AC 2010-1041: ELEMENTARY TEACHERS' PERCEPTIONS OF ENGINEERING AND FAMILIARITY WITH DESIGN, ENGINEERING AND TECHNOLOGY: PERSPECTIVES FROM A NATIONAL POPULATION

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Assessing Elementary Teachers' Perceptions of Engineering and Familiarity with Design, Engineering and Technology: Implications on Teacher Professional Development

Abstract

Sixty-nine elementary teachers voluntarily attended a career development workshop on integrating engineering into curriculum. A survey previously developed was administered to the group before the beginning of the workshop to assess their perceptions of and familiarity of design, engineering, and technology (DET). Quantitative analysis showed that the teachers thought DET was importance while rated their familiarity low. ANOVA found significant differences in how teachers with different levels of teaching experience rated the importance of DET and their familiarity with DET. The implications on teacher professional development are discussed.

Introduction and Purpose

Engineering education at the K-12 level is important. From a societal importance point of view, there is a need to educate engineering literate citizens, who can make informed decisions about technology use [1]. From an individual standpoint, engineering literate individuals can get benefits at home and work, such as operating systems correctly and choosing the best consumer products. "Engineering literacy" relates to understanding issues involving conceiving, building, maintaining and designing objects or processes in the man-made world. It is synonymous with "technology literacy" used in the national science standards [2]. In this paper, we will use the term design, engineering, and technology (DET) to capture the broader meaning of engineering education. In comparison to science and mathematics education, engineering education at the K-12 level is underdeveloped [3]. Therefore, National Academy of Engineering (NAE) and National Research Council (NRC) called for developing engineering learning standards at the K-12 level. Aside from the calls for better engineering education infrastructure from the top down, recent studies have also provided evidence that learning engineering content, especially engineering design, can motivate children and help them learn science [4].

K-12 teachers are one of the primary agents in infusing engineering in K-12 education. However, most K-12 teachers do not go through trainings in engineering education during their pre-service education. Hence, teacher professional development programs are necessary to familiarize teachers with engineering content. As a beginning step in developing teacher professional development for K-12 teachers in engineering education, we are interested in exploring teachers' attitudes towards engineering; particularly, their perceptions of engineering and familiarity with engineering content and processes.

Method

We adopted an existing validated instrument used to measure K-12 teachers' perceptions of and preparedness in the disciplines of design, engineering, and technology (DET)[5]. The survey was previously administered to 98 teachers throughout grades K-12 in the state of Arizona.

From the Arizona sample, four factors concerning preparedness and familiarity of DET were extracted: *importance* of DET, *familiarity* with DET, *stereotypical characteristics of engineers*, and *characteristics of engineering*.

We administered the DET survey, which consisted of 41 questions clustered under four factors. The sample we used was different from the study conducted by Yasar, et al. with Arizona teachers[5] in three ways. First, the teachers in our sample participated in a summer institute focused on engineering activities while the original study did not. Second, the teachers who participated in the summer institute volunteers who were interested in learning more about engineering. Thirdly, the participants came from five different states other than Arizona (FL, IN, MD, MI, TX).

Sixty-nine elementary school teachers participated in a week-long INSPIRE professional development workshop in the summer of 2008. The activities during the workshop focused on ways to integrate engineering content, such as design process, into science and mathematics curricula. Participation in the workshop was voluntary. The DET survey was administered before the introduction to any engineering content or process.

Sixty-five of the participants were female, and four were male. Seventy-eight percent were white Americans, while 12 percent were Latino/Latina, and six percent were Native American. The mean age of the participants was 40.72 (SD=11.46). The teachers came from five different states around the country. Twenty-five of the teachers had 1-5 years of full-time teaching experience, twenty-nine 6-15 years, and fifteen more than 16 years. Thirty of them has 1-5 years of science teaching experience, twenty-six 6-15 years, and thirteen more than 16 years.

Note that we did not do a post test after the workshop. Literature indicates that teachers' attitudes and beliefs mostly come from their classroom experience, and not commitment and enthusiasm after attending professional development activities [6]. As an on-going process, we are observing teachers who attended the workshop in their classrooms and will conduct post-test and interviews after the teachers implemented engineering content.

Research Questions

We seek to answer the following questions in our study:

1. What are INSPIRE participants' perceptions of DET and familiarity of DET?
2. How are INSPIRE teachers' perceptions of DET and familiarity of DET different from the participants of the Arizona sample?
3. What is the relationship between teaching experience and perceptions of DET?
4. What is the relationship between teaching experience and familiarity with DET?

Data Analysis

The responses were analyzed using the factors yielded in the original survey[5]. We performed an independent sample t-test to compare the Arizona sample and the INSPIRE sample on the responses of the four factors. We also computed Cohen's *d* effect size to show the scale of differences.

Within the INSPIRE sample, we grouped teachers into groups of new teachers (1-5 years), moderately experienced teachers (6-15 years), and expert teachers (more than 16 years) in terms of their full-time teaching experience or science teaching experience. We examined whether there were differences based on teaching experience by performing one-way ANOVA. Levene's test was performed to ensure homogeneity of variance, and q-q plot were examined to ensure normality. We also computed effect size w^2 for significant factors. If ANOVA showed significant differences, we performed Tukey's HSD post-hoc test to compare between groups. We did not explore differences between groups of different genders or grade levels because the sample was rather homogeneous in terms of these attributes.

Findings

<u>Results of the entire survey</u>

Overall, the summer academy participants thought DET was important (M=3.47, SD=0.35) (please note that 4 was the highest possible score, and 1 was the lowest possible score). However, on the average, their self-rated familiarity of DET content was moderately low

(M=2.21, SD=0.33).

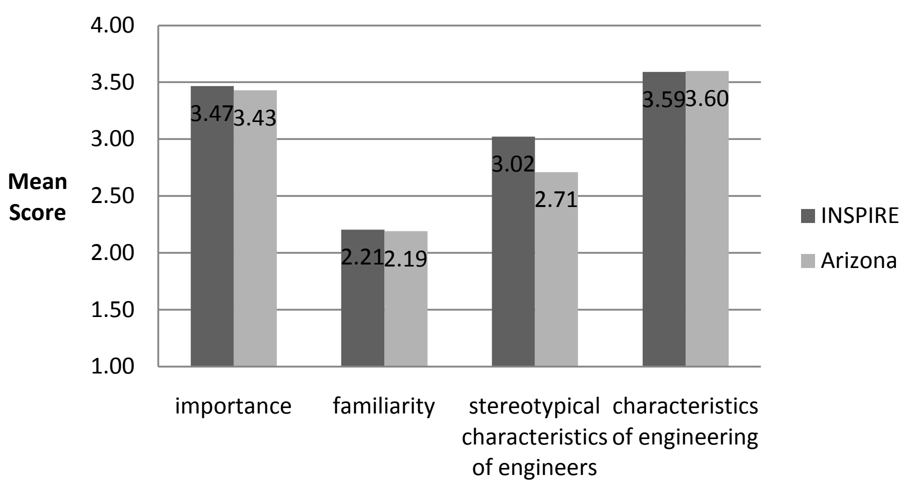
Mean item scores of more than three indicated that most teachers did not held stereotypical views of engineers and their skills (M=3.02, SD=0.45). For example, they believed that engineers had communication skills and worked well with others.

Also, with a mean score of 3.41 (SD=0.31) on the factor *characteristics of engineering* showed that teachers believed that engineering involved science and mathematics, engineers earned good money and liked to fix things. They also believed that DET had positive consequence for the society.

Results compared to the Arizona sample

An independent samples t-test at a significance level of 0.05 was conducted to compare the INSPIRE sample to the Arizona sample previously reported in Yasar et al.'s paper [5]. There was a significant difference in how the participants in the two studies rated the stereotypical characteristics of engineers, $t(165)= 3.58$, $p<0.01$, $d=0.70$. The INSPIRE participants were more likely to agree that typical engineers had people, writing and verbal skills. While their responses on the stereotypical characteristics of engineers showed significant differences, there were no significant differences in how the teachers in the two studies viewed the importance and characteristics of engineering. In both studies, teachers' rating of their familiarity of design, engineering, and technology were low. Figure 1 compares the mean scores of the four factors on the two studies.

Figure1. Comparing mean scores of the INSPIRE study and the Arizona study on the four factors



Between groups comparison within the INSPIRE sample

We further examined if there were significant differences in how the INSPIRE participants of different teaching experiences rated the factors. One-way ANOVA with a significance level of 0.05 revealed differences based on these elementary teachers' full time and science teaching experience.

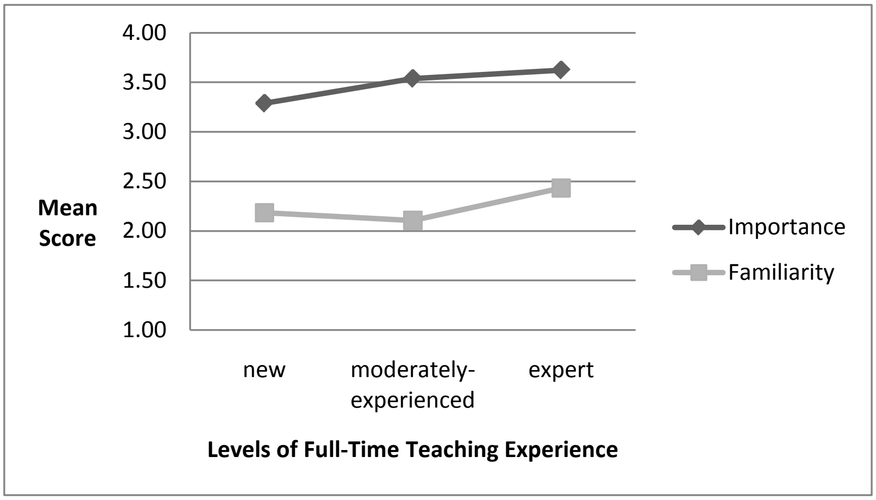
I. Full-time teaching experience

We conducted a one-way between-group analysis of variance at a significant level of 0.05 to explore how participants of different full-time teaching experience rated the items differently. As discussed in the data analysis section above, we divided the participants into three groups according to their reported full-time teaching experience: a) new teachers, b) moderately-experienced teachers, and c) expert teachers.

There was a significant difference in how participants rated the *importance* of DET, $F(2,66)=6.12$, $p<0.01$, $w^2=0.13$. Post-hoc comparisons using the Tukey's HSD test indicated that moderately-experienced teachers (M=3.53, SD=0.33) and expert teachers (M=3.62, SD=0.25) rated the importance of DET significantly higher than new teachers (M=0.29, SD=0.36). This result suggested that the teachers with more full-time teaching experience tended to think that DET was more important than teachers with limited experience.

The analysis of participants' self-rated familiarity of DET revealed similar results, $F(2,66)=5.76$, $p<0.01$, $w^2= 0.12$. Tukey's HSD test showed that expert teachers (M=2.43, SD=0.29) rated their familiarity with DET content significantly higher than the new teachers (M=2,18, SD=0.36). There were no significant difference between moderately-experienced teachers (M=2.11, SD=0.27) and the new teachers. Figure 2 depicted how the mean scores of the importance and the familiarity factors differ for teachers of different levels of full-time teaching experience. Also note that there are disparities between teachers' perceived importance of DET and their self-rated familiarity of DET.

Figure 2. Mean scores of importance and familiarity in terms of teachers of different levels of teaching experience.



We further examined the items that looked at what the teachers thought were the barriers in integrating DET in their own classroom. Experienced teachers were more likely to think that lack of time, training and administrative support were barriers than less-experienced teachers. They also were more likely to agree that lack of the knowledge was the barrier (although the comparison was not significant). Please refer to Table 1 for the descriptive statistics.

The analysis of the other two factors, *stereotypical characteristics of engineers* and *characteristics of engineering*, did not reveal any difference based on participants' full-time teaching experience.

Table 1. Comparison of descriptive statistics and ANOVA results for teachers with different full-time teaching experience

	a. new (n=25)		b. moderately-experienced (n=29)		c. experienced (n=15)		ANOVA Tukey's HSD test at 0.05 significance level
	M	SD	M	SD	M	SD	
Lack of time	2.96	0.79	3.07	0.84	3.67	0.49	ac bc
Lack of training	2.92	0.95	3.10	0.77	3.60	0.51	ac
Lack of administrative support	2.20	1.00	1.45	0.69	2.73	1.16	ab bc
Lack of knowledge	2.96	0.84	3.07	0.70	3.47	0.64	

II. Science-teaching experience

Similar to the analysis based on participants' full-time teaching experience, we also divided the participants into three groups in terms of their science-teaching experience: new teachers, moderately-experienced teachers, and expert teachers. Then we conducted ANOVA at a significance level of 0.05 to compare among groups.

We found significant differences in how teachers with different science teaching experience rated the importance of DET, $F(2,66)=4.01$, $p=0.02$, $w^2= 0.08$. Tukey's HSD, which has less power, could not discern differences. However, judging from the descriptive data (please refer to Table 2), the more science teaching experience teachers had, the more important they think DET was.

Table 2. Descriptive statistics of the *importance* factor rated by teachers of different science teaching experience

	Mean	SD
New teachers	3.29	0.36
Moderately-experienced teachers	3.54	0.33
Expert teachers	3.62	0.25

We also found significant differences in how teachers with different science teaching experience rated their *familiarity* with DET content, $F(2,66)=5.58$, $p<0.01$, $w^2=0.12$.Tukey's HSD showed that the expert teachers (M=2.44, SD=0.31) rated their familiarity higher than new teachers (M=2.20, SD=0.37) and moderately-experienced teachers (M=2.10, SD=0.20). There were no significant differences between the new teachers and the moderately-experienced teachers.

The analysis of the other two factors, *stereotypical characteristics of engineers* and *characteristics of engineering*, did not reveal differences based on participants' science teaching experience.

Discussion and Implications

The most significant result was that although the teachers believed DET was very important, their self-reported familiarity of DET was low. This result was consistent with the findings of the Arizona study and generalized the phenomenon to a wider population of teachers. In order to infuse engineering in K-12 education, a key barrier, teachers' unfamiliarity with the content, need to be overcome. Well-designed teacher professional development programs and scaffolding must be provided for teachers.

INSPIRE participants had less stereotypical images about engineers compared to the Arizona sample. The differences found between the two studies may be attributed to the fact that the participants of our study were voluntary attendees of an engineering workshop, which showed their interest and initiative in integrating DET into elementary classrooms. This suggests that teachers with motivation to learn about engineering are more likely to project engineering as a profession involving multi-faceted skills.

We found significant differences based on teachers' teaching experience, which were not evident in the Arizona sample. Teachers with more full time teaching and science teaching experience were more likely to think that DET is important than teachers with limited or moderate experience. Teachers with more full time teaching and science teaching experience rated themselves significantly more familiar than teachers with limited or moderate experience. When we looked at items that probed teachers' perceived barriers of integrating DET in their own classrooms, compared to less experienced teachers, experienced teachers tended to agree that the barriers were the lack of time, training, knowledge, and administrative. The differences we found based on teachers' experience were consistent with the literature on teacher change that pointed out that experienced teachers had different beliefs than new teachers. For example, in studying experienced science teachers, van Driel et al. [7]found that they had a set of integrated beliefs and knowledge and it also revealed that changes in attitudes occurred as a result of restructuring those beliefs and knowledge, not from adding new information. Therefore, the implication of our findings based on participants' teaching experience is that different kinds of scaffoldings should be provided to teachers with different teaching experiences. Further study is needed to identify teacher beliefs related to engineering education. There should be engineering education research that further explores the beliefs and knowledge that teachers with different experiences have in order to infuse DET in K-12 education.

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