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Elementary Teacher as Teacher of Engineering: Identities in Concert and Conflict

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Elementary Teacher as Teacher of Engineering: Identities in Concert and Conflict

Abstract

This paper shares the results of completed mixed-methods research on the ways in which 35 elementary teachers developed 'teacher-of-engineering' identities before and after teaching science-integrated Engineering is Elementary (EiE) units of instruction for the first time. Quantitative and qualitative research methods were utilized to examine how participants: viewed themselves, or perceived of how others (e.g., family, administrators, other teachers) viewed them as teachers of engineering; suggested ways in which teacher-of-engineering identities were in congruence or conflict with existing identities; and engaged in social interactions consistent with the development of teacher-of-engineering identities. Although participants largely agreed that they viewed themselves as teachers of engineering, they agreed less strongly that others saw them this way, and agreed more strongly that they were teachers of children, reading, and mathematics. Reasons for these differences included that: engineering was a new topic in elementary education, others cannot conceptualize what elementary engineering entails, and the public view that elementary teachers likely cannot teach engineering. Participants described both elementary teachers and engineers as smart and creative, yet predominantly described the professions using different language. Although participants regularly communicated with other teachers about the engineering units, they did so less frequently with individuals outside the school community. Many participants identified as generalists, a largely congruent identity that suggests that they can teach engineering, like any other subject; however, those who interpreted their generalist identity to mean 'teacher of basics' may have experienced difficulty incorporating a teacher-of-engineering identity. Implications for these findings suggest approaches to teacher professional development and further research.

Introduction

This paper shares the results of a study of the ways in which 35 elementary teachers developed 'teacher-of-engineering' identities before and after teaching science-technology-engineering integrated units of instruction (hereafter, STE units), each of which include an Engineering is Elementary (EiE) unit, for the first time. The theoretical background section of the paper discusses the construct of identity, as well as the importance of examining teacher-of-engineering identity. Next, the paper describes the context of the SySTEmic Project in which the study was situated. This is followed by a description of the quantitative and qualitative methods used to study teachers' experiences with and perspectives about identity. The findings section is divided into six major sections: 1) Teaching Roles; 2) Sense Making about Teacher-of-Engineering Identity; 3) Competence and Career Goals; 4) Describing Engineering and Elementary Teaching Professions; 5) Frequency of Social Interaction; and 6) Teaching Engineering: Similar to or Different From Any New Curriculum? Following the findings section, the paper concludes with a four key assertions from the study, and implications for them.

Theoretical Background

Identity refers to the ways that individuals enact, voice and embody certain ways of being. Gee associates this concept quite closely with (big "D") Discourses, i.e., "ways of being certain kinds of people" manifested in individuals' "expressed combinations of speech, action, body language, dress, beliefs or values, or the use of technologies, and in so doing, are "recognized as a certain 'kind of person' (e.g., as a certain kind of African American, radical feminist, doctor, patient, skinhead)." [1]

Identity development or formation may be construed as a process of learning and sense making. "Learning," offered Brickhouse, "is a matter of deciding what kind of person you are and want to be ..." (i.e., learning and identity are bound).[2] Working out the kind of person one wants to be, according to Gee, involves sense making:

> I work out my identity, in the modern sense, by making sense of, or interpreting, what it means to be a man or a woman of a certain sort, a worker or professional of a certain sort, an Anglo American or African American of a certain sort, or moral, witty, intelligent, or fit for leadership in certain ways and not in others.[3]

Ibarra offered that this sense-making process involves the re-crafting of personal narratives in response to "turning points" in which individuals do and learn new things or forge new relationships.[4] Sense making, described Eliot and Turns in their exploration of the construction of identity among engineering undergraduates, "includes the writing and re-writing of personal narrative, a signification of newly found interests and abilities in the context of existing ideas about who we are."[5] Note that the language here includes the terms *re*-crafting and *re*-writing, suggesting that new identities (e.g., teacher of engineering) must be negotiated in light of existing identities (e.g., teacher of traditional elementary subjects) at turning points.[6]

The construct of identity includes but goes beyond self-concept in two important ways: 1) identity includes how others perceive of us, and 2) identity includes how we react to others. Regarding the first point, Luehman's definition of "teacher professional identity" was "being recognized by self *or others* as a certain kind of teacher" [emphasis added].[7] Consider the following from a study of student engineering identities by Tonso:

> Students did not consider women [as] people who fit in the Nerd category. As one of the more enlightened men students put it when talking about "the nerd-type profile. You know, the pocket protector. The nerd-type guys. . . . You don't think of women as that, I guess. 'Cause, at least at this school, I think guys here so much appreciate that a girl chose to come to this campus that you're just like, 'Great!' There are so many guys that you can say 'this guy's a nerd,' the pocket-protector-wearing guy." He seemed to have no way to talk about women's absence from the Nerd territory, nor did other men, and no one seemed to notice that some of their descriptions for Nerd terms fit their women design-project teammates.[8]

The women in Tonso's study may have self-identified as Nerds (a typically derogatory term to which some engineering students may co-opt as a 'badge of honor' or term of endearment), yet this identity was not fully available to them since it was not recognized by others within their community of practice. A community of practice, as originally defined by Lave and Wenger,[9] is a group of individuals "who share a concern or passion for something they do and learn how to

do it better as they interact regularly";[10] in Tonso's study, this is a community of practice of engineering students.

Related to idea that identity is shaped, in part, by how others see us is Wenger's notion of a "regime of competence" within a community of practice. Part of the formation and ongoing maintenance of communities of practice is a process by which members co-define, implicitly or explicitly, a regime of competence, which is "a set of criteria and expectations by which they recognize membership."[11] The perceived actions and contributions of individuals, then, are evaluated by those in communities of practice, which may result in the affirmation or questioning of the appropriateness of fit for a particular or potential community member.

A second way to differentiate self-concept and identity is that our identities respond to these external judgments by others. Lave and Wenger suggest that sense making about our identity requires that we consider who we want to be not only within communities of practice, but also *in response to others*.[8] Thus, identity formation is relational, discursive and responsive to the broader social environment.[12]

In this study, I examine how elementary teachers negotiate the inclusion of 'teacher of engineering' within their existing identities as 'elementary school teachers' when a new elementary engineering curriculum created an institutionalized turning point. Many factors may impact the sense making when teachers incorporate a teacher-of-engineering identity. Two of these are that: 1) most practicing elementary teachers have not been exposed to engineering or learned engineering pedagogy in their pre-service education or professional development;[13] and 2) while gendered, stereotyped images of engineers are masculine (and indeed most engineering fields are still primarily populated by men), such images of elementary teachers (largely women) are typically feminine (e.g., eliciting images of nurturing and care).[14,15]

Context & Participants

Project Goals & STE Units

The 35 teachers involved in the present study—including 14 3rd grade, 13 4th grade, and 8 enrichment teachers—were participants in the 2009-2010 pilot year of the SySTEmic Project.[16,i] This project aimed to provide one STE unit per grade to all 15,000 1st through 5th grade children in a 40,000-pupil district by the end of the 2011-2012 academic year.[ii] The STE units: are blends of modified district science units and EiE units (Table 1); were designed to utilize 12 to 14 hours of instructional time; and contain one long (90 – 120 minute) EiE engineering design process lesson (i.e., the design of a windmill or a rock wall).[17]

Table 1. Pilot Year (3rd & 4th grade) STE Units for the SySTEmic Project.

	3rd Grade	4th Grade
Original District Science Unit	Energy in Motion	Rocks & Minerals
EiE Unit	Catching the Wind: Designing Windmills	A Sticky Situation: Designing Walls
STE Unit	Motion, Energy & Mechanical Engineering	Rocks, Minerals & Materials Engineering

Pilot Schools

Pilot year teachers who taught STE units to one or more classrooms of students were from 7 of the 33 elementary schools across the district (Table 2).[iii] These pilot schools were where each STE unit within the SySTEmic Project was taught one year prior to full implementation in the district. The pilot schools represent a diversity of size, socio-economic status and ethnicity of the student body, and geographic location within the district. All enrichment teachers at these schools agreed to participate early in the development of the SySTEmic Project. Those enrichment teachers helped to recruit 3rd and 4th grade teachers for the pilot year. Classroom teachers who ultimately participated in the project voluntarily chose to participate. In some pilot schools, all grade level teachers participated in the pilot year; in others, only a subset of 3rd or 4th grade teachers participated.

Table 2. SySTEmic Project pilot schools, school characteristics, and participants.

School	School Characteristics				Study/Pilot Year Participants		
	Size of school	School setting	Title I?	Approx. % Minority students*	# Enrichment teachers	# 3rd Grade Teachers in Pilot	# 4th Grade Teachers in Pilot
A	Medium	Rural	No	10%	1**	1	1
B	Medium	Rural	No	5%	1	3	2
C	Small	Rural	No	15%	1**	1	1
D	Medium	Small city	Yes	60%	1	2	3
E	Large	Suburban	No	15%	2**	3	3
F	Medium	Small city	Yes	50%	1	3	1
G	Large	Suburban	No	15%	1	2	2
				Totals ⇨	8	15	13

*Note: * Rounded to nearest 5%; Minority includes: American Indian/AK Native, African American, Asian/Pacific Islander, & Hispanic. ** Positions are part-time (1/2 time each in schools A and E; 1/5 time in school C).*

Professional Development

Prior to teaching the STE units, all teachers received nine hours of professional development (PD) to learn both unit content and pedagogy. Between four and five of these hours were spent focusing on the engineering (EiE) portion of the STE unit. Enrichment teachers participated in PD for both 3rd and 4th grade units. Classroom teachers attended a single session for their grade level only.

Enrichment Teacher Role

Enrichment teachers were included in the SySTEmic Project for multiple reasons. These teachers were seen as individuals who could support classroom teachers, particularly as they engaged in teaching STE units for the first time.[iv] This support could take the form of being a resource with respect to the STE unit (since the enrichment teacher also received PD), or by co-planning or co-teaching with classroom teachers.[18] Enrichment teachers were typically well suited to be resources for the engineering portions of the STE units based upon many of their collective prior experiences with engineering design challenges in after school activities like Destination Imagination, FIRST Lego League and the state's Engineering Challenge competition. Furthermore, enrichment teachers' focus on engaging students in higher level questioning and critical thinking was consonant with the skills needed to move through the engineering design process.

Research Questions and Null Hypotheses

This study aimed to investigate pilot year teachers' perspectives on their identities – as elementary teachers, broadly, and as teachers of engineering – before and after teaching the STE-integrated unit. Research questions were as follows:

1. How did participants view themselves – or perceive of how others (e.g., family members, administrators, teachers) viewed them – as teachers of engineering?
2. In what ways did participants suggest ways in which their teacher-of-engineering identities were in congruence or conflict with their existing identities as elementary teachers?
3. How did participants engage in social interactions consistent with the development of teacher-of-engineering identities?

In addition, five null hypotheses related to the above research questions were tested using quantitative methodologies described in the following section. These null hypotheses are as follows:

H_{01}: There is no difference between teachers' perspectives on the extent to which they view themselves and how they perceive that others view them.

H_{02}: There is no difference between teachers' perspectives on the extent to which they view themselves as teachers of children, exceptional children, reading, mathematics, social studies, science or engineering.

H_{03}: There is no difference between teachers' perspectives on the extent to which they

perceive others' views of themselves as teachers of children, exceptional children, reading, mathematics, social studies, science or engineering.

H_{04}: There is no difference between classroom teachers' and enrichment teachers' perspectives on identity.

H_{05}: There is no difference between teachers' perspectives on identity prior to teaching and their perspectives after teaching.

Note that H_{04} and H_{05} refer broadly to "perspectives on identity" rather than specific variables (e.g., the extent to which participants agreed that they are teachers of engineering, or the frequency with which they communicate with others about the engineering unit).

Methodology

Both quantitative and qualitative methods were employed to answer the above research questions, and quantitative methods were used to support or reject the null hypotheses. This mixed-methods approach was used to be able to: 1) determine whether certain measures that capture aspects of identity were significantly different across variables (e.g., views of self versus suspected views of others), including time (i.e., pre- versus post-teaching) and people (e.g., classroom versus enrichment teachers); and 2) create more open-ended opportunities for participants to reflect on survey responses and to capture the range of perspectives about teacher-of-engineering identities across participants. The first of these goals is the work of quantitative tools like items on the survey used in this study; the second is the work of qualitative items on surveys and within interviews.

The author and a colleague designed a pre- and post-teaching survey to examine pilot year teachers' perspectives on planning to teach and teaching the STE units. Survey items were developed after analysis of extensive interviews with and observations of two classroom-enrichment co-teaching pairs who taught an STE unit as a pre-pilot in the spring of 2009. Interview and observation analysis, coupled with discussions with other SySTEmic Project and district leaders, resulted in the range of questions about identity included in the surveys.

Approximately 20% of the pre-teaching and 7% of the post-teaching surveys were dedicated to questions about identity. Most (90%) of the identity-related questions on the pre-teaching survey, as well as all such questions on the post-teaching survey, asked participants to answer on a Likert scale with regard to level of agreement (e.g., strongly agree, strongly disagree) or frequency (e.g., sometimes, never). For example, teachers were asked to express their level of agreement regarding the statement, "I see myself as developing competence in a subject (engineering) for which (prior to the project) I was not trained." They were asked to share the frequency with which they "… communicate with other teachers (including co-teachers) about aspects of the unit."

Five questions on the pre-teaching survey were open-response questions. One such question was: "What kinds of words come to mind when you think of the engineering profession? (Please include a "brainstormed" list below.)" Qualitative research methods involving iterative searches of the participant responses to each question resulted in codes to

summarize the data and to provide a sense of the frequency of participant responses.[19,20] A total of over 70 codes and sub-codes emerged.

Surveys were sent electronically to classroom teachers via the online survey software, SurveyMonkey™. Classroom teachers who taught the unit to multiple classes of students were asked to complete the post-teaching survey after teaching all of their classes. Enrichment teachers were sent pre-surveys prior to working with classroom teachers, and were asked to complete post-teaching surveys after completing all work with classroom teachers in their buildings. SySTEmic Project leaders tracked when each teacher would teach the STE unit(s) and teachers received as many as three reminders to complete surveys. Response rates for the overall surveys were quite high: 100% (of 36 participants) pre-teaching survey, and 94% post-teaching survey. However, on average, the maximum response rate for identity questions on the pre-teaching survey was 97% (N = 35); 94% (N = 34) was the maximum response rate for identity questions on the post-teaching survey.[v]

Analysis of quantitative survey results involved a combination of descriptive and inferential statistics. In this paper, medians and frequencies of responses to Likert-scale questions were used in favor of means and standard deviations given the nonparametric nature of the data. A Kolmogorov-Smirnov test was run to verify that the data were, largely, not normal.[vi] Two types of non-parametric tests were used in the quantitative analysis program, SPSS®, to determine differences in perceptions of co-teaching experiences across teacher groups, time, or other variables.[20,21] Mann-Whitney-Wilcoxon (MWW) tests were used to determine if there were differences in response between enrichment and classroom teachers.[23] The Wilcoxon Matched-Pairs Signed-Rank test was used to examine differences in teacher response to the same questions across time (e.g., comparing post- and pre-teaching). Two-tailed significance was reported since the directionality of deviation from the null hypothesis was not predictably in one direction prior to data collection or analysis for any of the variables studied. The significance level reported throughout this study was 0.05.

After post-teaching surveys had been collected, teachers were invited to participate in an interview to elaborate their post-teaching survey results.[24] The identity portion of the interview was brief, and asked teachers to elaborate on their responses to questions regarding how they see themselves or how they suspect others see them as teachers of engineering. The interview also explored how teaching engineering was similar to or different than teaching other new curriculum (e.g., be it a new reading curriculum or something else). Prior to each interview, the author reviewed the post-teaching survey responses for that particular teacher and recorded individual follow-up questions on the interview protocol form to individualize the interview process.

Of the 36 pilot year teachers, 21 (nearly 60%) participated in interviews; of these, 8 were 3rd grade teachers, 8 were 4th grade teachers, and 5 were enrichment teachers. Teachers were paid a modest, grant-funded stipend for their time. Interviews were semi-structured in format, lasted approximately 1 hour, and were digitally recorded.[25] They took place at the teacher's school or home. Discussions about identity constituted approximately 5 to 10% of the interview duration. Interviews were transcribed, and all interviewees—as well as any other participants in the study who were named in interviews—were given pseudonyms.

Qualitative analysis of interview data involved a grounded theory approach, which utilized HyperResearch™ qualitative analysis software and involved iterative reviews of the transcripts and qualitative survey responses to search for recurrent themes.[19,20] Throughout this process, codes were identified, refined, and at times removed or renamed. Ultimately, a list of 25 codes and subcodes was used to code the interview data.

Participant Observation Role

The author's role in this study and in the SySTEmic Project is one of participant-observation, a role common to qualitative research.[25] As a participant, the author is an SySTEmic Project leader, is instrumental in blending the science and EiE units to create the STE units, is the lead professional developer for all pilot year teachers, and conducted extensive observations of most of the 4th grade unit lessons taught within two classrooms during the 2009-2010 year that is the focus of this study. These experiences afford the author many benefits of insight and understanding, including the ability to write contextually informed survey and interview questions. However, teachers may be less inclined to be critical of the project or to be doubtful of taking on teacher-of-engineering identities since they are reporting survey responses to the author and, for those who took part in the interview process, sharing their ideas verbally with the author.

Findings

The findings have been organized thematically into five sections: 1) Teaching Roles; 2) Sense Making about Teacher-of-Engineering Identity, 3) Describing Engineering and Elementary Teaching Professions, 4) Frequency of Interaction, and 5) Teaching Engineering: Similar to or Different from any Other New Curriculum? Each section is addressed, in turn, in what follows.

Teaching Roles

Before teaching, participants agreed that they saw themselves – and others saw them – as teachers of children, exceptional children, reading, mathematics, social studies, science and engineering (Table 3). Here, 'others' refers to a wide group of other people, and was defined as follows within surveys: "e.g., other teachers, administrators, family members." Median scores of agreement for both "I see myself as a teacher of _____" and "Others see me as a teacher of _____" were either a 5 (agree) or 6 (strongly agree) for each of these teaching roles. Only in the case of engineering did participants' views of themselves significantly differ from their perceptions about views of others, rejecting H_{01} for this teacher role only. While 100% of participants either agreed or strongly agreed that they saw themselves as teachers of engineering, 70% of participants agreed or strongly agreed that others saw them as teachers of engineering.

Table 3. Pre-teaching survey results for participants' perceptions of how they see themselves and how others see them in various teaching roles (e.g., as teachers of children, mathematics, engineering).

Item	N	Median	% Strongly Agree (6)	% Agree (5)	% Disagree (2)	% Strongly Disagree (1)	Self vs. Other Sig
I see **myself** as a teacher of **children**.	35	6	**91%**	9%	0%	0%	.180
Others see me as a teacher of **children**.	35	6	**83%**	17%	0%	0%	
I see **myself** as a teacher of **exceptional children**.	33	6	**52%**	49%	0%	0%	.157
Others see me as a teacher of **exceptional children.**	30	6	**67%**	33%	0%	0%	
I see **myself** as a teacher of **reading**.	34	6	**74%**	27%	0%	0%	.317
Others see me as a teacher of **reading**.	34	6	**68%**	29%	3%	0%	
I see **myself** as a teacher of **math**.	35	6	**74%**	26%	0%	0%	.059
Others see me as a teacher of **math**.	34	6	**65%**	32%	3%	0%	
I see **myself** as a teacher of **social studies**.	33	6	**55%**	42%	3%	3%	.161
Others see me as a teacher of **social studies**.	32	6	**53%**	38%	6%	3%	
I see **myself** as a teacher of **science**.	35	6	**69%**	31%	0%	0%	.131
Others see me as a teacher of **science**.	35	6	**60%**	34%	3%	3%	
I see **myself** as a teacher of **engineering**.	31	5	32%	**68%**	0%	0%	.004*
Others see me as a teacher of **engineering**.	*27*	*5*	*22%*	***48%***	*26%*	*3%*	

Note: N = number of teachers responding to the question out of 36 total teachers. Scale: 6=strongly agree, 5=agree, 4=slightly agree, 3=slightly disagree, 2=disagree, 1=strongly disagree. Highest percentages for each item have been bolded. No teachers slightly agreed or slightly disagreed. Significance based on Wilcoxon Matched Pairs Signed rank test (= $p<0.05$).*

Although most teachers either agreed or strongly agreed that they viewed themselves and others viewed them as teachers of children, exceptional children, reading, mathematics, social studies, science and engineering, there were differences in the relative strength of agreement for these roles, rejecting H_{02} and H_{03}. Table 4 provides all significant differences across teacher roles regarding participants' views of themselves and participants' perceptions of how others view them. Summarizing these findings, teachers most strongly identified with roles of teachers of children, reading, and mathematics, and identified least strongly with roles as teachers of social studies and engineering.

Table 4. Significant differences regarding how participants see themselves (or how others see them) in different teaching roles (e.g., as teachers of children, mathematics, engineering).

Relationship			**Teaching Role Difference Sig**
Participants **agreed <u>more</u> strongly** that:	I see myself as a teacher of **children** than as a teacher of:	Exceptional Children	.000*
		Reading	.034*
		Mathematics	.014*
		Social Studies	.000*
		Science	.011*
		Engineering	.000*
	Others see me as a teacher of **children** than as a teacher of:	Reading	.035*
		Mathematics	.021*
		Social Studies	.002*
		Science	.013*
		Engineering	.000*
Participants **agreed <u>less</u> strongly** that:	I see myself as a teacher of **exceptional children** than as a teacher of:	Children	.000*
		Reading	.033*
		Mathematics	.033*
	I see myself as a teacher of **social studies** than as a teacher of:	Children	.000*
		Reading	.035*
		Mathematics	.011*
		Science	.034*
	Others see me as a teacher of **social studies** than as a teacher of:	Reading	.039*
	I see myself as a teacher of **engineering** than as a teacher of:	Children	.000*
		Exceptional children	.035*
		Reading	.000*
		Mathematics	.000*
		Science	.000*
	Others see me as a teacher of **engineering** than as a teacher of:	Children	.000*
		Exceptional children	.001*
		Reading	.003*
		Mathematics	.001*
		Social Studies	.028*
		Science	.004*

Note: N ranged from 27 to 35 (of 36 total possible survey participants). Significance based on Wilcoxon Matched Pairs Signed rank test (= $p<0.05$). Significance values greater than 0.05 not shown here.*

For most teaching roles, enrichment teachers and classroom teachers responded similarly with regard their levels of agreement regarding how they see themselves (or how others see them). However, an MWW test revealed that H_{05} (i.e., there is no difference between enrichment

and classroom teacher perceptions of identity) was rejected for four items (Table 5). Not surprisingly, enrichment teachers perceived of themselves more strongly as teachers of exceptional children than did classroom teachers. Note that the term "exceptional children" refers not only to those with learning disabilities, but also those who are considered "gifted and talented", a group of focus for enrichment teachers. Further, classroom teachers, when compared to enrichment teachers, more strongly agreed that others see them as teachers of reading, social studies, and science (three of four main curricular areas). This may not be a particularly meaningful result, but suggests either that: teachers and administrators in the school system typically see enrichment teachers as individuals who support primarily tested areas (e.g., mathematics and literacy, including reading, but not science or social studies); or that "others" may not fully realize the range of subjects that enrichment teachers support.

Table 5. Significant differences regarding how enrichment teachers and classroom teacher see themselves (or how others see them) in various teaching roles.

Item	**Enrichment Teachers**		**Classroom Teachers**		**Enrichment vs. Classroom Sig**
	N	Median	N	Median	
I see **myself** as a teacher of **exceptional children**.	8	6	27	5	.021*
Others see me as a teacher of **reading**.	8	5	27	6	.029*
Others see me as a teacher of **social studies**.	8	5	27	6	.000*
Others see me as a teacher of **science**.	8	5	27	6	.001*

Note: Significance based on MWW test (= $p<0.05$). Significance values greater than 0.05 not shown here.*

On post-teaching surveys, participants were asked to re-evaluate their perspectives regarding how they saw themselves or others saw them as teachers of science and engineering—foci of the STE unit that they taught. (They were not asked again about their roles as teachers of children, exceptional children, reading, mathematics, or social studies.) There were no significant differences between enrichment and classroom teachers for these items, supporting H_{04}.

The post-teaching survey revealed that participants agreed that they saw themselves and others saw them as teachers of science and engineering. As shown in Table 6, participants agreed more strongly that they viewed themselves as teachers of engineering as compared to how they suspected others would view them, rejecting H_{01}. This was consistent with participants' views on the pre-teaching survey. Also consistent with the pre-teaching findings was that participants agreed more strongly that others viewed them as teachers of science than as teachers of engineering (sig = 0.034), rejecting H_{03}. However, H_{02} (i.e., that participants viewed themselves similarly across teaching roles) was supported for post-teaching views on participants' roles as teachers of science and engineering.

Table 6. Post-teaching survey results for participants' perceptions of how they see themselves and how others see them as teachers of science and engineering..

Item	N	Median	% Strongly Agree (6)	% Agree (5)	% Disagree (2)	% Strongly Disagree (1)	Self vs. Other Sig
I see **myself** as a teacher of **science**.	33	5	42%	**58%**	0%	0%	.157
Others see me as a teacher of **science**.	28	5	36%	**61%**	4%	0%	
I see **myself** as a teacher of **engineering**.	31	5	32%	**68%**	0%	0%	.038*
Others see me as a teacher of **engineering.**	24	5	13%	**79%**	8%	0%	

Note: N = number of teachers responding to the question out of 36 total teachers. Scale: 6=strongly agree, 5=agree, 4=slightly agree, 3=slightly disagree, 2=disagree, 1=strongly disagree. Highest percentages for each item have been bolded. No teachers slightly agreed or slightly disagreed. Significance based on Wilcoxon Matched Pairs Signed rank test (= p<0.05).*

The only significant difference between the pre-teaching and post-teaching surveys regarding teacher roles was that the participants' views of themselves as science teachers dropped slightly in the post-teaching surveys (Table 7), rejecting H_{05}. This may be due to some time for science being replaced by time to teach engineering, when comparing the "old" science-only unit with the "new" STE unit, outlined in Table 1.

Table 7. Pre-teaching versus post-teaching survey results for participants' perceptions of how they see themselves and how others see them as teachers of science and engineering.

Item	Pre-Teaching Survey		Post-Teaching Survey		Pre vs. Post Sig
	N	Median	N	Median	
I see **myself** as a teacher of **science**.	35	6	33	5	.012*
***Others** see me as a teacher of **science**.*	*35*	*6*	*28*	*5*	.343
I see **myself** as a teacher of **engineering**.	31	5	31	5	.782
Others** see me as a teacher of **engineering.	*27*	*5*	*24*	*5*	.163

Note: N = number of teachers responding to the question out of 36 total teachers. Scale: 6=strongly agree, 5=agree, 4=slightly agree, 3=slightly disagree, 2=disagree, 1=strongly disagree. Significance based on Wilcoxon Matched Pairs Signed rank test (= p<0.05).*

Sense Making about Teacher-of-Engineering Identity

Post-teaching interviews revealed some reasons why most participants tended to see themselves—or perceive that others see them—as teachers of science or other subjects more so than as teachers of engineering. In particular, one or more participants provided the following reasons:

1. Teaching engineering is new to elementary teachers.

2. There is a lack of understanding among 'others' about what teaching engineering at the elementary level looks like.
3. There is a general perception (in the public and by some elementary teachers themselves) that elementary teachers are generalists, not specialists (i.e., in engineering or any other specific subject).
4. Engineering is perceived as difficult and complex, as opposed to elementary subjects, which are perceived as simple and basic.
5. Some teachers already do not identify strongly as teachers of science, and thus are unlikely to identify strongly as teachers of engineering.
6. There is limited time in the elementary teaching day designated for teaching science, and even less time to teach engineering

Each of these will be described, in turn, in this section. This will be followed by a discussion of a counterpoint: i.e., that some participants felt more strongly that they were (and others saw them as) teachers of engineering as opposed to other subject areas.

Reason 1 - Teaching Engineering is New. For many of the participants (33% of those interviewed), despite having taught an STE unit that included teaching engineering via the SySTEmic Project, teaching engineering was still a new endeavor relative to teaching other subjects. This newness resulted in an identity of "teacher of engineering" that did not yet feel complete. For example, Linda shared that she only slightly agreed that she saw herself and others saw her as a teacher of engineering because: "I've been teaching language arts for 25 years, [and have] been teaching engineering for one. So once I think I have another year or two under my belt, I would say … strongly agree." Karen offered a similar sentiment:

> I think if I were to teach it again, I would see myself as a teacher of engineering, but I was kind of just testing the waters and feeling it out this year. So I don't think that other people would say, "she teaches engineering." I think they would say, "she's trying – [she's] piloting the new program." (Interviewee: Karen)

Engineering was still such a new subject for Becky that in the post-teaching survey she, like Linda and Karen, slightly agreed that she was a teacher of engineering. When asked to elaborate on this choice, she shared:

> I'd never really thought of engineering [pause] as what I teach. But with this unit, I could see the connection between math and science and all that kind of stuff. And I think now that I taught [the unit] that I can se myself as a person that is now teaching engineering, because now I know those things … (Interviewee: Becky)

Here, although Becky acknowledges the newness of teaching engineering, she also acknowledges the way in which her new knowledge and experience is moving her identity as teacher of engineering towards firmer ground.

Reason 2 – What does Elementary Engineering Teaching Look Like? Some participants (14%) suggested in interviews that they were uncertain or doubtful that others understood what engineering at the elementary level looks like. Sharon wondered, "I don't know where people would stand in their understanding of what engineering is," particularly given "how we [she and her colleagues] came in new to the staff development." The following exchange between the

interviewer/author further elucidates the idea that others are unlikely to view elementary teachers as teachers of engineering:

> Becky: I do not really think that anybody else thinks, 'Oh so you are teaching engineering stuff now,' you know. I think it is new to curriculum, really … and … I don't think that they would label it as engineering. They would say more science or math or the two, at least at the elementary level.
>
> Interviewer/Author: Do you think that people would think of an elementary school teacher and … think of the subjects they teach and include engineering?
>
> Becky: See I don't think so yet. I think that with more of this kind of stuff, I think that it would be. I don't think they automatically think that's what is going on.
>
> Interviewer/Author: Right.
>
> Becky: I think more like earth science kind of stuff for plants and animals and that kind of thing.

Becky suggests here that more curricula like that used in the SySTEmic Project may change public perception of elementary teacher roles, albeit perhaps slowly.

Reason 3 - Elementary Teachers are Generalists. Some participants (10%) suggested that others perceived of elementary teachers more so as generalists or those who teach the basics. Heather explained:

> Interviewer/Author: [Referring to post-teaching survey] You rated that you see yourself as a teacher of science and of engineering [with] 'very strongly agree' and … you put for … the way [others] see you – you said 'agree'. … Can you explain generally why you would have a difference there?
>
> Heather: I think in elementary schools you have to be an expert in all areas, so it's not like someone is look[ing] at me [saying] … science isn't one of my [strengths]. I don't have a huge background in science, from college or graduate school or anything like that, so I don't think people would see me as a science guru.
>
> Interviewer/Author: Right.
>
> Heather: But more of a generalist – that I am a science teacher, I am a math teacher, I am a writing teacher, I am a reading teacher. I am a character teacher.

Similarly, Ellen shared that both she and others have viewed elementary teachers as covering "the basic, core subjects, as opposed to specialties." She went on to say: "If I said, 'Would you look at me as an algebra teacher?' – I would think they [a general person] would say, 'no.'" Prior to sharing this, Ellen offered about others not seeing her as a teacher of engineering: "I didn't know what an engineering teacher was before I started this process, so I think anyone has not gone through this training [wouldn't]."

Reason 4 – Engineering is Difficult and Complex. Both Linda and Melanie, representing 10% of interviewed participants, suggested that they did not identify with the complexity and difficulty of professional engineering. Linda, offered that – beyond the newness of teaching engineering - she didn't fully see herself, nor did she think others would see her, as a "teacher of engineering" because she approached engineering at a basic level:

> And this is basic engineering and you know [others might think that] she [Linda] knows about engineering well basics - and I know the engineering design process – but believe me I could not construct a bridge. People perceive things differently I guess so I understand more about what engineering is. (Interviewee: Linda)

Similarly, Melanie explained while engineering, like science, could be taught in an elementary way, she still could not see herself – nor did she suspect others would see her – as a teacher of engineering:

> I think engineering is so complex and I don't see myself as a complex person. [When] I think of elementary science – [of] me teaching science – I feel like I am teaching complex concepts, but we're doing it in more of a simple way. And still even though engineering [pause] you know, the engineer[ing] units are very elementary in how they teach them and I love that, I still don't see myself, you know, really seeing myself being that confident of an engineering teacher. So I think it's just because engineering to me just seems so complex, even though I understand that it can be simple and you can make things simple so that people can understand that, I still think that the whole society views it as a complex topic. And I don't think that I could go, you know go teach it at a higher level, so that's my understanding, that's my thinking. (Interviewee: Melanie)

Melanie's way of thinking about engineering as being complex is in direct conflict with how she sees herself – as someone whose profession typically engages her in what is, both literally and figuratively, elementary.

Reason 5 – Weak Science Identity / Weak Engineering Identity. Some interviewed participants (10%) provided a reminder that for many elementary teachers, science – closely associated with engineering in the STE units – is not a preferred subject, helping to explain lukewarm agreement about being seen as teachers of science or teachers of engineering. For example, when asked in the interview to elaborate on her survey responses, Angela shared that she interpreted all of the survey questions to relate to science teaching even though some explicitly asked about engineering. After this, she asked and answered, "Is science my best subject? No." Sharon offered a similar sentiment, that science is "not necessarily what I would say my greatest strength is as far as teaching."

Julie, who articulated her own preferences for particular subjects (e.g., preferring science to social studies, for example) in her interview, shared the astute observation that elementary teachers, most of whom must be generalists, "know their strengths and their weaknesses and they play up to them or they compensate for them." Overall, the participants in the study – most of whom readily volunteered to participate in the SySTEmic Project pilot year – were fans of science, with 33% of interviewees sharing explicitly that science (or science together with math) was their favorite subject compared to all others, perhaps making them more receptive to the related idea that they could develop identities as teachers of engineering.

Reason 6 – Other Teachers do not Know What I'm Teaching. One participant (5%) explained that the sometimes-insulated environment of the classroom may prevent others from coming to see her as a teacher of science or engineering. This is evident in the following interview exchange that took place after the interviewer/author reviewed survey responses in

which Jean shared that she 'strongly agreed' that she saw herself as a teacher of science and engineering:

> Interviewer/Author: … but you were undecided [i.e., selected slightly agree or slightly disagree] about how others might see you. Is that largely because you don't know what other people are thinking?
>
> Jean: I can't remember why I thought that at the time [pause]. Oh I think I was thinking more about … not everybody in the school really knows what the unit was, so they might not know what I am doing in here and so maybe they wouldn't think of me as that. But I did I ask our principal and assistant principal [to come to my classroom], because I thought it was cool, but nobody stopped in. I don't think anybody would think I can't do it [i.e., teach science or engineering] … but I don't know if they would say to you [that] I am a great science teacher, because I don't think they know what goes on in here. We never get to watch each other.

Constraints like a lack of time or interest (e.g., on the part of some administrators), or a problem with logistically allowing teachers to observe one another, is at work here in Jean's school. An unfortunate result is that the piloted, 'tried on' roles (e.g., as teachers of engineering) of some teachers at her school are isolated from those who did not sign on to the pilot. Those other teachers – and other administrators – then, do not reap the benefits of considering the expanding identities that elementary teachers may try on and take.[vii]

Reason 7 – There is No Time to Teach Science and Engineering. Only one participant (5%) explicitly connected her reason for agreeing less strongly that she and others saw her as a teacher of engineering to instructional time. Heather offered in her interview, "I probably would feel stronger [about identifying] as a math or reader teacher just because there's more time dedicated to it and more training …" Although only one participant shared this lack of time for science/engineering as a reason, many others mentioned the limited actual instructional minutes that science (and thus the STE integrated instruction) takes with respect to reading, Integrated Language Arts, and mathematics. As Susan described about science, "[Time for] science is coming back up … [but] for a number of years, if you don't get to it, you don't get to it, don't worry about it." The rhetorical question becomes: How can elementary teachers forge identities as teachers of science or teachers of engineering if they rarely teach these subjects?

Counterpoints. It is interesting to note two counterpoints; in other words, two participants (10%) who shared in interviews that they see themselves more so as teachers of engineering than as teachers of other subjects. Thus, they did not share any of the above reasons for thinking otherwise. Both of these individuals are enrichment teachers, who have worked for many years as leaders of after-school clubs that include engineering-like activities. Paula explained how others, including teachers in her building, parents and volunteers, see her "as the engineer":

> Interviewer/Author: You are the only [participant] that rated yourself higher [on the post-teaching survey] in terms of how you see yourself and how others see you in engineering as opposed to science.
>
> Paula: I think that has been because I have been doing engineering challenges for eight years and because I have worked with / several engineers who have come in as dads or volunteers who have raised my comfort level. People in the building view me as the

> engineer, because Paula does engineering with the kids every year so she already knows what engineering is and not understanding is such a broad subject. I don't know everything, but that's how they see me as having a lot more experience with engineering.

Although Nancy did not rate her own and others' views of herself as a teacher of engineering higher than that of science (all ratings for these measures were 'agree'), she described herself as being more strongly in the realm of engineering than in science. She attributed that to her decades-long participation in Destination Imagination in which "it's just always made sense that the kids are excited about what they are doing, they are thinking, they are making decisions [about] … engineering, and learning."

Competence & Career Goals

In addition to assessing participants' identification with aforementioned teaching roles, pre-teaching surveys included four questions, three of which were replicated in post-teaching surveys, which aimed to assess participants' perceptions of their competence to teach engineering and their perception that their participation in the SySTEmic Project might contribute to their career goals (Table 8). There were no significant differences between enrichment teacher and classroom teacher responses to these items on either pre-teaching or post-teaching surveys, supporting H_{04}.

On the pre-teaching survey, participants overwhelmingly agreed that their participation in the SySTEmic Project helped them to develop competence in an area in which they were not previously trained and in an area unique among other elementary teachers. Despite these positive conceptions of their own competence, the participants disagreed that the public-at-large viewed them as competent to teach engineering to children. The difference in participants' perception of their own competence versus what they perceived the public's perception of their competence was significant (sig = .000 when comparing either of the first two items in Table 8 regarding teacher's self perception to the third item regarding public perception, rejecting H_{01}.)

Further, teachers expressed a mixture of agreement – ranging from 'slightly disagree' to 'strongly agree', with most responses (63%) being 'strongly agree or agree' – regarding whether their participation on the SySTEmic Project would contribute to their resume' and career goals. After teaching on post-teaching surveys, participants were asked to re-evaluate three of four items in Table 8 (i.e., all but the item regarding public perception). There was no significant difference between participants' responses to items regarding competence on pre-teaching as compared to post-teaching surveys; however, participants were more positive that participation in the SySTEmic Project would support their professional goals, rejecting H_{05}.

Although no interview protocol questions attempted to explicitly elicit questions about competence, interview data from one participant provided some insight that articulated this notion that the public is unlikely to see elementary teachers as being competent teachers of engineering. The exchange, below, followed an interview excerpt in which Melanie, perhaps questioning her own competence as a teacher of engineering, suggested that engineering was complex, and she did not see herself as a complex person (the quote was shared in full the previous section.)

> Interviewer/Author: … So … is there a difference between how society views elementary teachers and how society views engineers? … I mean I don't want to put words in your mouth.

Melanie: Yeah, I think if you were to ask people if you thought elementary teachers were capable of being an engineer or thinking like an engineer, I think most people would say no, just because you know when a lot of people think of engineer - even I did prior having been exposed to this unit - it just seems like it's so technical and it's almost like you have to be like a scientist and actually have to go to school to be in that sort of thinking. And after teaching the unit, it's really easy to see that anybody can be an engineer and anybody can use that design process to solve a problem, but I think society's not educated that way. So they don't view engineers in that light.

Interviewer/Author: Like you said, they [engineers] either are seen as being complex whereas the elementary stuff is more simplified in a way?

Melanie: Mmm hmm [yes].

Based on this and the aforementioned other excerpt from Melanie, she seems to oscillate between feeling like a competent teacher of engineering (at the elementary level), and wondering – with other people – if this is truly the case.

Table 8. Teachers' reported perceptions competence and career goals before and after teaching.

Item	Pre or Post-Teaching	N	Median	% Strongly Agree (6) or Agree (5)	% Slightly Agree (4) or Slightly Disagree (3)	% Disagree (2) or Strongly Disagree (1)	Pre vs. Post Sig
I see myself as developing competence in a subject (engineering) for which (prior to the project) I was not trained.	Pre	35	5	**86%**	11%	3%	.310
	Post	34	5	**91%**	9%	0%	
I see myself as developing competence in a subject (engineering) that most other elementary teachers do not have.	Pre	35	5	**91%**	9%	0%	.819
	Post	34	5	**88%**	12%	0%	
Most members of the public view elementary teachers as being competent educators on the subject of engineering.	Pre Only (no post)	35	2	9%	37%	**54%**	N/A
I see my participation in the project as contributing to my resume and career goals.	Pre	35	5	**63%**	29%	9%	.003*
	Post	34	5	**79%**	21%	0%	

Note: Highest percentages for each item have been bolded. Significance based on Wilcoxon Matched Pairs Signed rank test (= $p<0.05$)*

Alternatively, two participants – Nancy, in a pre-pilot interview (see methodology section), and Donna, in the post-teaching interview – shared that perhaps they could have been engineers instead of teachers. Nancy shared that she grew up in a time when girls played with stereotypically 'girl things', and boys played with stereotypically 'boy things' (e.g., erector sets). Despite being more intrigued with the boy things, she was not encouraged to go into a field like

engineering which especially then and even now (in most fields) is predominantly male. Donna shared that she wished someone had told her about engineering in high school, was certainly not encouraged to consider such a profession, and reflected on her late-career encounter with the topic:

> Donna: I was fascinated personally. I was like, I would have loved to have done this …
>
> Interviewer/Author: To be an engineer kind of a thing?
>
> Donna: Yeah …

Both Nancy and Donna's perspectives and experiences suggests that they both see themselves as individuals who were quite capable of becoming engineers – and thus competent as teachers of engineering - if only the expectations about gender roles or awareness of this career possibility had been different.

Describing Engineering & Elementary Teaching Professions

As mentioned above, Nancy and Donna, both successful elementary teachers, suggested that they would have liked to have been engineers. This next portion of the study examines participants' perspectives on these two professions. On the pre-teaching (post-PD) survey, participants were asked to respond to the following two questions, each in a separate open-response text box:

1. What kinds of words come to mind when you think of the engineering profession?
2. What kinds of words come to mind when you think of the elementary teaching profession?

Participants collectively described the engineering profession using 160 words and short phrases; they used 179 to describe their own profession, elementary teaching. Many of these words or phrases (e.g., "creative" or "intelligent") were used by multiple participants. One participant, for example, described engineers as "intelligent, patient, innovative," and elementary teaching as "rewarding, time consuming, can shape lives and education, Jack of all Trades." Another used the words "science, creative, intelligent, hands-on, problem solvers" when describing the engineering profession, and used "understanding, well-planned, and flexible" to describe elementary teachers.

Analysis of participants' descriptions of engineering and teaching involved: 1) qualitative coding of all participants' words and phrases into categories (e.g., the words "creative", "create" and "creativity" were all grouped into the category, "creative"); and 2) quantitative assessment of the frequency of each category for each profession. Categories were defined as descriptors in which two or more participants contributed words or phrases captured by that category. A total of 19 categories were generated as descriptors for the engineering profession, with 12 additional unique descriptors contributed by one participant each, and 5 words contributed by six participants that had unclear meaning (e.g., "ideas"). For elementary teaching, 32 categories were generated, with 7 descriptors by one participant each, and 17 words/phrases with unclear meaning (e.g., "diverse").

Table 9 provides the results of this analysis for categories in which over 11% (N = 4) of participants offered words/phrases that fell into the same category to describe one or both of the professions. The use of 11% here was relatively arbitrary, and intended to help focus on major

categorical descriptions and reduce the bulk of data shared here. Two categories – "creative" and "smart" –were used frequently to describe both professions. The strongest commonality, also apparent in Figures 1 and 2, was the idea that both engineers (described by 31% of participants) and elementary teachers (31%) are creative. Interestingly, words captured in the "smart" category for elementary teachers seemed to be more tempered (i.e., "knowledgeable", "competent", "educated") than those used to describe engineers (i.e., "intelligent," "smart", "brains", and "educated").

Table 9 also reveals ways in which participants considered the professions to be different. Engineers—much more so or exclusively when compared to elementary teachers—were described as innovators (37%) who: draw from and are good at science and mathematics (37%), are problem solvers (31%), engage in hands-on activity (29%), employ experimental procedures and trial and error (26%), design (23%), modify and improve things (17%), and think critically (14%). Elementary teachers—much more so or exclusively when compared to engineers—were described as: generalists (e.g., "Jack of All Trades") (34%) who are caring (31%), flexible (20%), patient (17%), engaged in challenging work (17%) that benefits society (17%), passionate and dedicated (14%), organized (14%), and, not surprisingly, child-centered (14%).

After describing engineers and elementary teachers, participants were asked if they "see any potential areas of conflict or concern regarding teaching engineering" given how they described the two professions. Over two-thirds (71%) responded with "no"; one adding, "I think both incorporate the same thoughts and strategies." Thus, somewhat less than one-third of participants responded with some degree of concern. Although one participants' contribution was unclear in its meaning, some (20%) expressed concerns regarding how to fit engineering into the elementary school day or – more to the point of the question – how the differences in the professions may emerge as conflicts when teaching engineering in elementary school.

Two participants (6%) expressed concern over time to teach engineering in the elementary school day. Related to this were two additional participants' (6%) sentiments that because they must teach multiple subjects (i.e., are generalists, as described in Table 1), focusing on teaching engineering may prove to be difficult. One shared:

> Not a conflict, but I feel as though a teacher could do a better job if [s/he] could concentrate on one subject like in middle school so one can become an expert rather attempting to be an expert at everything.

These concerns about time and the ability to focus on teaching engineering—expressed by a total of four participants (11%)—were less about conflicts in approaches to these professions, and more so about how to fit engineering into the elementary teacher's school day, replete with multiple demands on attention and time.

Shifting this idea of teachers' focus on engineering towards a comparison of the two professions, another participant offered: "I think teachers see the big picture more than engineers, and teachers have to move on and do the best they can with what they are given." This participant described engineers, among other descriptors, as "driven" and "focused on a single subject" and teachers as "flexible" and "knowledgeable on many subjects." Teachers, the participant suggests above, may not be able to focus as intensively as engineers while teaching

engineering. Further, the participant suggests, the constraints under which teachers work may be less ideal than those under which engineers work.

Table 9. Participant descriptors of engineers and elementary school teachers (as suggested by >11% of participants to describe engineers, teachers, or both). (N=35)

Category	% participants who used this descriptor for **engineers**	**Descriptor**	% participants who used this descriptor for **elementary teachers**
More than 11% (>N=4) of participants described **both** teachers and engineers as …	31%	Creative.	31%
	37%	Smart.	17%
More than 11% of participants described **engineers** as …	37%	Innovative.	9%
	37%	Good at science and mathematics or using/teaching these subjects.	6%
	31%	Problem solvers.	6%
	29%	Engaged in hands-on activity.	11%
	26%	Engaged in experiment or trial and error.	6%
	23%	Engaged in design or product development.	0%
	17%	Engaged in processes of change, modification or improvement.	6%
	14%	Critical thinkers.	6%
More than 11% of participants described **elementary teachers** as …	0%*	Generalists (i.e., skilled in multiple subject areas).	34%
	3%	Caring.	31%
	0%	Flexible.	20%
	3%	Patient.	17%
	9%	Engaged in challenging work.	17%
	3%	Engaged in work that benefits society.	17%
	0%**	Passionate and dedicated.	14%
	6%	Organized.	14%
	6%	Child-centered.	14%

* However, 6% described engineers as specialists.

** However, 8% described engineers as motivated, driven, or inquisitive.

Three other responses (9%) more pointedly attend to differences across the professions. These comments reflect differences with respect to gender, competence, and failure. Perhaps difficult to interpret, one participant's entire response was "stereotypes". This participant was one of two who described each profession according to gender (i.e., s/he used "men" to describe engineers and "women" to describe teachers). It is likely that the stereotypes to which she referred were those regarding the conflict wherein largely female elementary teachers are teaching a predominantly "male" subject, engineering. Another participant suggested the following regarding the public perception of elementary teachers' competence to teach engineering: "The public, and perhaps many teachers, do not see competence in elementary teachers teaching engineering to students." Yet another attended to a critical aspect of engineering—failure, and the learning that comes with it—that is something elementary teachers are often disposed to avoid:

> Sometimes it's hard for teachers to take a back seat and be the "guide on the side" when it comes to teaching elementary children. It will be hard not to make suggestions that would let all children be 100% successful. "Failure" is an option and sometimes is the best learning experience.

As this participant suggests, allowing children to fail and learn from their mistakes is an important part of teaching engineering.[viii] However, the images of the elementary teacher conjured by the descriptors in Table 1 (e.g., caring, passionate, flexible, patient) may be difficult to merge with one-who-lets-children-fail (albeit for their own good).

Participants were also asked if, based upon the ways they described the two professions, they anticipated seeing any "potential areas of resonance or 'good fit' regarding teaching engineering." Nearly all participants who responded to this question responded "yes" (94% of all participants), with one participant simply responding "no" (with no further explanation) and another leaving the response blank. Although 23% of participants responded yes without elaborating further, 74% offered elaboration of their affirmative responses. Those responses were coded and into four groups:

1. engineers and elementary teachers have common or complementary descriptors;
2. elementary teachers, as generalists, can and do teach anything and everything;
3. teaching engineering is good for students; and
4. teaching engineering fits well within the current curriculum.

Some responses were coded in two groups. Three responses (9%) were unclear and not coded.

The first two of the four groups were most tightly associated with participants' perceptions of their own and the engineering profession. Those 37% of participants who shared common descriptors of engineering and teaching collectively offered that both teachers and engineers are: creative, problem solvers, engage in hands-on activity, are innovative, build, design, think outside of the box, do challenging work, are flexible, experiment, use technology, and draw from bodies of knowledge to do their work. A sample response by a participant was: "… like engineers teachers often have to be innovative, problem solvers that think outside the box." Another participant did not offer common descriptors (as was the case for all other

responses coded in this group), but shared a general observation that "the words used to describe each [profession] complement each other."

Teaching engineering at the elementary level was seen as a good fit by some participants because elementary teachers are generalists (11%) One participant expressed: "Elementary teachers are 'Jacks of all trades', able to teach any subject with competence and confidence." Others shared that teachers "can do anything" and "are patient and willing to learn."

Some participants (17%) focused on the idea that teaching engineering would bring unique and important learning experiences to their students, and on the good fit of the subject of engineering into the existing curriculum (11%). Engineering, participants offered: would be fun and enjoyable for students; engage students in hands-on activity; enable them to create their own technologies, "rather than using technologies others created"; help them "think outside of the box", think differently, and problem-solve; and help students "view materials engineering in a whole different light". Further, as one participant offered, teaching engineering "meshes well with math and science already taught."

Finally on the pre-teaching survey, teachers were asked: "How do you anticipate teaching this unit will influence the way you think about yourself as a teacher?" Most (94%) of the participants responded by sharing an anticipated change; the remainder anticipated no change (3%), was unsure (3%), or provided a response that was difficult to interpret (3%). Table 10 summarizes the ways in which participants anticipated changing, grouped into categories.

Table 10. Participant responses to the question, "How do you anticipate teaching this unit will influence the way you think about yourself as a teacher?" (N=35).

Categories of Anticipated Change		% Participants	Example quotes
Benefits to Self	Becoming more knowledgeable about engineering	31%	"Competent to think outside the box, to generate new ideas and ways of thinking, overall better understanding of the world around me."
	Building confidence	14%	"It will enhance my thinking about myself, giving me additional confidence to teach many subjects and skills."
	Doing something new	11%	"Open to try new things."
	Developing skills in co-teaching and collaboration	11%	"Work on art of collaboration."
	Learning a new (engineering) pedagogy	6%	"I think that it will force me to teach something differently than the other units are taught."
	Broadening as a generalist	6%	"More well rounded and diverse!"
	Developing as a professional	6%	"It will help me see myself as more professional."
Benefits to Students	Exposing students to thinking and learning inherent in engineering	26%	"I think that it will help me to help my students become better problem solvers."
	Exposing students to the profession of engineering	11%	"Open children's eyes to becoming engineers."

The most frequent responses, as summarized in Table 10, were that participants would learn more about engineering (a benefit to themselves as teachers) (31%), be able to expose students to engineering (a benefit to students) (26%), and gain confidence as teachers (a benefit to themselves as teachers) (14%).

Frequency of Social Interaction

Pre- and post-teaching surveys inquired about the frequency with which participants reported engaging in behaviors that reflect social engagement and networking (i.e., within communities of practice) consistent with identity development. It is important to note that while these questions represent participants' reflections on social interactions, all of the participants had engaged in social interaction with other teachers as they received nine hours of professional development for the unit, and then co-taught – to greater or lesser degrees – parts of the unit with another teacher.

Prior to and after teaching, most participants reported that they often or sometimes communicated with other teachers within the project or helped other teachers understand aspects of the unit (Table 11). There was a significant difference (Pre-teaching sig = .002; post-teaching sig =.004) between participants' reported frequency in which they communicated about the unit (median = 4) and the degree to which they did so to help others understand the unit (median =3). Participants reported discussing the project beyond the walls of the school significantly less frequently than either of the other two measures in Table 7 (Pre-teaching sig = .000 and .011, respectively; post-teaching sig = .000 and .021, respectively).

Table 11. Participants' reported frequency of behaviors that reflect social engagement and networking consistent with identity development before and after teaching.

Item	Pre or Post-Teaching	N	Median	% Always (5)	% Often (4)	% Sometimes (3)	% Rarely (2)	% Never (1)	Pre vs. Post Sig
I communicate with other teachers (including co-teachers) about aspects of the unit.	Pre	35	4	9%	**51%**	34%	0%	6%	.452
	Post	34	4	6%	**62%**	32%	0%	0%	
I help other teachers understand aspects of the unit.	Pre	35	3	3%	34%	**49%**	3%	11%	.475
	Post	34	3	0%	**44%**	38%	18%	0%	
The unit has become a part of my everyday conversation with others outside of the school community about the work that I do.	Pre	35	3	3%	6%	**54%**	26%	11%	.263
	Post	34	3	12%	**32%**	**32%**	18%	6%	

Note: Highest percentages for each item have been bolded. Significance based on Wilcoxon Matched Pairs Signed rank test (= p<0.05).*

Teaching Engineering: Similar to or Different from any other New Curriculum?

In the post-teaching interviews, participants were asked the following question: "Was teaching engineering different than teaching any other new curriculum?" Perhaps the most interesting finding that is relevant to identity here is that no participant responded that teaching engineering was radically different from teaching other subjects, adding further reinforcement to the idea that elementary teachers are quite amenable to teaching different subjects (i.e., are generalists), including engineering. Many interview participants (43%) explicitly included language that teaching engineering was 'very similar' to teaching any new concept, but with one or a few exceptions. Becky offered a typical response:

> Interviewer/Author: How was teaching engineering different than or similar to teaching any other new concept or skill?
>
> Becky: I think it was similar, I mean, I had to do a little bit more research on the background part of the unit … just so I kind of know the force energy all that kind of stuff … So it was enjoyable for me, because I got to learn new stuff, too, and in doing so, I could help my kids understand it better, I think it's pretty similar to teaching any new unit, concept, whatever.
>
> Interviewer/Author: There wasn't anything particularly scary or weird about teaching engineering?
>
> Becky: No, not really.

A total of 43% of interview participants, including Becky, expressed that teaching engineering was different in that it was a new content area with new vocabulary and new concepts (e.g., the engineering design process. Unlike a new reading curriculum, where the pedagogy may be different but the content is familiar, the content (e.g., the engineering design process) and unit was new.

Also related to identity formation as teachers of engineers, another response to this question (i.e., of how teaching engineering was different than teaching other new curriculum) had to do with the institutional resources put forth by leaders of the SySTEmic Project to support those teachers. Nearly one third (29% of participants) shared that teaching engineering was different because they received intensive PD prior to teaching it, they had access to high-quality curriculum (EiE lessons as well as integrated science lessons), were able to share ideas with other teachers as part of post-teaching meetings to improve the STE units, had co-teachers or were in schools where other teachers were teaching the same unit. Two quotes exemplify these ideas:

> But with this unit and with the extensive training that I had, and with the resources that were available to me, and the lessons that were so nicely written for me, I felt like I am a teacher of science, I can teach engineering. I can do this, because I have the resource. It was the support that was there. … I had never taught engineering per say before, because it wasn't in my curriculum … So I guess that is why I feel as an elementary school teacher I am more of a generalist - kind of a little bit of knowledge in all areas - but through this unit I gained more knowledge in / engineering. (Interviewee: Heather)

> A really important part is that somebody like you who has the knowledge, but also the ability to bring it down to our level so that we don't feel intimidated [is giving us professional development]. I mean there are so many people who having knowledge but can't bring it down to your level. So that part is important that you made us feel like we could do it. I didn't feel intimidated by it this is not something I can do. I stayed away from that whiteboard [smart board] thing because I felt intimidated by it and she [another professional developer] had me down there for an hour and a half [saying] "this is so cool" but I don't think I could put it together. (Interviewee: Donna)

Perhaps these institutional factors helped to contribute to the overall aforementioned agreement (median = 5) that after professional development (before teaching) and after teaching, participants – most of whom had never taught engineering before – largely saw themselves as teachers of engineering. In addition, other responses to the question, "Was teaching engineering different than teaching any other new curriculum?", reflected positive ways in which the engineering curriculum was different to the benefit of students, e.g.,: the STE units were more engaging (29%), encouraged students to use critical thinking and problem solving (24%), and connected to real life (5%). Only two participants suggested challenges beyond concerns with the newness of the content. These had to do with the time teachers needed to prepare for engineering as compared to other instruction (10%).

Discussion & Conclusion

This study has used multiple means to attempt elucidate participants' sense making about the formation of teacher of engineering identity, and how this developing identity is in concert or conflict with preexisting identities. This is a challenging task for a topic – identity – that can be difficult to ascertain. However, the following major conclusions from this study can be made:

1. When teachers are learning to teach engineering, attention must be paid to development of their 'teacher of engineering' identities.
2. Proper institutional support is fertile ground for teachers to develop teacher-of-engineering identities.
3. Elementary teachers' existing identities as generalists may be both helpful and challenging with regard to forming a teacher of engineering identity.
4. For others to perceive of elementary teachers as teachers of engineering, the engineering education community has marketing work to do.

A description of each of these conclusions, as well as their implications, follows.

Attending to Identity Development. The first assertion was one that began outside of this study, through Brickhouse's claim that learning and identity are bound.[2] Those who are interested in engaging elementary children in high quality engineering education must not only provide professional development to teachers, write good curriculum, and facilitate access to materials, we must also be concerned with the way in which elementary teachers develop identities as teachers of engineering. As discussed earlier, identity development involves sense making during which personal narratives are re-written as new identities are considered and taken on.[4] Providing teachers with opportunities to discuss the ways in which they do or do not see themselves – or suspect that others see them – as teachers of engineering, perhaps as a part of

the professional development process, is a good place to start. Ideas, for example, about 'simple versus complex' aspects of engineering and teaching professions could be unpacked, enabling a forthright discussion about: 1) the ways in which engineering is indeed complex, 2) whether or not this feature of engineering is important to emphasize in elementary teaching and learning, and 3) the ways in which elementary education is also complex, albeit in different ways. Professional attributes of engineers and elementary teachers (as was explored in the pre-teaching survey) – both stereotypical and otherwise – could be discussed as a part of professional development. Teachers might also explore ways that they could help inform others (e.g., parents, other teachers, administrators) about what elementary engineering instruction, with a specific intention to do so to recast what elementary students can learn and elementary teachers can teach. These others may then begin to see elementary teachers as teachers of engineering as much as they are teachers of mathematics, science, reading, or other subjects.

Proper Institutional Support. Gee referred to I-Identity or institutionalized identity as identity that is imposed by institutions.[26] In the case of the SySTEmic Project, both the school system and project itself imposed institutional identities on the study participants, who willingly accepted these labels by volunteering for the project. By participating in the project, teachers were necessarily teachers of engineering (I-Identity). Although this I-Identity has not been the focus of this paper, the institutional impact on participants is noteworthy. Institutionalized forms of support by the SySTEmic Project and school system have helped participants to see themselves (and suspect that others see them) as teachers of engineering beyond the new, imposed label. Professional development, quality curriculum, and ongoing help from co-teachers and other classroom/enrichment teachers – mentioned specifically by participants as positive ways in which teaching engineering was different from teaching other new curricula - constitute a system of support for participants. This system of support benefits teachers (and, in turn, students), helping to forge new and potentially fragile teacher-of-engineering identities that may only remain institutionalized labels if teachers are not supported and do not feel successful. Further, these support systems include opportunities for teachers to interact with one another, another crucial part of identity formation.[4,9,24]

The Benefit and Challenge of the Generalist Identity. As mentioned by participants across data sets (i.e., from qualitative questions on pre- and post-teaching surveys and throughout interview data), many teachers see themselves as generalists, or 'Jacks of all Trades'. There are two ways that this can be interpreted, one more judicious than the other. In the positive sense, generalists are willing to take on any number of subjects—a sentiment expressed by many participants in interviews who did not see engineering as terribly different from other subjects that they teach. This way of positioning the 'generalist' suggests that elementary teachers may readily take up teaching engineering and adopting teacher-of-engineering identities since they are teachers of all subjects (a slight exaggeration).

The other connotation is negative, but seems to be on the minds of many participants according to both survey and interview data regarding competence, comparisons of engineering and elementary teaching professions, and reflections on participants' lukewarm assessments of their own views and others' suspected views about their identities as teachers of engineering. The rest of the figure of speech, 'Jack of all trades,' is 'master of none', which some participants seem to suggest about themselves (preferring that which is simple, basic or non-specific) and

many more suspect is the feeling of 'others' outside of the classroom. The juxtaposition here of a profession historically rooted in 'the basics' (elementary teaching) versus a profession regarded as being highly specialized and specific (engineering). The related question that has an impact on the formation of teacher-of-engineering identities is: How then can elementary teachers be expected to teach engineering, such a difficult and specialized subject? The same question might be posed about science, mathematics, or history—areas with professional specializations as complex as engineering—yet they have simply been a part of the 'basics' for a longer period of time than has engineering.[ix]

The associated implication here is that for most teachers, their perspectives as generalists actually seem to be helpful when it comes to forging teacher-of-engineering identities. However, those involved in teacher professional development and other aspects of elementary engineering education should know that those who see themselves as 'Jacks of all trades' may also question—or wonder if others question—whether they are capable of teaching this particular trade.

There is Marketing Work to Do. At a soccer game with my son, I encountered a grandparent who was excited and supportive of the new STE units in the school system. She shared an encounter that she had a few weeks earlier with a parent of a child at another school in the system. The parent shared that her child would be learning engineering soon, and wondered aloud why her child should be learning engineering since everything had already been invented. While taken aback by this statement that reflects astounding ignorance, I trust the source. It would be helpful for many reasons for the public to have a better understanding of what engineers do, what it means to engineer, what technologies are, and that—no—we are not 'out of' ideas as a society. Further, and more to the point, given a perspective on identity that goes beyond teachers' self concept to include how others see teachers, more marketing must be done to educate those within and outside of schools that engineering is not only possible, but also worthwhile, engaging, and purposeful at the elementary level.

Finally, it behooves me to mention that with regard to both pre-teaching survey open-ended questions and post-teaching interviews, I expected to read and hear more explicitly about issues of gender. Minimally, I anticipated hearing about engineering as being a profession of largely men, quite different than elementary teaching; only two participants did so. I further wondered if participants would suggest that this fact caused them angst or discomfort; none did. This may be due to a number of factors. One such factor may be that the participants' professional developer who was a former engineer who happened to be female.

What was more prevalent, however, was that many participants used gendered language to describe engineers (e.g., use of action words, more emphasis on how engineers are intelligent) and elementary teachers (e.g., use of words to describe emotions such as care, patience, passion).[14,15,27] Future research may find ways to explore how gendered perceptions about these professions may support or hinder elementary teachers' teacher of engineering identity formation.

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[i] A total of 36 teachers were involved in this year of the SySTEmic Project; however only 35 provided data relevant to this study.

[ii] This goal has been met. As of the spring of 2012, all children in grades 1-5 in the district learn at least one STE unit per year.

[iii] Although 28 classroom teachers (i.e., 3rd and 4th grade teachers) were involved in the SySTEmic Project, 49 classrooms of children were taught an STE unit during the pilot year. Ten classroom teachers taught the STE unit to more than one classroom of students: 8 each taught the unit to 2 classrooms (their own and another teacher's students); one taught the unit to 3 classrooms; and one taught the unit to 4 classrooms.

[iv] Note that no "science specialists" or "STEM specialists" or other similarly titled individuals exist within the school system in which the SySTEmic Project takes place. Such individuals (in other school systems) are science/STEM focused, available to assist teachers with these content areas, yet - like enrichment teachers - are not tied to a particular classroom. Enrichment teachers have many responsibilities outside of the SySTEmic Project (most especially to enhance and extend integrated language arts and mathematics instruction), and these other responsibilities take up the vast majority of these enrichment teachers' time.

[v] Teachers who were involved in the pilot year signed a pledge acknowledging that their grant-funded stipend to participate in the project included not only payment for additional time required for implementation, but also for participation in surveys. (Those who did not complete post-teaching surveys received no negative repercussions as a result.)

[vi] Of a total of 42 variables, only 5 were deemed normal via this test. Nonparametric tests were used throughout for consistency.

[vii] This is likely to be a non-issue in Jean's school now, since all teachers in first through fifth grades in her school should be teaching the complete 'science' curriculum, which includes the STE unit.

[viii] However, it is interesting to note that only one participant used "fail" as a descriptor for engineers.

[ix] That being said, many elementary teachers are not entirely comfortable teaching these subjects, especially science and mathematics, as was mentioned by a few participants and as is well documented in the science and mathematics education literature.