?

Oliver: Because I went to school. I went (.) I went and did lots of schooling…

Daughter: [laughs]

Oliver: …so I can be an engineer. I can solve problems.

5.8 Summary

- Parental strategies for incorporating engineering included physical response, questioning, affirmation and clarification.
- Occupational knowledge about engineering included general and specific information.
- Engineering association with train drivers was still evident

CHAPTER 6. IMPLICATIONS AND CONCLUSION

The purpose of this study aimed to look at the strategies that engineering parents engaged with children during a storybook reading session (RQ) with specific focus on the knowledge (RQa) and attitudes/ beliefs (RQb) shared during that interaction.

6.1 Implications for Further Research

The findings from this study indicate that engineering parents want their children to learn about engineering and even want their children to consider it as a potential occupation. However, there is a division regarding the necessity of introducing engineering at a young age, though research has supported that it is a critical time for the development of occupational interest. Mothers were found to have a stronger agreement (though not statistically significant) about young children learning engineering than did fathers. However, the small sample size could have underscored the significance and it would be useful to look at a larger population of engineering parents to discern differences and commonalities. It would also be of interest to compare and contrast non-engineering parents to engineering parents to see if there are certain knowledge, attitudes and beliefs that engineers have than non-engineers might not express.

Engineering parents also were able to share engineering knowledge through either discipline specific or general knowledge. Engineering attitudes and beliefs were only minimally evidenced during the book reading, though PEAS responses showed that in general there was agreement for a parent's attitudes and beliefs regarding wanting children to understand engineering, and even pursue a career in the field.

One broad theme that emerged from this study was the idea that the engineering parents missed opportunities to discuss engineering with their children such as connections to their own career. This was evidenced through children not connecting that their parent was an engineer and the parent not putting forth their own occupation. Additionally, there were opportunities for parents to negate or expand upon certain misidentifications with engineering such as the strong association with trains. It was more prevalent for parents to explain and/or reinforce that an engineer drives a train, rather than expound on their own occupation. Having said this, there is the caveat that the engineering parents are not as immersed in the literature regarding engineering education and may not be aware of how important it is to appropriately showcase engineering to young children to garner potential interest in the field. Another possible explanation is that the parents did not think that this was the right time to correct the misconception – perhaps because they recognized that their child was distracted or perhaps they were nervous about being recorded for a study.

6.2 Implications for Parents and Educators

Qualitative research has a key import in being translatable to a broad range of users – in this case to parents, caregivers, and educators. Turns et al. (2014) developed a framework as a tool for articulation of main implications of research to a wider audience. The framework is comprised of three parts: the action being encouraged by the researcher, the nature of the action and the actor taking action (Turns et al., 2014). This study thus developed key recommendations to which adults (those both familiar with engineering and those who aren't) can use the storybook to discuss engineering with their child. The recommendations are as follows:

Recommendation 1: Use the word "engineer" in everyday talk as repeated exposure will allow a child to use it in everyday conversations. Point out the word if you hear it in a commercial or see it in a book or on television.

Recommendation 2: Make a connection to personal occupation as parents are the major source of occupational knowledge and it is never too early. If you feel that the topic is too complex, talk about where you work, what you work on, who you work with and what kinds of things you do (e.g., work outside, use a computer, draw, talk with others, etc.).

Recommendation 3: Address inconsistencies early, and stray away from train / mechanic / construction associations. These beliefs are often hard to mitigate later down the line and those that are not interested in these association may not consider engineering as an ample field of study.

Recommendation 4: Increase interactive strategies for reading through questioning behavior and physical proximity (eye contact, sharing of book, etc.).

While much research is disconnected from real-world problems, this study intends to disseminate recommendations to help others in discussing engineering. These recommendations will be included in the final published version of the storybook. At the time of this study the storybook is currently being self-published through a third-party printing site, but other publishing options will be considered.

6.3 Limitations of the Study

There were several limitations of this study regarding how the findings were interpreted and how generalizable the data are. One large limitation of this study was the data collection itself. While having the participants be in charge of the data collection gives a more naturalistic response, there is no way for the researcher to “control” the situation. For example, the camera may record the participants reading, but the angle does not allow the researcher to determine where someone is pointing on the page. Additionally, with the researcher removed from the data collection process, it is hard to clarify and/or make changes (e.g., minimize outside distractions) or to capture further conversation that might occur after the camera is turned off.

Also, this study looked at a highly homogenous sample (predominately white, middle class, educated, 30s-40s, etc.) of engineers. While the exploratory nature and the methodology of this study don’t lend towards generalizations, it can be looked at as a small piece of the occupational socialization of children. While it can’t inform general theory per se, the findings are relatable to a general audience. Also, while this study is looking at socialization, it does not aim to include every aspect, nor does it attempt to discern how the phenomena of occupational inheritance is formed.

Lastly, the small sample size was sufficient for this type of exploratory study, but it potentially impeded efforts to look at difference in gender as well as the impacts of different dyad combinations.

6.4 Methodological Insights

The methodology used for this study has significant strengths such as the removal of the research from the data collection and naturalistic observation. However, there were also some drawbacks such as long lag time and incorrect data collection. In order to improve on the methodology several items should be taken into account. First, like in design, you need to understand the user – and in this case the participant is the user who is responsible for the accurate data collection. Participants' responsibilities included:

1. Written assent to be included in study (which consisted of their mailing address)
2. Reading all communications including detailed instructions outlined in the cover letter.
3. Pre-reading the engineering book in a setting of their choice, at a time of their choosing
4. Recording the reading session (with the correct book outlined on the cover letter)
5. Filling out the PEAs survey (either online or hard copy)
6. Sharing the video file
7. Reading the book to their child
8. Signing of the consent form
9. Returning the study book and signed consent forms

As the researcher, I anticipated a few issues such as long lead time during the holidays and issues regarding the return of materials. As such I labeled all key research with "Return" status. To take this further, I should have differentiated the "study" book from the honorarium book by presenting it in wrapped paper, as several participants ended up reading the wrong book. Additionally it would be useful for the parent-child dyads to have a debriefing interview after reading to determine what they found was useful and if they had anything that needed to be clarified.

Several changes will be made to the storybook as well. While the train imagery was meant to inspire conversation it could also reinforce this misconception and will not be included in future editions. Additionally, more prompts to encourage talk and an additional page (for the guy with the concrete block) will be included in the final version of the book.

6.5 Recommendations for Further Research

In addition to doing a more detailed study on the implications mentioned in Section 5.1, this study could be extended to look at how parents not familiar about engineering engage with their children about engineering, while using the findings from this study as an intervention to promote increased parental self-efficacy around engineering and shared engagement. Additionally, while the focus of this study was on parents, it is also important to investigate how the child's learning about engineering is engaged through the use of this storybook, especially with under-represented groups.

Also as previously mentioned, a larger sample size would be useful in looking at genders. Repeated readings as well as semi-structured interviews between parent and child would be useful in determining prior and post knowledge with this type of methodology. Also a parent's self-efficacy on teaching engineering should be assessed.

6.6 Conclusion

This study is just one small look at a subset of a larger process of occupational socialization that allows us insights into how engineering parents talk about their occupation with young children. From this study, it was found that while parents engage with children about engineers through sharing of engineering knowledge, attitudes and beliefs, they may not push to clear inconsistencies that the engineering education field is attempting to improve.

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APPENDICES

Appendix A PEA Survey

** Please fill out the following survey and return in envelope provided. If you wish you can fill out an online version at tinyurl.com/engstorybook in which you will need to input your participant ID above. Thanks!*

1. How would you describe your association with engineering (work in engineering field, hold a degree in engineering, job title, etc.)?

2. Indicate your responses to each of the following statements in reference to your knowledge of engineering using the provided scale.

	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
a.	I know how engineers use engineering design principles.
b.	I know how engineers use problem-solving strategies.
c.	I know what engineers do.
d.	I know how engineering is related to science, mathematics, and technology.
e.	I know how engineering can be used to help society.
f.	I know how engineering is different from science.
g.	I know how engineering is different from mathematics.
h.	I know how engineering is different from technology.
i.	I know how to teach engineering skills to my child(ren).
j.	I know how to apply engineering-related concepts in my daily life.
k.	I know how to explain engineering-related concepts to my child(ren).
l.	I know how to help my child(ren) with his/her engineering ideas and skills.
m.	I know how to identify and solve problems.
n.	I know how to find out more about engineering information to help my child(ren)'s learning.
o.	I know where to search to find more about engineering-related information.
p.	I am aware of engineering curriculum at my child(ren)'s school.

2-1. Please provide any additional thoughts or comments related to your knowledge of engineering you might have.

3. Indicate your responses to each of the following statements in reference to your beliefs about engineering using the provided scale.

	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
a.	I believe engineering improves our quality of life.
b.	I believe engineers make our life more convenient.
c.	I think that engineering is worth studying.
d.	I think engineering improves our society.
e.	I believe engineers make my child(ren)'s lives easier.
f.	I want my child(ren) to pursue a career in engineering.
g.	I think my child(ren) would enjoy studying engineering in college.
h.	I believe that learning engineering ideas and skills would be good for my child(ren).
i.	I think engineering skills would be useful for my child(ren)'s career.
j.	I think my child(ren)'s school should teach engineering concepts and skills.
k.	I think my child(ren) would enjoy learning engineering in K-12.
l.	I think learning engineering in K-12 allows my child(ren) to better understand other subjects, such as science, mathematics, and technology.
m.	I believe my child(ren) would have an improved life quality if they learn engineering in K-12.
n.	I want my child(ren) to learn engineering skills.
o.	I want my child(ren) to understand what engineers do.
p.	I think it is more important for girls to learn engineering than it is for boys to learn engineering.
q.	I think it is more important for boys to learn engineering than it is for girls to learn engineering.
r.	I think it is equally important for girls and boys to learn engineering.
s.	I am interested in attending workshops about engineering at my children's school.
t.	I think it is necessary to learn engineering as early as possible.

3-1. Please provide any additional thoughts or comments related to your beliefs about engineering you may have.

4. ***<u>Think about your child aged 3-5 years when you answer this question</u>*.**

4-1. ***<u>Please indicate the gender and age of the child you are answering this question about.</u>***

Boy (_____ years) Girl (_____ years)

	4-2. Please mark the frequency that you perform each of the behaviors listed below by checking the appropriate responses using the following scale provided. *1 = Never, 2 = Less than once a year, 3 = Once or twice a year, 4 = About once a month, 5 = At least once a week*	***Never*** **1**	***Less than once a*** **2**	***Once or twice a*** **3**	***About once a*** **4**	***At least once a*** **5**
a.	I play with engineering-related toys (for example, Legos, Blocks, or Puzzles) with my child.	]	]	]	]	]
b.	I watch TV shows with my child that has engineering topics in them (for example, Mythbusters, Engineering TV show, Design Squad, or etc).	]	]	]	]	]
c.	I read books, stories, or articles about engineering topics/issues with my child.	]	]	]	]	]
d.	I encourage my child to play with engineering-related toys (for example, Legos, Blocks, Puzzles, or Building something).	]	]	]	]	]
e.	I encourage my child to identify and solve problems.	]	]	]	]	]
f.	I give my child some projects that he/she needs to use engineering skills for.	]	]	]	]	]
g.	I play games with my child using technology (for example, computers).	]	]	]	]	]
h.	I visit children's museums with my child to improve engineering knowledge.	]	]	]	]	]
i.	I go to the park with my child for his/her engineering knowledge.	]	]	]	]	]
j.	My child and I have attended engineering fairs together.	]	]	]	]	]
k.	My children and I go to buy toys together to help his/her engineering learning.	]	]	]	]	]
l.	I would encourage my child to participate in engineering fairs.	]	]	]	]	]

4-3. What toy do you play most often with your child?

4-4. What was your favorite toy when you were your child's age?

4-5. Approximately how many books per week does your child read per week, either by self-reading, at a daycare/Sunday school facility, or through another person (parent, family member, babysitter)?

a. None
b. 1 -2
c. 2-5
d. 5-10
e. 10-15
f. 15-20
g. 20-25
h. 25+

4-6. Approximately how many children's books do you have at home?

a. None
b. 1-10
c. 10-25
d. 25-50
e. 50-75
f. 75-100
g. 100-125
h. 125-150
i. 150+

4-7. In general, how many times does your child go to a bookstore or library per month?

a. Never
b. Once
c. 2-3 times
d. Weekly (4-5 times)
e. Frequently (6-15 times)
f. Daily

4-8. How often does your child read a book on their own (if able) per week?

a. Never
b. 1 -2
c. 2-5
d. 5-10
e. 10-15
f. 15-20
g. 20-25
h. 25+

4-9. How often do you (or your significant other) read a book to your child per week?

a. Never
b. 1 -2
c. 2-5
d. 5-10
e. 10-15
f. 15-20
g. 20-25
h. 25+

4-10. How often do others (family members, caregiver's, older siblings) read to your child?

a. None
b. 1 -2
c. 2-5
d. 5-10
e. 10-15
f. 15-20
g. 20-25
h. 25+

4-11. What types of books does your child have? (Please check all that apply)

a. Story books (more words than pictures)
b. Picture books (pictures with minimal words)
c. Non-fiction books (about real world events)
d. Easy Reader Books (e.g. Dr. Suess)
e. Trade books (have factual information on a certain subject)
f. Educational Books (e.g. Dora the Explorer, Sesame Street)

4.12. What is your child's favorite book(s)?

4-13. How many times is the child's favorite book(s) read per month?

a. None
b. 1 -2
c. 2-5
d. 5-10
e. 10-15
f. 15-20
g. 20-25
h. 25+

4-14. Do you read anything else with your child? (Please check all that apply)

a. No
b. Magazines
c. Comic Strips
d. Cereal Boxes
e. Newspaper
f. Other

4-15. In what location do you normally read to your child?

a. None
b. Daycare
c. Library
d. Bedroom
e. Bookstore
f. Home
g. Car
h. Other

4-16. Does your child attend any of the following:

a. None
b. Daycare
c. Library Events
d. Pre-school
e. Museum Exhibits
f. Other

5. Is there anything else that you think should be in this survey?

6. Do you have any other comments?

7. What is your sex?

a. Male
b. Female

8. Which grades are your children currently in? (Please check all that apply – Answer this question with all of your children in mind)

Boy	Girl		Boy	Girl		Boy	Girl	
☐	☐	Infant/Toddler	☐	☐	4th grade	☐	☐	9th grade
☐	☐	Preschool	☐	☐	5th grade	☐	☐	10th grade
☐	☐	1st grade	☐	☐	6th grade	☐	☐	11th grade
☐	☐	2nd grade	☐	☐	7th grade	☐	☐	12th grade
☐	☐	3rd grade	☐	☐	8th grade	☐	☐	Other ___________

9. What best describes your household type?

a. Married-couple, children living at home
b. Married-couple, children not living at home
c. Single householder, children living at home
d. Single householder, children not living at home
e. Unmarried-couple, children living at home
f. Unmarried-couple, children not living at home
g. Single, never married
h. Other ___________

10. Which of the following age groups do you belong to?

a. Under 20
b. 20 – 24
c. 25 – 29
d. 30 – 34
e. 35 – 39
f. 40 – 44
g. 45 – 49
h. 50 – 54
i. 55 – 59
J. 60 and above

11. What is your approximate annual household income?

a. Less than $10,000
b. $10,000 - $19,999
c. $20,000 - $39,999
d. $40,000 - $59,999
e. $60,000 - $79,999
f. $80,000 - $99,999
g. $100,000 - $119,999
h. $120,000 - $139,999
i. $140,000 and above

12. Which of the following best describes your ethnic origin?

a. White/Caucasian
b. African-American
c. Native American
d. Asian
e. Latino/a
f. Other

13. What is your current occupation?

a. Manager/Executive
b. Technician/Operation
c. Engineer
d. Scientist/Mathematician
e. Professional
f. Teacher/Educator
g. Sales/Service
h. Farming/Fishing
i. Homemaker
j. Student
j. Retired
k. Unemployed
l. Other

14. Which of the following best describes your highest level of education?

a. Less than high school
b. High school
c. Associate
d. Bachelor’s degree
e. Master’s degree
f. Doctorate degree
g. Other

15. Do you have a degree in any of the following areas?

a. Yes, I have a degree in science.
b. Yes, I have a degree in mathematics.
c. Yes, I have a degree in technology.
d. Yes, I have a degree in engineering.
e. No

16. Does your child interact with any engineers?

a. Yes, I am an engineer.
b. Yes, my significant other is an engineer.
c. Yes, another relative is an engineer.
d. Yes, a family friend is an engineer.
e. Yes, other: __________
f. No

Appendix B ACIRI

Adult Child Interactive Reading Inventory - From (DeBrui-Parecki, 1999)

ADULT READING BEHAVIORS

Enhancing Attention to Text

1. Attempts to promote and maintain physical proximity
2. Sustains interest and attention through use of child adjusted language, positive affect and reinforcement.
3. Gives child opportunity to hold book and turn pages.
4. Shares book with child (i.e., displays sense of audience in book handling when reading).

Promoting Interactive Reading and Supporting Comprehension

1. Poses and solicits questions about the book's content
2. Points to pictures and words to assist child in identification and understanding.
3. Relates book content and child's responses to personal experiences.
4. Pauses to answer questions child poses

Using Literacy Strategies

1. Identifies visual cues related to sotry reading (e.e, pictures, repetitive words).
2. Solicits predictions.
3. Asks child ro recall information for the story.
4. Elaborates on child's ideas.

CHILD READING BEHAVIORS

Enhancing Attention to Text

1. Child seeks and maintains physical proximity.
2. Child pays attention and sustains interest.
3. Child holds book and turns pages on his/her own when asked.
4. Child initiates or responds to book sharing which takes his/her presence into account.

Promoting Interactive Reading and Supporting Comprehension

1. Child responds to questions about book
2. Child responds to parent cue or identifies pictures and words on his/her own
3. Child attempts to relate book content to personal experiences.

4. Child poses questions abou the story and related topics.

Using Literacy Strategies

1. Child responds to parent and/or identifies visual cues related to the story him/herself.
2. Child is able to guess what will happen next based on picture cues.
3. Child is able to recall information from story.
4. Child spontaneously offers ideas about story.

Item Score (0-3)

3 = Most of the time (4 or more times)

2 = Some of the time (2-3 times)

1 = Infrequently (1 time)

0 = No evidence

VITA

VITA

Brianna L. Dorie

EDUCATION

Ph.D. Engineering Education / Ecological Science & Engineering – Purdue University, Aug 2015
M.S. Environmental Engineering – University of Arizona, August, 2006
B.A. Civil Engineering, Environmental Track – University of Portland, May, 2004

AWARDS

Purdue Graduate Student Government Travel Award, 2011, 2013
Women in Engineering Travel Grant Recipient, 2012
Featured in Purdue University's "5 Student who are Green Makers", September 2011
Purdue College of Engineering Outstanding Service Scholarship, 2011
Matthew Edward Kern Environmental Engineer Scholarship, 2007
Featured in ASEE Prism Magazine,"Teaching Toolbox: Live Green or Die" April 2007
Purdue University Elmer Balloti Memorial Fellowship, 2007
Purdue University Lynn Fellowship, 2006
Boeing Scholar, 2004
American Society of Civil Engineers Byron Jones Scholarship, 2004
Society of Women Engineers Columbia River Scholarship, 2003, 2004
University of Portland Engineering Scholarship, 2000-2004
University of Portland Katz Scholarship, 2000-2004

RESEARCH & WORK EXPERIENCE

Purdue University, West Lafayette, IN
Graduate Research Assistant **2011 - Present**
Working with INSPIRE and Science Museum of Minnesota to research the role of gender on adult-child discussions in informal engineering environments.

Purdue University, West Lafayette, IN
Sustainability Intern **2008 - 2012**
Gathered information regarding the University's sustainability initiatives, as well as benchmarked programs in respect to other academic institutions. Acted as a liaison between administration and student groups. Coordinator for Green Week, a week-long focus on sustainable initiatives on campus and around the community.

Purdue University, West Lafayette, IN
Graduate Research Assistant **2006 - 2008**
Part of an interdisciplinary NSF project that combines civil and environmental engineering with material science, industrial ecology and political science to quantify the emissions of brominated flame retardants in consumer products for a life cycle analysis.

University of Arizona, Tucson, AZ
Graduate Research Assistant **2004 - 2006**
Collaborated on a project involving the measurement of estrogenic activity in subsurface wetlands. Was responsible for monthly sample collection, processing and analysis using a yeast bioassay. Also assisted in lab management and direction of undergraduate workers.

Department of Environmental Services, City of Gresham, OR
Engineering Intern, Wastewater Division **2003**
Introduction to practical engineering applications of design, construction, surveying, and other engineering duties performed in a municipal setting. Helped to implement the first stages of public awareness for replacement of a sewer system.

TEACHING & MENTORING EXPERIENCE

Purdue University, West Lafayette, IN
Guest Lecturer, Engineering Education **2015**
Developed a lesson plan and coordinating activities for a large (n=120) undergraduate introduction to engineering course (ENGR 131) on excel programming using a "flipped" classroom pedagogy.

Purdue University, West Lafayette, IN

Graduate Faculty Apprentice, Engineering Education 2014
Co-taught a graduate level course (ENE 695: Theories of Development and Engineering Thinking) with responsibilities entailing syllabus creation, lesson plans, feedback, rubric development, grading, and class management.

Purdue University, West Lafayette, IN
Camp Director, Women in Engineering Program Summer Camps 2009 - 2011
Responsible for two national summer camps aimed at introducing seventh to tenth grade girls to the engineering disciplines. The week-long camps included industrial tours, faculty lab visits, and hands-on engineering activities.

Purdue University, West Lafayette, IN
Program Coordinator, Women in Engineering K-5 Outreach Program 2008 – 2011
Part of a program designed to increase awareness of engineering to after school elementary students. After a year as a graduate team leader, became coordinator of the entire program. Responsibilities included management of forty undergraduate workers, scheduling of twelve schools, curriculum development and expansion of the program.

Purdue University, West Lafayette, IN
Leadership Team, Women in Engineering - Graduate Mentoring Program 2008 – 10
Worked in a group setting to provide resources and events for the retention of graduate women in engineering.

Purdue University, West Lafayette, IN
Instructor, Gifted Education Resource Institute - Super Saturday 2008 - 2010
Taught and developed differential curricula for talented and gifted elementary students, for introduction to chemical engineering (2 sessions), environmental engineering and an engineering design course.

Purdue University, West Lafayette, IN
Graduate Teaching Assistant, Purdue University 2008
Assisted with the Women in Engineering Seminar (ENGR 194) in which duties included class administration, liaising with speakers, and mentoring of incoming female engineering freshman. In addition, also prepared the annual report.

Purdue University, West Lafayette, IN

Facilitator/Assistant Camp Director, Women in Engineering Program Summer Camp **2007- 2008**

Helped to coordinate a summer camp program for middle and high school age girls to promote various engineering disciplines. Assisted in development of camp curriculum, including development of hands-on engineering activities.

University of Arizona, Tucson, AZ

Graduate Teaching Assistant, Civil Engineering **2004 - 2006**

Collaborated on curriculum, proctored exams, taught several class sessions, met with students upon request, and graded all written work (excluding exam papers) for an introductory environmental engineering class (CE 350).

University of Portland, Portland, OR

Undergraduate Teaching Assistant **2003 - 2004**

Graded papers for three undergraduate courses including introduction to environmental engineering (CE 356), statistics (ENE 374) and engineering fluid mechanics (ME 320).

University of Portland, Portland, OR

Engineering Mentor **2003 - 2004**

Participated in a program that mentored at-risk engineering freshmen to increase their study skills for engineering program retention. Also assisted with departmental engineering recruitment.

PEER REVIEWED PUBLICATIONS / PAPERS

Dorie, B.L., Littlehat, P., Quanrud, D, Ela, W.P., and R.G. Arnold. "Fate of estrogenicity during subsurface wetland treatment." Conference Proceedings: *Arizona Hydrological Society 12th Biennial Symposium on Groundwater Recharge*, Tucson, AZ June 2005

Dorie, B.L., Littlehat, P., Quanrud, D, and R.G. Arnold. "Removal of endocrine disrupting compounds (EDCs) during subsurface wetland treatment." Conference Proceedings: *National Groundwater Association 5th International Conference on Pharmaceuticals and Endocrine Disrupting Chemicals*, Costa Mesa, CA March 2006.

Hua, I, Dorie, B.L., and Y. Kuo. "Quantifying brominated flame retardant content and emissions in polymers." Conference Proceedings: *Materials Research Society Symposium on Pb-Free and RoHS-Compliant Materials and Processes for Microelectronics*, San Francisco, CA April 2007.

Dorie, B.L., and J. Groh. ”Innovation, imagination, discovery & design: Informal environments for engineering learning.” Conference Proceedings: *P-12 Engineering and Design Education Research Summit*, Seaside, OR August 2010.

Dorie, B.L., and M. Cardella. “Integrating children’s literature into occupational learning about engineers” Conference Proceedings: *American Society of Engineering Education Annual Conference & Exposition,* Vancouver, BC June 2011.

Dorie, B.L., Dakenbring, C.A., Denick, D.L., Ferguson, D., Huff, J., Phillips, C., Schimpf, C., and M.E. Cardella. “FILE: A taxonomy of formal and informal learning environments” Conference Proceedings: *American Society of Engineering Education, IN/IL Regional Conference,* Valparaiso, IN March 2012.

Dorie, B.L., and M. Cardella. “Parental strategies for introducing engineering: Connections from the home” Conference Proceedings: *2nd P-12 Engineering and Design Education Research Summit*, Washington D.C., April 2012.

Dorie, B.L., and M. Cardella. “Engineering childhood: Knowledge transmission through parenting” Conference Proceedings: *American Society of Engineering Education Annual Conference & Exposition*, Atlanta, GA June 2013.

Dorie, B.L.,Tranby, Z., Van Cleave, S., Svarovsky, G., and M. Cardella. “Using puppets to elicit talk during interviews on engineering with young children” Conference Proceedings: *American Society of Engineering Education Annual Conference & Exposition,* Atlanta, GA June 2013.

Cardella, M., Svarovsky, G., and B.L. Dorie. “Gender Research on Adult-child Discussions within Informal Engineering environmeNTs (GRADIENT): Early findings.” Conference Proceedings: *American Society of Engineering Education Annual Conference & Exposition,* Atlanta, GA June 2013.

Dorie, B.L., Dorie, B., Pollock, M., Jones, T., and M. Cardella. “Parents as a critical influence: Insights from five studies” Conference Proceedings: *American Society of Engineering Education Annual Conference & Exposition*, Indianapolis, IN June 2014.

Dorie, B.L., Cardella, M.E., and G. Svarovsky. “Capturing the design behaviors of a young children working with a parent” Conference Proceedings: *American Society of Engineering Education Annual Conference & Exposition,* Indianapolis, IN June 2014.

Dorie, B.L., and M. Cardella (2014). “Engineering at Home” *Engineering in Pre-College Settings: Research into Practice,* West Lafayette, IN: Purdue University Press.

Dorie B.L., and M. E. Cardella. "An engineering tale: Using storybooks to analyze parent-child conversations about engineering." Conference Proceedings: *American Society of Engineering Education Annual Conference & Exposition*, Seattle, WA June 2015

Dorie B.L., Cardella, M.E., and G. Svarovsky, "Engineering together: Context in dyadic talk during an engineering task." Conference Proceedings: *American Society of Engineering Education Annual Conference & Exposition,* Seattle, WA June 2015.

ADDITIONAL PRESENTATIONS

"Seasonal variation of estrogenic activity in secondary effluent polished at the CERF subsurface wetlands." Presented at the *Arizona Water Pollution Control Association Annual Conference*, Phoenix, AZ May 2005.

"Fate of estrogenicity during subsurface wetland treatment." Presented at the *Arizona Hydrological Society 12th Biennial Symposium on Groundwater Recharge*, Tucson, AZ June 2005.

"Development of a method to efficiently extract polybrominated diphenyl ethers (PBDEs) from consumer products." Poster presented at the *Society of Environmental Toxicology and Chemistry North America 28th Annual Meeting*, Milwaukee, WI November 2007.

"Alternatives to brominated flame retardants in consumer products: Environmental responsibility versus industrial need." Presented at the 2nd annual *Potawatomi Student Industrial Ecology Conference*, Angola, IN March 2007.

"Engineering children's literature." poster presentation at the *American Society of Engineering Education Annual Conference & Exposition*, Vancouver, BC June 2011.

"Did you know? Sustainable practices at Purdue University" social media presentation during the University wide sponsored Green Week Event, 2010.

PROFESSIONAL MEMBERSHIPS / INVOLVEMENT

American Society of Engineering Education (ASEE), since 2009

- Part of mentorship program in GEECS, since 2011
- Purdue University Chapter Member since 2011

American Society of Civil Engineers (ASCE), since 2000

- Member of Arizona Younger Member Forum, 2004-2006
- Zoom into Engineering Volunteer, 2003-2006
- President for the University of Portland student chapter, 2002-2004
- Co- organizers for the Oregon ASCE 2004 Annual Meeting
- Secretary for the University of Portland student chapter, 2001-2002
- Attended the Workshop for Student Leaders, 2003
- University of Portland Concrete Canoe Team Member, 2000-2002; Steel Bridge Team Member, 2002-2003
- University of Portland Planning Committee Chair, 2002
- Attended ASCE Regional Student Conference, 2001-2004

Society of Women Engineers (SWE), since 2000

- Held leadership positions (Treasurer – 2002; Vice President – 2003) in University of Portland student chapter.
- Attended 2002 National Conference in Detroit, MI.
- Also set up an after-school science mentoring program for local elementary school girls.

Visitor Studies Association since 2012

SERVICE

Reviewer for American Society for Engineering Education National Conference – Student Division (2011-2014), K-12 Division (2011-2014), Journal of Women and Minorities in Science and Engineering (2010-present), Journal of Pre-College Engineering (2011-present) and First Opinions, Second Reactions (2009).

Purdue University School of Engineering Education Graduate Committee Member, 2011-2012

Engineering Education Graduate Student Association President, 2010-2011

Judge for Undergraduate Sustainability Poster Competition "The Last Mile", 2008

Coordinator and Environmental Engineering Session Leader for "Introduce a Girl to Engineering Day", 2008-2011

Member of Purdue University Sustainability Council, 2008-2010.

Co-founder and coordinator for inaugural Ecological Science and Engineering Symposium "Keeping the World Green: An Interdisciplinary Approach to Sustainability" at Purdue University, November 2007.

Coordinator for 2nd Annual Potawatomi Student Industrial Ecology Conference, March 2007

Coordinator for University of Portland Engineering and Technology Job Fair, 2003

Planning committee Co-Chair for Society of Women Engineers Region J Conference, 2003