Head Start on Engineering: Early Findings (Work in Progress)

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Head Start on Engineering (HSE) is a collaborative, NSF-funded research and practice project designed to develop and refine a theoretical model of early childhood, engineering-related interest development. The project focuses on Head Start families with four-year-old children from low-income communities and is being carried out collaboratively by researchers, science center educators, and a regional Head Start program. The ultimate goal of the HSE initiative is to advance the understanding of and capacity to support early engineering interest development for young learners, especially for children from low-income families and traditionally underserved communities. Building on prior work that examined the conversations of parents and young children engaged in engineering design (Dorie, Carella, & Svarovsky, 2014; 2015), the beginning stages of HSE explore the perceptions, interactions, and interest development of young children and their parents while engaged in activities that incorporate elements of the engineering design process. We specifically focus on parent-child interactions because of role that early interest (Maltese & Tai, 2010) and parents (Mannon & Schreuders, 2007) play in the occupational choices of populations traditionally underrepresented in STEM (Eccles et al., 1999).

HSE project launched in October 2016 and began offering programming and resources for families in December. For the first two years of the project, the team has worked with teachers at one Head Start location to plan, gather input from families, and test new programs and activities. In the fall of 2016, the team offered two full-day professional development workshops for staff, during which teachers learned about engineering, explored examples of engineering and design in their own lives, tested new activities for families and young children, and provided input on future programs. In January 2017, a group of Head Start families was recruited to participate in five months of program and research activities, including parent nights, home visits, take-home activity kits, and a field trip to OMSI.

Background and Theoretical Framework

In recent years, there has been a rapid increase in the number of engineering learning opportunities created specifically for young children. From curriculum packages like Engineering is Elementary to engineering-themed children's museum exhibits and library-based Maker Faires, there are more ways than ever for young children to participate in activities intended to promote early engineering interest and understanding. However, as these opportunities continue to expand, the phenomenon of young children engaging in engineering design continues to be under-researched and under-theorized. Similarly, with the increasing emphasis on STEM education for early learners (e.g., Office of the Press Secretary, 2016), the need to understand these learning environments and experiences is greater than ever.

Prior studies of early childhood engineering have explored the engineering design processes that occur during free play (e.g., Bagiati & Evangelou, 2015; Bairaktarova et al., 2011), perspectives of early childhood educators attempting to engage their students in engineering (Bagiati & Evangelou, 2015; Lachapelle et al., 2014), teacher practices related to engaging young learners in engineering (Bairaktarova et al., 2012; Molitor et al., 2014), learning experiences for young children working with robotics (Bers et al., 2002; Bers & Portsmore, 2005) and parents and children interacting during engineering-themed activities (Dorie, Cardella, & Svarovsky, 2014).

Seeking to extend the literature in this area, HSE builds on this research base and focuses on early childhood engineering-related interest development (Alexander et al., 2015; Hidi & Renninger, 2006). We conceptualize this process as a distributed, family-level phenomenon, involving ongoing, transactional changes in the interests, beliefs, and behaviors of both parents and children (Pattison, Svarovsky, Corrie, et al., 2016). Although researchers have almost exclusively conceptualized interest as an individual phenomenon, scholars studying child development have long emphasized the transactional, reciprocal relationships between children and adults, especially in early childhood (NRC, 2000; Sameroff, 2009). Research using oversimplified, unidirectional models of development (e.g., parent factors that influence children's interests) can underestimate the ways that parent and children change in response to each other throughout development (Hume et al., 2015; Martin et al., 2013). Our work, therefore, is focused on describing the family-level early childhood interest system related to engineering and identifying its phases and components, including parent attitudes and beliefs, characteristics of parent-child interactions, children's developing interests, and broader family routines and resources.

The project is currently mid-way through program implementation and data collection. In this paper, we describe the work in progress and highlight two important issues that have emerged. First we discuss intriguing findings about perceptions of engineering by Head Start families and staff from front-end data collection. Second, we describe our process for early childhood engineering activity development and the tensions that emerged around connections and distinctions between scientific inquiry and the engineering design process.

I. Perceptions of Engineering by Head Start Families and Staff

Before developing pilot programs or activities, the team collected front-end data from Head Start parents and staff members in order to ensure that the project was aligned with the interests and needs of the community and built on the prior experiences and funds of knowledge (González, Moll, & Amanti, 2005) of families and staff. The data collection was driven by three broad questions, developed collaboratively across the partner organizations:

1) What are parents' beliefs, attitudes, and interests related to engineering?
2) What funds of knowledge do parents and families bring to the experiences that can be integrated into the programs to make them more successful?
3) What opportunities and barriers exist for Head Start families that should be considered in the design of the educational programs?

As with all aspects of the project, this phase of data collection was informed by perspectives from community-based participatory research (Hacker, 2013; Israel, 2013) and culturally responsive research (Kirkhart, 1995). During front-end data collection, strategies included collecting information in the primary language of participants (English and Spanish), working with a bilingual/bicultural research team, reviewing research instruments and protocols with key community informants (e.g., Head Start staff members and family workers), and sharing out findings with participants (e.g., during staff and parent meetings) so that results could benefit both the project and the community.

Methods

The primary data collection methods for this phase were paper surveys administered to Head Start parents and staff members. Develop in both Spanish and English in collaboration with Head Start staff members, the final parent survey included both closed- and open-ended questions and asked respondents to share information about their interests and their children's interests related to engineering, their associations with the words "engineer" and engineering," their perceived importance of young children learning about engineering, their interest in the HSE program, and the goals they would prioritize if they participated with their children in the project. When asked about their associations with engineering, participants could either write or draw responses. The staff survey was similar, but focused both on staff members' own beliefs and perceptions, as well as their thoughts about how families might feel about engineering and engineering activities.

The parent surveys were administered by team members at four separate Head Start parent meetings. Staff surveys were emailed, completed by staff members individually, and then returned to the project team. A total of 79 and 22 parent and staff surveys were completed, respectively. Analysis of responses included descriptive summaries of the close-ended questions and content analysis of open-ended responses to identify the most common response categories. Initial findings were shared with the project team and Head Start staff members from the primary implementation site so that the group could collaboratively discuss and interpret the results, aligned with a team-based inquiry process (Pattison, Cohn & Kollmann, 2013).

Key Findings

In this article, we focus on a few key findings from both the parent and staff surveys. Full descriptive results are available on request.

Interest and value for engineering were high for both families and staff

When asked to rate how important they felt it was for their children to learn about engineering, 50% of parents responded that it was "very important," 42% marked "important," and 8% marked "in the middle." Similarly, when asked how interested they would be in participating in the program, 60% indicated "very interested" and 30% responded "interested." Surprisingly, parents indicated a reasonable level of comfort talking about engineering with their children or doing engineering activities as a family. A total of 41% of adults said they were "very comfortable" and 43% responded that they were "comfortable."

Staff also indicated interest in the topic, but at a lower level than parents. When asked how important they thought it was for parents and children in the Head Start program to learn about engineering, 50% indicated "very important," 28% "important," and 22% "in the middle." Staff members also underestimated parents interest in the topic. Only 28% of staff members thought parents would be "very interested." A total of 48% thought parents would be "interested" and 28% thought parents would be "in the middle." These differences across staff and parents responses may reflect staff members' own hesitation about the topic as appropriate for early childhood education, as well as feelings that there are already many other content areas that the program must cover.

Families and staff primarily associate engineering with building and construction

Despite their excitement and interest, both parents and staff members indicated a somewhat narrow perception of engineering, although a large minority of respondents mentioned planning and problem solving. Table 1 highlights the most common coded response categories for each group and the frequency of responses within each category. Building and structures were by far the most common type of responses for both parents (83%) and staff (77%). Staff members were more likely to associate engineering with planning and problem solving, math, and engineering-related values, while parents were more likely to associate the terms with careers and planning and problem solving.

Table 1. *Frequency of most common associations with the terms "engineer" and "engineering"*

Categories	Parents (n=79)	Staff (n=19)	Example
Building, structures	83%	77%	*Construction sites, buildings.*
Planning, problem solving	34%	65%	*People who solve a problem with the help of technical knowledge*
Careers	46%	24%	*"Good Career, good money*
Math	7%	41%	*Math and spatial awareness*
Engineering-related values	0%	35%	*I think that more women are going into the field and I'm really glad about that*

Note. Responses could be coded within multiple categories.

II. Approach to Collaborative and Iterative Activity Development

Based on front-end results, the team began to develop a suite of activities and programs to leverage parent excitement about the project and also broaden perceptions of engineering and the engineering design process. Particular attention was given to making intentional connections between engineering activities and existing areas of interest for the target audience (e.g., engaging characters and stories within children's books, nature and the outdoors, and common play activities for preschoolers). The project team initiated activity development by examining and adapting activities developed and researched in a prior study involving young children and their parents designing solutions for problem contexts involving fictional characters (Dorie, Cardella, & Svarovsky, 2015). During this process, key engineering concepts were identified and articulated by the project team, which included an overview of the engineering design cycle and example indicators of engineering thinking and design for young children and their families.

While these guidelines informed the development of new activities for the project, one area that required specific attention from the team was the epistemological differences between the inquiry practices of science and the design practices of engineering. Differentiating between these two sets of practices for K-12 educators can be an essential first step in creating learning experiences that focus specifically on developing engineering interest and understanding (Cunningham & Kelly, 2016). While inquiry and design have many similarities, differences in the aims and goals of each process can lead to different pedagogical techniques and different ways of questioning (Bybee, 2011; Katehi et al., 2009).

For example, one of the new activities developed by HSE for families involved designing a bubble wand out of pipe cleaners. Building on an early STEM activity developed for a different project, the HSE project team revised several aspects of the activity in order to shift the activity from an inquiry exploration focus to more of an engineering design and iteration focus, as seen in the following modifications:

- A storybook was added to the activity in order to provide more context for the design challenge and more information for the families as they engaged in the problem scoping and idea generation.
- Articulation of the design goals was refined in the development of a family activity guide, moving from vague objectives (e.g. "Make a bubble wand!") to more specific design objectives (e.g. "Create a bubble wand that can blow bubbles that are at least the size of a golf ball").
- Questions in the activity guide were rephrased to focus less on open exploration (e.g. How long can the bubble float?") to more specific design constraints (e.g. "What is the smallest bubble wand you can make that can still give you a golf-ball sized bubble?").

In making these adaptations to the original bubble wand activity, the aim was to promote not only general STEM engagement and learning for families and children, but also to foster the development of more specific engineering interest and understanding. These types of modifications were made to all of the activities included in HSE, which will be introduced to families in the next phase of the study.

Conclusion and Next Steps

Our work to date has helped to shed light on the ideas that Head Start staff and families have about engineering, and how researchers and educators can leverage these perceptions to create engaging activities that go beyond scientific inquiry and focus specifically on engineering and design. The team is currently testing these activities with families and collecting data on how the experiences catalyze long-term family interests in engineering-related topics and skills. Findings will ultimately provide the field with a deeper understanding of what engineering looks like for young children in a family learning context and how early experiences with this topic can shape the ongoing learning pathways of children and their parents.

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