AC 2011-330: PARENTS' PERCEPTION OF AND FAMILIARITY WITH ENGINEERING

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Parents' Perceptions of and Familiarity with Engineering

Introduction

There is a growing concern in the engineering community that the interest among young people in engineering is declining. There is a need to strategically plan how a stronger engineering workforce in the United States can be accomplished [1]. While some efforts had been made in improving undergraduate education and recruitment, other efforts, like this study, focus on K-12 education and how we can improve students' understanding of engineering at early ages. Furthermore, recent studies have provided evidence that learning engineering content, especially engineering design, can motivate children and help them learn science [2] Most studies to-date on this issue have focused on K-12 teachers and students, leaving the role of parents out of the limelight.

We know from studies in science education that parents can impact their children's attitudes towards learning a subject [3]. Kluin, Cardella and Purzer concluded from a comprehensive literature review on parental influence in science education and engineering education that parents can be engineering career motivators, engineering attitudes builders, student achievement stimuli, and engineering/scientific thinking guides[4]. As crucial as parental roles are in engineering learning, it is necessary to understand parental attitudes towards engineering.

We are in the process of developing an instrument to assess parents' perceptions of engineering, their interest in having their children learn about engineering, and their preparedness to support their children in learning about engineering. Furthermore, we would like to explore the factors that might affect parents' perceptions and knowledge which could in turn impact children's learning. We report in this paper the results of a pilot study.

Theoretical Framework

In order to understand the complex relationships between what parents know about engineering, what their attitudes towards engineering are, and their influence on children's learning, we adopt the Knowledge, Attitudes and Behaviors (KAB) framework [5]. The KAB approach recognizes the interactive relationship between the three dimensions. What one knows may affect his or her attitudes about the topic, and how he or she feels about the topic may influence behavior [5].

We operationalize the KAB framework by concentrating on different aspects of each dimension. For example, parents' background, occupation, and educational experiences are the focii of the knowledge self-efficacy dimension. For the attitude dimension, we bring our attention to parents' perception of engineering, engineers, engineering as their children's future profession, and importance of engineering. For the behavior dimension, we concentrate on the activities parents do with their children that would potentially support their engineering learning.

Methods of Survey Construction

As the first step taken to understand parents' viewpoints in children's engineering learning, we constructed a short survey mainly to probe parents' knowledge, self-efficacy and attitudes. We adopted 10 items from an instrument that was used to assess teachers' perceptions and familiarity with the domains of design, engineering and technology [6]. In addition, we added three questions that pertained to the focus of the study: parental roles and children learning engineering (see Table 1). We used a 5-level Likert scale (5-strongly agree; 4-agree; 3-neutral; 2-disagree; 1-strongly disagree) and asked the participants to rate their level of agreement with each statement. We also included "do not know" and "decline to answer" as options in order to detect confusion participants might have with wording or issues that might be particularly sensitive. A content expert in engineering education reviewed several versions of the draft before the final version was deployed. Thirteen graduate students from different background such as sociology, consumer behavior, and technology reviewed the item wording together. Any confusion on wording was clarified during the process facilitated by a director of a university-based sociology research center.

Because engineering can be a vague concept, at the beginning of the survey we included a scenario of how engineering could be incorporated in K-12 classroom using design activities, and how mathematics and science concepts can be learned through these engineering activities. The 13-item survey, *Survey of Parents on Engineering Education,* was deployed as part of a larger class survey, which included several different topics, such as online purchase habits and e-commerce (before the beginning of each topic, there is a paragraph of introduction to facilitate the transition between topics). The learning goal of the class was to learn about survey research using various methods, such as phone interview and internet deployment, using items contributed by each student in the class. The organization of the class allowed limited number of questions contributed by each student.

Research Participants

In the spring of 2009, participants were recruited from a national population through an internet survey service company. Six hundred and fifty-nine parents (134 males, 519 females, and 6 unidentified) took the survey and were compensated $5 for their time spent taking the class survey. The average age of the participants was 43.76 (SD=9.85). Eighty-one percent of the participants indicated that they were Caucasian, and 16% others. A small percentage of the participants were high school dropouts (2%), 68% were high school graduates, and 30% were college graduates. Of the participants, 21% were from an urban school district, 47% suburban, and 29% rural (3% unidentified).

Data Analysis

I. Principal component analysis and validity evidence

We carried out an exploratory factor analysis to examine the 13 items. We conducted principal component analysis (PCA) with Varimax rotation. We also examined the internal consistency of the instrument by computing Cronbach's alpha using Statistical Package for the Social Sciences (SPSS). Prior to performing PCA, we assessed the suitability of data for factor analysis. Inspection of the correlation matrix revealed that all coefficients were 0.30 and above. The Kaiser-Meyer-Olkin (KMO) statistic was 0.90, which is at a superb level as suggested by Hutcheson and Sofroniou [7]. Bartlett's test reached statistical significance ($p<0.01$), supporting the factorability of the correlation matrix.

The principal component analysis revealed the presence of three factors with eigenvalues above 1. Please also refer to the Scree plot in Figure 1. To ensure internal consistency of each factor, we examined the reliability of each factor and overall items. We excluded one item from the analysis because it conceptually did not fit well within its highest factor, loaded fairly equally on one other factors, and lowered the reliability of its factor. Factor 1, *importance* of children learning engineering, accounted for 43.4% of the total variance with Cronbach alpha of 0.95. Factor 2, *parents' familiarity (self-efficacy)* with engineering content, accounted for 19% of the total variance with alpha= 0.80. Lastly, the two negatively worded items loaded to factor 3, *parents' disinterest* in having engineering in K-12. This factor accounted for 14.7% of the variance with alpha=0.78. The overall Cronbach alpha for the 12 item survey was 0.79. We present the loadings of each item in the rotated component matrix in Table 1. The item that was excluded from the analysis is shown with a strikethrough.

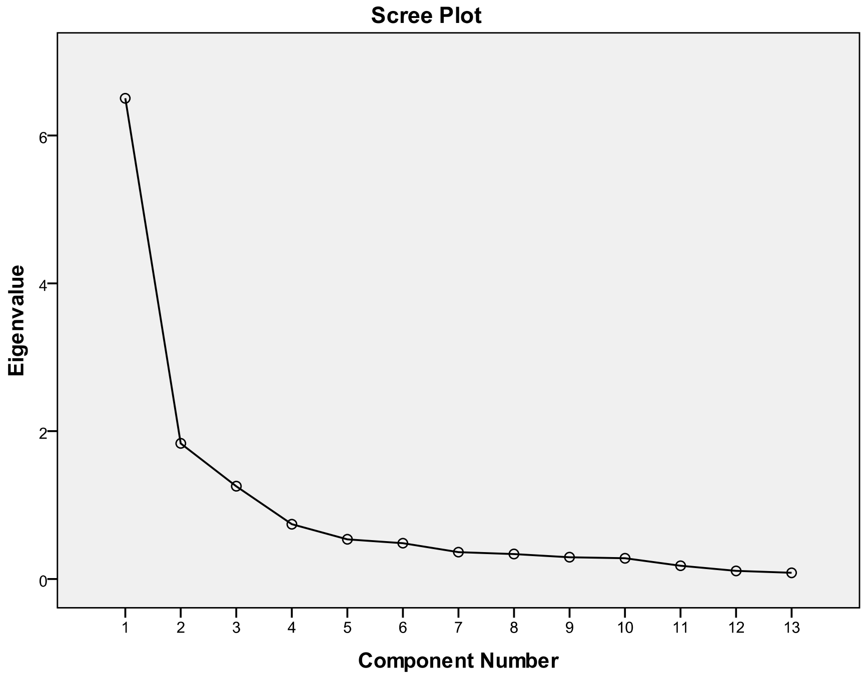

Figure 1. Scree plot as a result of the principal component analysis

Table 1. Items, rotated component matrix loadings, means, and standard deviations

Item	Factor 1 Importance (alpha=0.95)	Factor 2 Familiarity (alpha=0.78)	Factor 3 Disinterest (alpha=0.80)	Mean[a]	SD[b]
I believe engineering should be integrated into the K-12 curriculum.	.790			4.01	.909
I believe boys should learn about engineering in their K-12 education.	.858			3.95	.912
I believe girls should learn about engineering in their K-12 education.	.863			3.95	.909
In science curriculum, it is important to include the use of engineering in developing new technologies.	.861			4.14	.751
I would like my children to understand the use and impact of engineering.	.883			4.16	.761
I would like my children to understand the science underlying engineering.	.874			4.14	.760

My motivation for my children to learn engineering and science is for them to develop an understanding of the technical world	.791			4.12	.756
~~My motivation for my children to learn engineering and science is for them to become scientists or engineers.~~	~~.465~~		~~.516~~	~~3.18~~	~~.946~~
I am familiar with some science content.		.798		3.90	.835
I am familiar with some engineering, design, and technology content.		.861		3.42	1.038
I feel comfortable working with my children on school projects or homework concerning engineering.		.823		3.53	1.057
I think my children should only learn engineering once they choose to major in a related field in college.			.822	2.47	1.018
I think learning engineering in the K-12 curriculum would add an extra burden to my children's learning.			.714	2.45	1.042

[a]Values reported in mean are based on a 5-point scale (5: strongly agree; 4: agree; 3: neutral; 2: disagree; 1: strongly disagree)
[b]Standard deviation

II. Between group comparisons

After the factor analysis, we examined differences in parents' perceptions of and familiarity with engineering depending on their demographic characteristics. If a variable, such as gender, had two levels, we used independent-samples t-test with a significance level of 0.05 to compare two groups. Otherwise, if a variable had more than three levels, we used one-way ANOVA with significance level of 0.05. We examined the Levene's statistics (alpha=0.05) to make sure the equal variance condition held before we used Tukey's HSD test for post-hoc comparisons.

Overall Results and Between Groups Comparison

Overall, the sample as a whole indicated that it was important for children to learn engineering (M=4.03, SD=0.75). On average, their self-rated familiarity with the engineering content was moderately high (M=3.60, SD=0.85). The last factor indicating parents' disinterest in having engineering in K-12 was below 3 (M=2.47, SD=0.93), which meant overall the participants showed moderate interest in having engineering in the K-12 curriculum. Please refer to Figure 2 for the overall scores. Depending on the item, 4%-7% of the participants used the option "do not know" and "decline to answer".

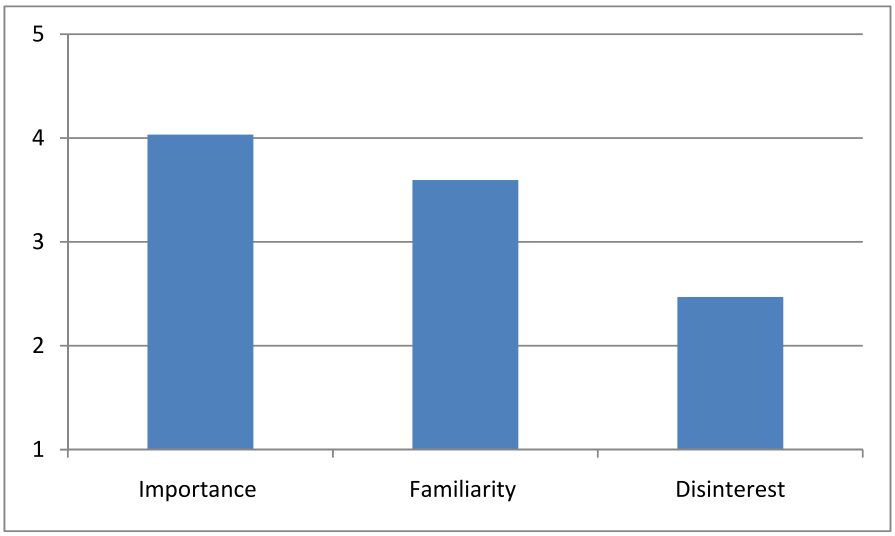

Figure 2. Overall mean scores for the three factors

We further examined if there were significant differences in how parents of different demographic groups rated the factors. We found differences among parents of different genders and education levels.

I. Gender differences

The independent-samples t-test with a significance level 0.05 was used to explore the gender differences in the three factors. The analysis showed that male and female parents did not differ in their perception of the *importance* of children learning engineering, $t(639)=0.81$, $p=0.42$. In addition, there were no significant differences in parents' *disinterest* in having engineering in K-12, $t(629)=0.13$, $p=0.89$. However, when the second factor was explored, it was found that male parents rated their *familiarity* with engineering content (M=3.96, SD=0.73) significantly higher than female parents (M=3.51, SD=0.85), $t(640)=5.60$, $p<0.01$. Please refer to Figure 3 for the comparison of genders on the three factors.

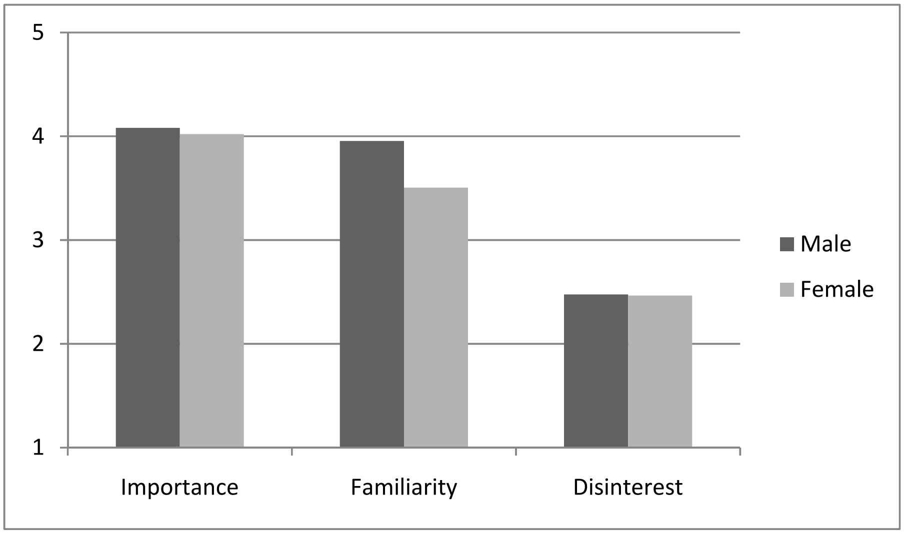

Figure 3. Gender comparison on the three factors

We further looked at the individual items loaded onto the second factor. We found that male and female participants showed significant differences in all three items in the *familiarity* factor. The scores of male parents were higher on all three items. Compared to female parents, male parents indicated higher familiarity with some science content ($t(628)=4.15$, $p<0.01$) as well as design, engineering, and technology content ($t(624)=5.23$, $p<0.01$). Also, male parents felt more comfortable working with their children on school projects or homework concerning engineering, $t(615)=4.53$, $p<0.01$.

II. Education level differences

We conducted a one-way between-groups analysis of variance to explore how parents of different education levels rate the items differently. We divided the participants into three groups according to their reported highest level of education completed (Group 1: below high school; Group 2: high school or GED; Group 3: college and above).

There was no significant difference in the *importance* of children learning engineering. However, there was a statistically significant difference at the $p<0.05$ level in parents' *familiarity* with engineering content between the three groups, $F(2,640)=9.41$, $p<0.01$. Post-hoc comparisons using the Tukey HSD test indicated the mean score for Group 3 (M=3.81, SD=0.76) was significantly higher than Group 2 (M=3.50, SD=0.87). Group 1 (M=3.58, SD=0.76) did not differ significantly from either Group 2 or 3. On the average, these results suggest that parents with a college degree rated themselves as more familiar with engineering/science content and more comfortable helping their children with engineering homework than parents with a high school degree.

The analysis of factor 3 revealed that there was a significant difference in parents' *disinterest* in having engineering in K-12, $F(2,629)=3.89$, $p=0.02$. Tukey HSD test showed that the mean score of Group 2 (M=2.54, SD=0.96) was significantly higher than Group 3 (M=2.32, SD=0.90), and that Group 1 (M=2.32, SD= 0.78) showed no significant difference from other two groups. We further examined individual items in this factor and found that parents in Group 2 with high school degrees were more inclined to agree that their children should only learn engineering once they choose to major in a related field in college (M=2.55, SD=1.02) than parents in Group 3 with college degrees (M=2.30, SD=1.00). Please refer to Figure 4 for the comparison of the three groups on the factors.

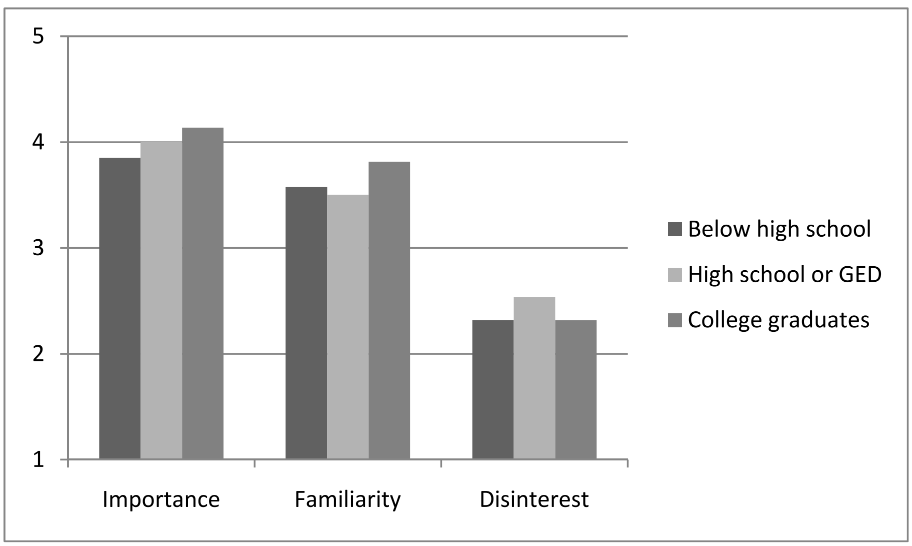

Figure 4. Comparison of parents with different education background

III. School district differences

None of the factors revealed any differences based on the school districts the parents were in (urban, suburban, or rural). On the other hand, examining individual items with one-way ANOVA indicated that there was one item in the *Importance* factor with significant difference between parents in the suburban and the rural school districts: parents' belief that engineering should be integrated into the K-12 curriculums, $F(2,599)= 4.11$, $p=0.02$. The suburban parents showed stronger agreement that engineering should be integrated into the K-12 curriculum (M=4.11, SD=0.85) than urban parents (M=4.05, SD=0.90) and rural parents (M=3.87, SD=0.99). Nonetheless, on average parents in all three categories of school district agreed that engineering should be integrated into the K-12 curriculum. Please refer to Figure 5 for the comparison of the three groups of parents.

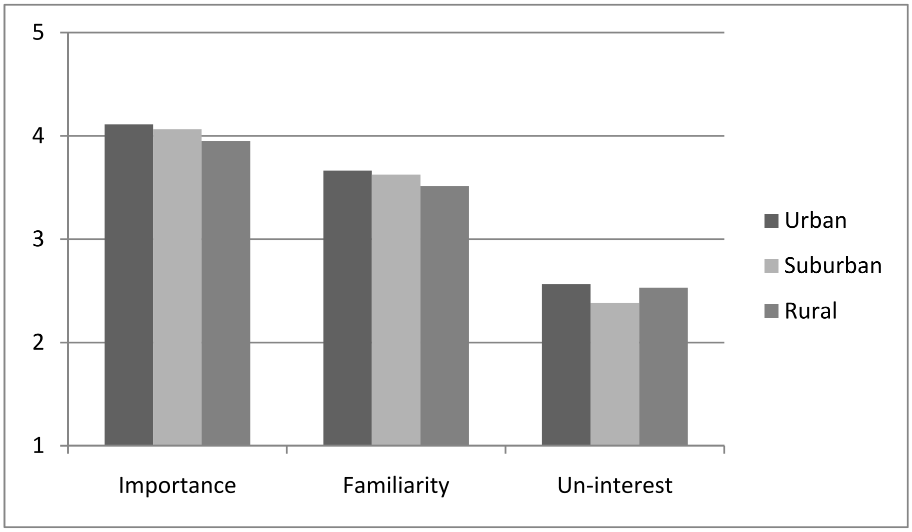

Figure 5. Comparison of parents from three different types of school districts

Conclusions and Recommendations

We designed an instrument, *Survey of Parents on Engineering*, to assess parents' perceptions of engineering and familiarity with engineering. In this paper, we report the findings of a pilot study. The participants represented a national sample of parents. We retracted three factors from the principal component factor analysis with Varimax rotation: a) *importance* of children learning engineering, b) *familiarity* of engineering content, and c) *disinterest* in having engineering in K-12. Both the *importance* factor and the *disinterest* factor served as subcategories in the Attitude dimension in the KAB framework, whereas the *familiarity* factor relates to the Knowledge dimension.

Looking at the *importance* and the *disinterest* factors, we found the participants perceived it was important for children to learn engineering but at the same time showed only moderate interest in having engineering integrated into the K-12 curriculum. There is a need to investigate the concerns parents have and any reason behind this imbalance. In addition, these parents indicated they were moderately familiar with engineering content and felt moderately comfortable in helping their children with engineering assignments. Future research should focus on comparing parents' knowledge with the recently added engineering standards in many states to see if parents understand engineering concepts correctly and if any hurdle exists in counting parents as a resource in children's engineering learning.

The significant differences in parents' self-reported attitudes and familiarity confirmed the notion that pre-college students' parents are not a homogeneous group. They come from diverse background, and they differ in their attitude towards the importance of engineering and towards the issue of integrating engineering in the K-12 curriculum.

Our investigation of gender differences showed that female parents did not rate their *familiarity* with the engineering content as high as male parents. Even though we did not gauge their knowledge objectively, what they think they know about engineering has a potential influence on their behavior of doing engineering activities with children. This result along with the evidence that mothers' influence through discussion with girls towards science has higher impact than fathers [8] suggests that parents can play an importance role in promoting diversity in engineering. We also found a difference in *familiarity* and *disinterest* between parents with different education background. College educated parents were more familiar with engineering and more interested in having engineering in K-12 schools than parents with only a high school education.

Although the statistics gave evidence of validity and reliability of the items described in this pilot study, examining the results conceptually rendered problems to be addressed to further understand how parents knowledge, attitude, and behavior towards engineering education at the K-12 level. In the preceding discussion, we mentioned: i) further research the attitude dimension to understand the unbalance between the *importance* and *disinterest* factor, ii) explore parents' knowledge about engineering beyond their self-report familiarity. Furthermore, the behavior dimension also needs to be addressed. We are in the process of developing items to address the above issues found with this pilot study. The expansion will also help us understand the differences found between parents of different genders and among parents of different education background.

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References

1. Committee on Prospering in the Global Economy of the 21st Century, *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. The National Academies Press: Washington,

D.C., 2005.
2. Silk, E. M.; Schunn, C. D.; Cary, M. S., The impact of an engineering design curriculum on science reasoning in an urban setting. *Journal of Science Education and Technology* **2009,** 18, (3), 209-223.
3. George, R.; Kaplan, D., A structural model of parent and teacher influences on science attitudes of eighth graders: Evidence from NELS: 88. *Science Education* **1998,** 82, (1), 93-109.
4. Kluin, J.; Cardella, M. E.; Purzer, S., The role of parents in engineering education: Four themes from the literature. *Journal of Engineering Education* **2011,** Under review.
5. Schrader, P. G.; Lawless, K. A., The knowledge, attitudes, & behaviors approach how to evaluate performance and learning in complex environments. *Performance Improvement* **2004,** 43, (9), 8-15.
6. Yasar, S.; Baker, D.; Robinson-Kurpius, S.; Krause, S.; Roberts, C., Development of a survey to assess K-12 teachers' perceptions of engineers and familiarity with teaching design, engineering, technology. *Journal of Engineering Education* **2006,** 95, (3), 205-216.
7. Hutcheson, G.; Sofroniou, N., *The multivariate social scientist: Introductory statistics using generalized linear models*. Sage Publications Thousand Oaks, CA, 1999.
8. Bhanot, R. T.; Jovanovic, J., The Links Between Parent Behaviors and Boys' and Girls' Science Achievement Beliefs. *Applied Developmental Science* **2009,** 13, (1), 42 - 59.