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Engineering together: Context in dyadic talk during an engineering task (K-12 Fundamental)

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Introduction

The exploration of how children develop early interest and understanding in engineering can provide useful information for the ongoing efforts to increase the access of women in engineering careers. Prior to reaching middle school, girls have been found to have lower interest in STEM careers than boys, especially for math-intensive fields such as engineering.^{1,2} This lack of interest has been connected to a narrow and often inaccurate view of the engineering profession and the perceived misalignment between what engineers do and what girls value in future careers.^{3,4} Namely females tend to place a high value on helping others in their work, but do not often realize that careers in engineering can lead to these types of endeavors.⁵

In 2008, the National Academy of Engineers released a report delineating market tested and approved messages regarding engineering.⁵ These messages recast engineering as inherently creative and concerned with human welfare, as well as an emotionally satisfying calling which resonates strongly with women. Therefore, adding layers of social context that highlight the connections between engineering endeavors and improving the lives of others may create a more engaging experience for girls and women, and potentially lead to increased development of girls' engineering interest and understanding.

Additionally, informal learning environments are positioned to become a pivotal role in inspiring today's youth to pursue careers in STEM. These contexts have already been shown to be important avenues in which children can develop lifelong interest and understanding within a broad range of STEM topics. Moreover, informal learning environments often allow parents and children to work together to foster interest and engagement within STEM.

Parents can play a tremendous role in their children's learning experiences, as children typically spend more than 80% of their waking hours in outside-of-school settings.⁶ Research suggests that children develop critical and lasting attitudes towards science at young ages⁷, and at this age children spend much of their out-of-school time with their parents. This is further supported by research that has shown that parents' involvement in their children's education is most important in these early school years.^{8,9} Not only can parents affect young children's interest and curiosity in engineering and science, but they also can help students to improve their scientific reasoning skills. Noorbakhsh et al. (2006) found that parents act as a bridge between museum exhibits and children by assisting and guiding in children's understanding.¹⁰ This is similar to the developmental theories that hold that parents provide scaffolding consistent with the level of their child.¹¹

In our investigation of the types of engineering behavior that children *can* engage in,^{12,13} we are not concerned with what the children can do independently so much as what the children can do with or without support from parents (or others). Exploring parents and children during joint engineering design activities is one context for examining parent-child interactions to identify ways in which parents scaffold their children's participation through specialized language, the parent's own engagement in design activities and the parent's approaches to directing the learning experience. The overarching goal of the study is to advance the understanding of how parent-child conversations and activity within informal engineering environments can contribute to the development of girls' interest and understanding in engineering. Specifically, this paper will examine the differences in the use of context between fathers and mothers interacting with their daughter within the preliminary and follow-up phases, including the frequency and type of context used towards the design of the towers.

Methodology

Parent-child dyads that were visiting a metropolitan science museum as part of a program for preschool-aged children were asked to participate in a study that explores parent-child conversations during engineering activities. As we were particularly interested in the engagement profiles for young girls, we used purposeful sampling to engage equal amounts of fathers and mothers. Further investigations will include parent-boy dyads for comparison, but was not collected at this time.

Dyads consisting of a parent with their daughter (aged 3-5 years) were video-recorded while engaged in two different engineering tasks: building a tower out of familiar materials and constructing a second tower out of unfamiliar materials (Figure 1). In the preliminary phase, participants ($n = 25$) were asked to build a tower with a specified goal (i.e. to a specific height), whereas participants in the follow-up phase ($n = 25$) were given the same directions though infused with a social context (i.e. building for someone, for a specified purpose) (Table 1). Within the preliminary phase there was a limited context belated to the participants, allowing the problem to be set up as a discrete problem with the foam blocks (e.g. taller than the plant) without limiting the end goal (e.g. how much taller than the plant). The dado squares represented a more open-ended activity as there was no height requirement given. The inclusion of additional context for the activity in the second condition enabled us to examine the impact of the context on children's design behavior as well as interest in the task. Both of the prompts for the follow-up phase built upon the existing prompt (i.e. build a tower) and incorporated the concept of helping others. For the foam block activity, two different characters – Foxy the Fox and Clucky the Chicken – were introduced, and the participants were asked to build a tower that would help to protect Clucky's eggs from Foxy. In both the preliminary and follow-up phases the intended height of the tower was held constant through comparison with a plant (see Figure 1a) and a picture of a fox (Figure 2).



a) Dyad building a tower with foam blocks



b) Dyad building a tower with Dado Squares

Figure 1. The two design challenges adult-girl dyads engaged in.

Table 1. Activity prompts for the two design challenges.

	Activity 1 - Foam Blocks	Activity 2 - Dado Squares
Preliminary Phase	Build a tower higher than this plant (specified distance).	Build a tower as high as you can.
Follow-up Phase	When Foxy the fox stands on her tiptoes, she can reach really high. See? And Clucky the Chicken is worried about keeping her eggs safe from Foxy. Can you build a tower for the eggs that is taller than Foxy's reach?	The zoo builds tall places for monkeys to climb on. Can you use the blocks to build a tall tower for this monkey to climb?



Figure 2. Example set-up for foam blocks in follow-up phase.

In each phase, transcribed verbal and non-verbal segments (identified with either the child or parent as the speaker/actor) were analyzed using a robust coding scheme that was developed previously and that had undergone multiple cycles of discussion and revision as well as checks for inter-rater reliability.^{12,13} Within the code for the engineering behavior of “problem scoping”, there was a sub-code that related to the use of context – either being the addition and/or the expansion of the relevant information given in the activity prompt (Table 1). To further illuminate the use of context, four case studies (two from preliminary phase, two from follow-up) were used to get a more in depth analysis of how the context was used in these settings.

Results

In the preliminary phase we observed that both children and parents would verbally add on additional context to the activity through a) the type of structure they were making b) relation to previous experiences and c) giving the structure additional purpose, including intended user feedback. With both activities we observed additional context such as:

- The building of a castle, chicken coop, or stairs.
- Relating to an existing known structure (skyscraper downtown)
- Creating areas for a different purpose (e.g. bridge, bedroom, road)

In the follow up phase, we observed that a majority of the context references pertained to the storyline, though there was some additional context added such as additional purpose. For example, while building with the dado squares a child brought in the design element of stairs. While the problem prompt was originally worded as to build a structure that the monkeys could climb, the child was concerned with the ability of the monkeys to do so showing some evidence of user centered design thinking. Her mother on the other hand showed astonishment that her daughter was still engaged within the problem as she had been focused on construction of the tower.

<i>Child : And how bout stairs for the monkey to climb up?</i>
<i>Mother: Stairs for the monkey to climb?</i>
<i>Child: To get up.</i>
<i>Mother: I'm impressed that you're still remembering about the monkey.</i>
<i>Child: To get up, see. The monkey can't get up that [points to tower]</i>

It is interesting to note that by providing additional social context, the average duration of each activity was decreased. This could potentially be to the more focused problem definition, but warrants further exploration as it was hypothesized that it would take a longer amount of time since there were additional constraints regarding the users (e.g. Clucky the Chicken and the monkeys).

Table 2. Mean activity durations in seconds (n=25)

	Foam Blocks	Dado Squares
Baseline	384	359
Round 2	346	309*

* Sample for this subset is n=26.

Table 3. Number of instances that dyads mentioned storyline contexts while building in follow-up phase (n=25)

	Yes	No
Foam Blocks	17	8
Dado Squares	20	5

Context was observed more frequently in the follow-up phase for each portion of the dyad and activity. However, in the follow-up dado square activity children engaged in more contextual factors, often relating certain areas of the tower design as special rooms for the monkeys to play in. These considerations of the “user” are relevant to the engineering profession and show that the girls were cognizant of what they were designing for.

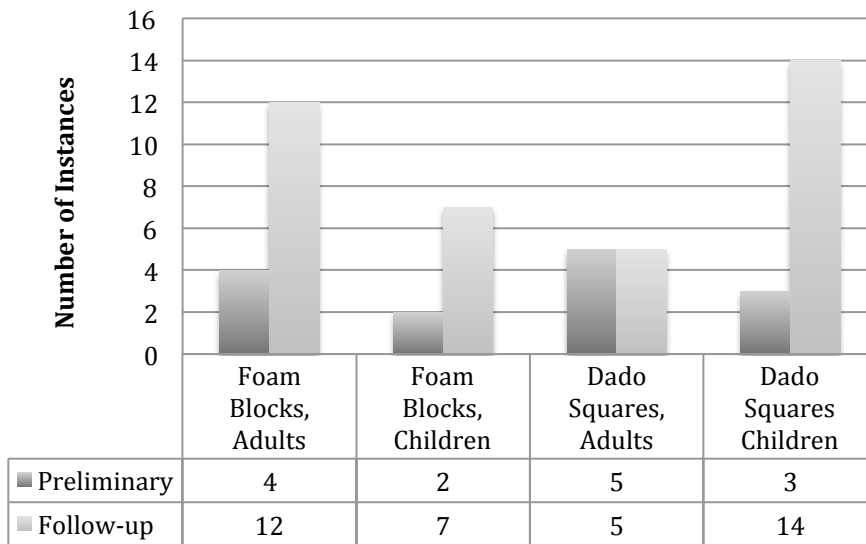


Figure 3. Average number of instances context was mentioned during building activities in preliminary and follow-up phases

Conclusion

It was found that in the preliminary phase that both parents and the children added context to the task – a finding that resonates with the research that girls are more interested in socially relevant activities. When given a more detailed background, children integrated the given context within design decisions and explanations even going so far as to expand on the original information. This study helps to outline the importance of using context within informal engineering programming. The tendency for both parents and children to add context resonates with research that suggests that girls are more interested in pursuing activities and fields of study that are socially relevant—that is, by demonstrating the social relevance of engineering, and the larger context of engineering problems, we can attract more women to engineering. This finding is promising, and this suggests that parents may already be helping their daughters to connect engineering–related activities to a larger context, thus increasing their daughters’ interest in these types of activities.

By further examining the dyad’s interaction, we hope to identify recommendations we can make to other parents on how to foster engineering interest in their children, as well as contribute ideas for activities for K-5 classrooms to reach a wider range of children.

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