AC 2011-1695: EXPOSURE TO EARLY ENGINEERING A PARENTAL PERSPECTIVE

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Exposure to Early Engineering: A Parental Perspective

According to the developmental engineering hypothesis young children's exploratory, inquisitive, and creative behaviors resemble traits highly desirable in engineering[1] and children's interactions with human-made artifacts have developmental value in their lives[1]. Work built on this hypothesis is intended to foster, support and promote young children's natural propensities for engineering thinking by providing appropriate formal and informal learning experiences . Currently, science, technology, and math, three of the four disciplines comprising STEM, have an established presence in the early childhood education curriculum and practice while engineering is a relative newcomer with regards to both content and pedagogy as well as the manner in which it can be integrated into an early education classroom[2,3]. Research studies within developmental engineering can contribute to the knowledge needed in creating developmentally appropriate engineering-relevant curricula and practice[4].

Identifying appropriate ways to introduce engineering to preschool age children is a challenging question because any approach would need to reconcile the developmental characteristics (appropriateness) of young children with the highly complex content of technical knowledge (engineering fidelity). To date most approaches seem to be encouraging early exposure by creating familiarity through field trips, meeting experts and engaging in simple activities. Our approach sought to explore the curricular dimensions of introducing engineering to young children through the use of human made artifacts in a semi structured exploratory play situation. The selection of human made engineered artifacts as proxies of engineering for young children meets both criteria of appropriateness and content fidelity. It capitalizes on young children's propensity for handling and exploring through manipulation while the integrity of the technical content stays intact through the presence of a coherent artifact. Results of the study are reported in a previous study[4]. In this study we report findings on parental perceptions on the value and use of artifacts for introducing young children to engineering.

In early childhood education parents play an essential role in young children's learning. Parental education[5], family income[5], and parental involvement[6] in children's learning (both at home and at school) are strongly predictive of children's future academic achievement and school success. Numerous studies suggest that parental involvement, particularly during the preschool years, is important in promoting children's learning as they make the transition from home to preschool and beyond[6]. Understanding the contributions that parental involvement makes in young children's interest about engineering is therefore key to a appreciating the developmental antecedents of interest and mastery in engineering.

This paper presents findings on parental characteristics, artifact availability in the home and parental reports on children's interactions with artifacts. Participants came from varied socioeconomic status. Parents report on the everyday use of specific artifacts as ways of exposing preschoolers to engineering related concepts, and on their motives and methods while doing so.

Method

This study used quantitative measures to understand how parents expose thei preschool children to engineering through formal and informal interactions with a set of artifacts (see Table 1). Thirty-nine parents of children ages 4-5, from 6 Midwestern preschool classrooms participated in the study. Families differed in their socioeconomic status. Eleven parents were recruited from 3 classrooms in a university-based laboratory preschool and 28 were recruited from 3 Head Start classrooms in the local community. Head Start is a program of the US Department of Health and Human Services that provides comprehensive education, health, nutrition, and parent involvement services to low-income families and their children. Head Start parents have incomes below the poverty line and tend to have relatively low education (high school, GED, or less is common). Lab-school parents consist mainly of university faculty, staff or graduate students. They tend to have moderate-to-high incomes and are well educated. For the rest of this paper parents whose children attend a Head-Start program will be referred to as HS parents, and parents whose children attend a Lab school program will be referred to as LS parents.

Participating parents completed a written Home Environment Engineering Measures (HEEM) questionnaire. The first part of the questionnaire contained questions on demographic information; followed by questions regarding the presence/availability of specific artifacts in the home. The set of artifacts was selected to vary in the expected familiarity of the artifact to preschool children. The research team intentionally selected some artifacts that were likely to be quite common in children's environments, as well as some that were likely to be quite rare. The third part contained both yes/no and open-ended questions regarding parental attitudes and beliefs about engineering, beliefs about children's early exposure to engineering concepts and content as well as questions on the modes parents might use to expose children to engineering concepts (see Appendix 1). For the rest of this study we will refer to the third part as the "engineering questionnaire". A $5 gift card to a general merchandise store was given as compensation to the parents upon the conclusion of the questionnaires.

Data analysis

Data that included Yes/No answers were analyzed quantitatively and parental answers to open-ended questions were analyzed qualitatively using the open coding method. Categories in the qualitative analysis stem exclusively from the parental responses that included additional elaboration.

Findings

Findings regarding the existence of specific artifacts at home (see Table 1) show that many items were common in the two types of homes. However, in all cases in which artifacts did not appear in both households, the university-based families were reported to have the object. In the cases that significant difference regarding the artifacts acquisition, difference has been reported up to a

42% . For example, 58% of HS parents reported having a stapler in the home, while 100% of LS parents did.

Table 1: Artifact availability comparison using T-tests

Significant difference	Moderately significant	Not significant
Binoculars	Compass	Bellows
Bells	Stethoscope	Binoculars
Lockbox		Blood pressure cuff
Hole punch		Camera
Stapler		Castanets
Shoehorn		Egg-beater
		Glow stick
		Instant light-up
		Mechanical Pencil
		Newton's cradle
		Notepad
		Pencil
		Phone
		Tape recorder
		Tongs

Analysis of the Engineering Questionnaire present notions that parents of different socioeconomic status hold regarding the necessity of children's early exposure to engineering. They also report o4n their everyday use of the artifacts to expose preschoolers to engineering related concepts.

Quantitative analysis (T-tests and X^2 –tests) revealed no significant differences between the answers of the two parental groups beliefs on the importance of children's early exposure to engineerin. Both groups seem to agree that it is important. No significant differences appear on their approaches used to achieve this early exposure (see Table 2). Qualitative analysis of answers permitted additional insight into parent reasoning on importance.

Table 2: T-tests and X^2–tests findings on parental responses to the "engineering questionnaire".

T-test	X^2–test
Does parent have an engineering background?	
No significant difference; means were generally low	No significant difference
Is it important for children at this age to learn about engineering?	
No significant difference; means were generally high	No significant difference
Do you identify and describe the characteristics of natural materials with your child?	

No significant difference; means were fairly high	No significant difference
Do you identify and describe the characteristics of human-made materials with your child?	
No significant difference	No significant difference
Do you identify and describe some uses of natural materials with your child?	
No significant difference	No significant difference
Do you identify and describe some uses of human-made materials with your child?	
No significant difference	No significant difference
Do you identify and describe how tools and materials can be used to create simple structures with your child?	
No significant difference; means were fairly high	Significance at the 5% level
Do you identify and describe the characteristics of simple machines with your child?	
No significant difference; means were fairly low	Significance at the 5% level

It was fairly common for LS to be related to an engineer or to be an engineer. Nine percent (1/11) of LS reported being related to an engineer and 18% (2/11) of LS reported being one (at the Ph.D. level). In contrast, only 3.5% (1/28) of HS reported relation to an engineer. No HS were engineers.

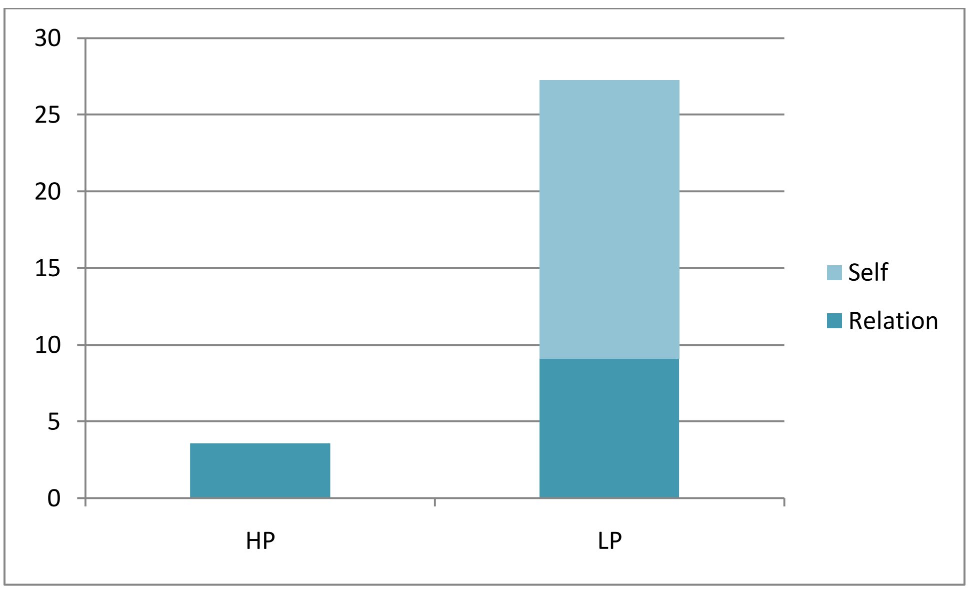

Figure 1: Percentage of parents that have a background in engineering

While 72.3% (8/11) of LS responded to the question about their understanding of what engineering is, the response rate for HS was 39.3% (11/28). Open coding led to 5 categories stemming both from the HS and the LS responses (see Table 3).

Table 3: *Parental understanding of engineering*

Categories	HS Example quotes	LS Example quotes
Verbs/nouns indicating manual work	"Build" , "Construct", "Maintenance"	"They create items or buildings", "They construct"
Verbs/nouns indicating phases of the engineering process	"Design", "Drawing", "Improve", "They put things together"	"Design process", "They implement mechanical systems", "They make models"
Phrases relevant to education	"They learn it at school"	"Technical Disciplines: Mechanical, Electrical, Aeronautics etc", "Applied Science"
Phrases indicating relation to problem solving skills	"Make things work", "How we make our world work"	"Figure out how things work", "Solve problems"
Other	"They work with chemicals"	"Make our lives easier, safer and better"

NOTE: *Answers to open-ended questions provided by 11 out of the 28 HP, and by 8 out of the 11 LP.*

While 78.6% (22/28) HS agreed "it is important for children at this age to learn about engineering", 21.4% (6/28) thought it was not. 81.8% (9/11) of LS agree it is important, 9% (1/11) is not sure and 9% (1/11) disagrees (see Figure 2).

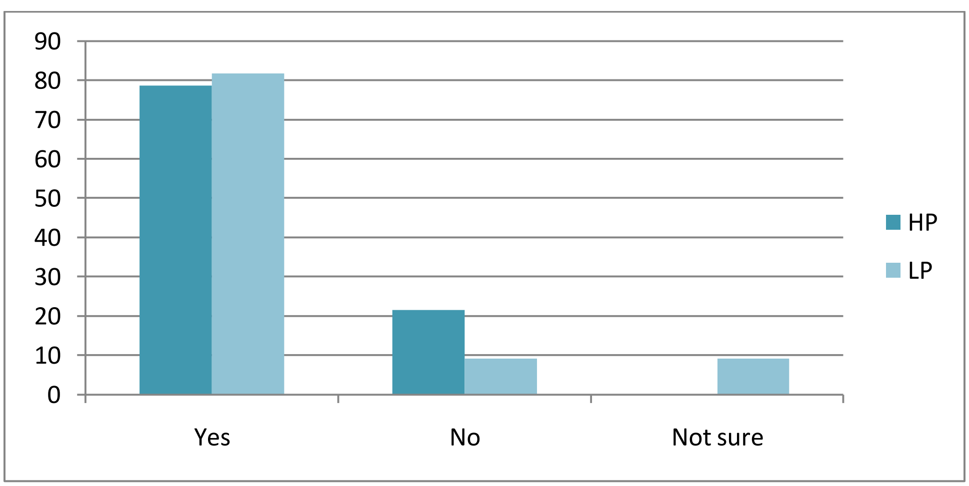

Figure 2: Percentage of parents that consider learning about engineering at the preschool level to be important

Overall findings reveal that HS think learning engineering at an early age is important base their answers on reasons related to cognitive development, enjoyment, and future career paths, while LS referred to reasons related to cognitive development and skill learning (see Table 4). Parents who responded that learning about engineering at the preschool level is not important justified their responses on the young age of the children

Table 4: *Reasoning on whether young children should/shouldn't be exposed to early engineering*

Categories	HS – "Yes" Example quotes	LS – "Yes" Example quotes
Cognition	"So they can understand more", "So they know", "Installs curiosity"	"Life knowledge and advancement", "They learn the end products of engineering efforts", "Understand how things interact", "For future learning processes"
General Skills	"To build", "To improve things"	"Become more curious", "Base their learning on true things"
Problem Solving	"To learn how to solve a problem", "Helps problem solving"	"Important for problem solving", "Develop problem solving while playing and be creative", "Basic problem solving is essential at any age", "Solve technical problems"
General Knowledge	"The more they know the better", " Just to learn", "So they know and be open minded"	"Figure out how things work"
Fun	"They may like it"	
Future Career	"It's a good field", "An idea of what to become", "A degree is good"	
	HS – "No" Example quotes	**LS – "No" Example quotes**
Age	"She will not understand", "She's 4"	"Too young, but artifacts are important!"

NOTES: *Answers to open-ended questions provided by 21 out of the 22 HP, and by 9 out of the 9 LS that responded positively; and by 2 out of the 6 HS and 1 LS that responded negatively*.

Through the Engineering Questionnaire (EQ) parents were asked whether they engage in a range of activities with their children, including discussing the characteristics and uses of various materials. Both groups reported discussing and using natural materials more than human-made artifacts with their children (see Figure 3).

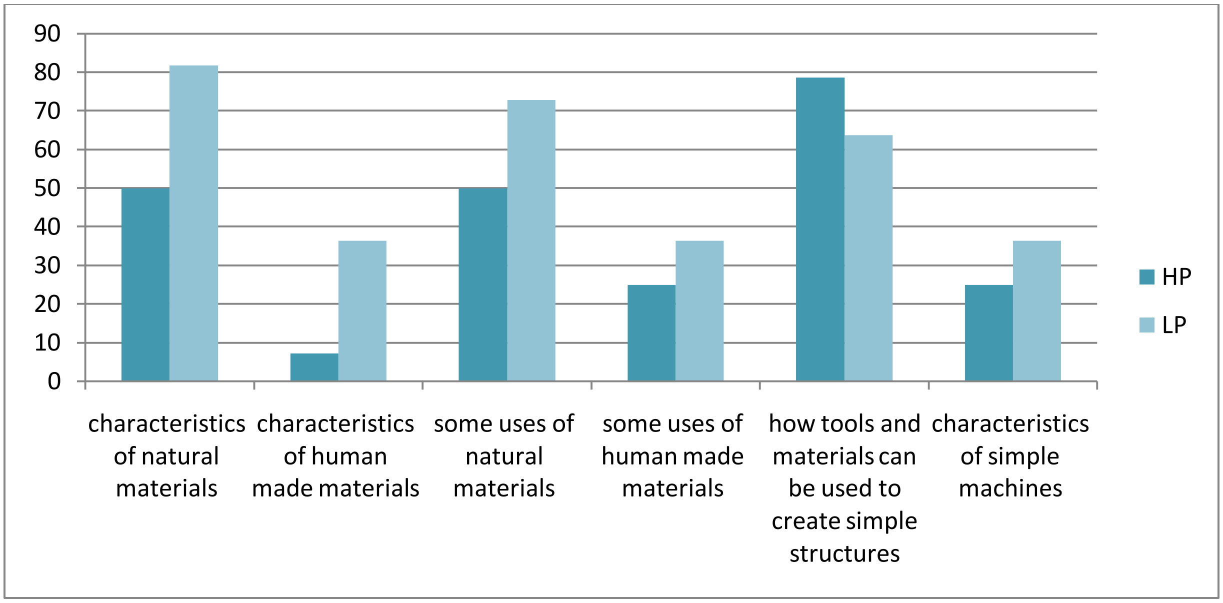

Figure 3: Percentage of parent's participation in identifying and discussing the specific topics mentioned in the graph

Categories about how HS interact with their children, while trying to expose them to engineering were "tell", "show", "touch", while LS parents also included "exploration" in their responses. An additional category emerged on the intentionality of parental participation in these activities.

Table 5: *Types of parent-child interactions while discussing the characteristics of natural materials*

Categories	HS Example quotes	LS Example quotes
Tell	"I tell what it is", "I tell her"	"She asks and I tell her", "I explain with simple words"
Show	"I show them", "I point it out"	
Touch	"She touches it", "Texture/feel"	"If we see something we stop and touch it", "We see how it feels"
Explore		"We stretch it", "We see if it floats"
Accidental participation	"If she asks I tell"	
Other	"I study anthropology"	

NOTES: *Answers to open-ended questions provided by 12 out of the 14 HS that responded positively.*

Table 6: *Types of parent-child interactions while discussing the characteristics of human made materials*

Categories	HS Example quotes	LS Example quotes
Show	"I point it out"	
Tell		"I use adjectives", "If she asks I will research and explain"
Touch	"He picks it up"	"Touch"
Explore		"We talked about how foam floated when we put it in the bathtub"

NOTES: *Answers to open-ended questions provided by 2 out of the 8 HS and by 4 out of 4 LS that responded positively.*

Table 7: *Types of parent-child interactions while discussing uses of natural materials*

Categories	HS Example quotes	LS Example quotes
Tell		"I use adjectives", "I'll tell him that trees are cut down and the wood is used to build things or is used as a utility pole"
Show and Do	"We go on walks (wood, leaves), I'm growing bamboo", "As we build, we can use wood for that or to create things like wooden spoons"	"When camping I described how wood and paper burned in the fire"
Touch		"Touch"
Accidental participation	"If she asks I will tell"	

NOTES: *Answers to open-ended questions provided 6 out of the 14 HS and by 7 parents out of the 8LS that responded positively.*

Table 8: *Types of parent-child interactions while discussing uses of human made materials*

Categories	HS Example quotes	LS Example quotes
Tell		"We often talk about recycling +what plastics glass and metal turns into after recycling",

		“Answering questions”
Touch	“Textures”, “Picks it up”	“Touch”
Accidental participation	“If it’s around”	

NOTES: *Answers to open-ended questions provided by 3 out of the 7 HS and by 4 out of the 4 LS that responded positively.*

Table 9: *Types of parent-child interactions while discussing how tools and materials can be used to create simple structures*

Categories	HS Example quotes	LS Example quotes
Tell	“I tell her how she has to use those things”, “Tell name and what they do”	
Show + Do	“When we make projects”, “I like to show her how to do with an item that she wants”, “Play arts/crafts”	“We build a "computer screen" out of styrofoam, aluminium and foil and duck tape. We built a cardboard car with cardboard, string, felt and washes. Both needed scissors, tape, paper, ruber. He sees them to make covers for the copies of his cd's we burn”, “We always use tools and materials while doing crafts and I will explain what each tool is used for and why”
Safety	“Because they’re dangerous”	

NOTES: *Answers to open-ended questions provided by 14 out of the 22 HS and by 6 out of the 7 LS that responded positively*.

Table 10: *Types of parent-child interactions while discussing characteristics of simple machines*

Categories	HS Example quotes	LS Example quotes
Tell	“How they work”, “I describe how machines work to him and functions”	“We explain how things work”, “We have a marble game… Sometimes I may offer explanation of why the marble may be going off course”
Show + Do	“Show how to use when it’s around”, “He likes to work and experiment with all	“Gears move together to spin each other. We have 2 games at home with plastic gears that

	kinds of tools"	when layed correctly move each other and spin"
Other	"My husband"	

NOTES: *Answers to open-ended questions provided by 5 out of the 7 HS and by 3 out of the 4 LS that responded positively.*

Conclusions

Findings from the engineering related questions show that the two parent groups answer similarly. Findings from the open ended questions though, show that many parents (mainly HS) do not respond at all when it comes to providing explanations, and when they do, they respond with short phrases and language that comprises of single words, while the LS provide more detailed answers.

Discussing parental perspective regarding the importance of early exposure to engineering both groups appear to agree on the fact that it is important, but the reasoning provided for this response was different. Both groups seemed to acknowledge the cognition and the skills that may get developed, but only HS that mentioned "fun" and "future career as reasons for their response.

Regarding the type of interactions that parents mention while addressing engagement to engineering related instance with their children, both groups mention *telling* or *showing* something to their children. *Doing* and *touching*, that are more interactive types of learning were also mentioned, but the experimental nature of this type of interactions, which could be identified as the one closest to the engineering nature, seems to occur intentionally in a small group of LS parents.

Furthermore, when discussing parental intentional engineering related interactions, the accidental factor seems to be mentioned by a number of HS parents. This factor leads us to wonder if the availability of artifacts at home enhances children's development of engineering thinking but systematic effort by parents towards this direction might also be required in order to enhance the effects of exposure to engineering through the use and play with human made artifacts.

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Appendix 1 : Parent's Engineering Questionnaire

1. Do you have a background in engineering?

   Yes ☐ No ☐

2. If yes, describe your engineering background.

3. Describe what you understand engineering to be.

4. Do you think it is important for children at this age to learn about engineering?

   Yes ☐ No ☐

5. Why or why not?

6. Do you participate in the following activities with your child?

i. Do you identify and describe the characteristics of natural materials (for example, silk, wood, etc.)?

Yes ☐ No ☐

If yes, describe how or give an example:

ii. Do you identify and describe the characteristics of human made materials (for example, Styrofoam, polyester, etc.)?

Yes ☐ No ☐

If yes, describe how or give an example:

iii. Do you identify and describe some uses of natural materials (for example, silk, wood, etc.)?

Yes ☐ No ☐

If yes, describe how or give an example:

iv. Do you identify and describe some uses of human made materials (for example, Styrofoam, polyester, etc.)?

Yes ☐ No ☐

If yes, describe how or give an example:

v. Do you identify and describe how tools and materials (for example, scissors, toothpicks, rulers, tape, paper) can be used to create simple structures?

Yes ☐ No ☐

If yes, describe how or give an example:

vi. Do you identify and describe the characteristics of simple machines (for example, gears, levers, ramps)?

Yes ☐ No ☐

If yes, describe how or give an example: