Spanish Night: Attitudinal Analysis From a Short-Term STEM Intervention Targeting the Hispanic/Latino Community

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Background

Over the past two decades, many sources have pointed to the growing divide between the science, technology, engineering, and mathematics (STEM) infrastructure and the corresponding labor force arising from the educational apparatus of the United States (Jackson, 2002; Porter & Stern, 1999; President's Council of Advisors on Science and Technology (PCAST), 2012). Given the ever-increasing technological nature of human society, producing scholars and practitioners of STEM fields is important for geo-political stability, progress, and the environmental health of the planet. Said simply, what was once Jackson's (2002) "quiet crisis" has now become a center stage issue in the American dialogue: schools are doubling down on STEM majors, alternative educational pipelines are cropping up (e.g., App Academy in San Francisco), and national initiatives are working to get more young people excited about programming (e.g., Code.org's "Hour of Code"). Together, these initiatives are working to 'disquiet' and allay the STEM crisis in America – to close the 'million scientist shortfall' mentioned in the 2012 President's Council of Advisors on Science and Technology (PCAST) report.

Nevertheless, more work is needed to understand and solve this complex problem. Indeed, while several efforts have endeavored to understand the causes of this crisis from a global perspective (Seymour & Hewitt, 1997; Seymour, 2006), much remains to be understood at the local level – dealing with particular programs or constituencies. Situating the discussion at the local level is particularly important, for if STEM reform attempts fail to recognize the crucial role of cultural norms and communities of practice, then they will necessarily fall short in leveraging the full arsenal of local resources (financial, sociocultural, institutional, etc.). As Gutstein writes: "respecting and listening to – and learning from – children and adults who make up the school and community are *essential* to help students develop such identities" (2003, p. 40, emphasis added). While he speaks here of social-justice-based identities, the point remains equally valid for identities built around positive views on STEM fields. This issue is particularly important when working to raise STEM enrollment rates of women and minorities. As of 2010, while women comprised roughly 51% of the populace, they held only 19% of engineering jobs; similarly, Hispanics and African Americans were 28% of the population but maintained only 9% of STEM-related positions (National Science Board, 2010). In an effort to reach these underserved populaces, Space and Naval Warfare Systems Center Pacific (SSC Pacific) – a scientific/research arm of the United States Navy – developed a half-day event to introduce Hispanic students and their parents to the world of STEM. This effort, begun in 2012, was labelled Spanish Night, as it was often offered in the evening at partnering middle schools across San Diego county. This paper explores the attitudinal effects of the Spanish Night program on both students and their parents. In doing so, it provides a useful research paradigm for future researchers interested in gauging the efficacy of their efforts at the local level, a theoretical framework for structuring new interventions, and a collection of results offering support for the value of the Spanish Night program.

Theoretical Framework

This study builds on the ideas in Deckard, Quarfoot, and Csanadi (2014) in which the effects of a similar style intervention were explored for middle school girls and their parents. In that paper, three overarching constructs formed the structural backbone of the event, determining both how the event was set up and how it was evaluated: Engineering Awareness, Pathway, and Philosophy (Deckard et al., 2014). In the work below, three similar constructs are employed: STEM Awareness, Pathway, and Philosophy. These categories infused various aspects of the program and are further articulated by the following goals:

STEM Awareness – Greater understanding of the breadth of the STEM landscape (e.g. different types of engineering, various work environments for scientists, etc.); improved appreciation for the type of work STEM professionals do each day; growing knowledge of the widespread and dense innervation of STEM ideas in everyday life

Pathway – Knowledge of educational routes to STEM careers; discussion of explicit and implicit high school coursework requirements vis-à-vis college acceptance; challenges and rewards of STEM careers

Philosophy – Exposure to Hispanic STEM role models at the college and professional level; awareness of diversity-based student organizations; knowledge of race-based representation disparities in STEM fields

Together, these three constructs represent fundamental components of inspiring students to the STEM pipeline. The first is quite general and provides necessary information in learning about the various disciplines available for further exploration. As seen below, middle school students often have quite limited views of what engineering is about ("I thought it would be like taking apart an engine's motor" – student, age 10), and one critical component in finding one's niche is an awareness of the vocational landscape. Pathway and Philosophy were stressed in this intervention because minority students necessarily have less close-to-home modeling of career pathways because their communities have less current representation in these fields. Reversing this trend requires additional efforts to illuminate these pathways as well as efforts that reshape beliefs concerning who should and currently does have access to them. Said simply, students might have an excellent awareness of the STEM landscape and yet no knowledge of how to reach it, or worse yet, the belief that they do not belong or are not welcome in such a space. As a whole, the three constructs form a unified thread: Awareness to shine light on the landscape ahead; Pathway to articulate the route to that future; and Philosophy to inspire students to begin taking those first, sometimes apprehensive, steps.

Description of Spanish Night

While Spanish Night began as a recurring evening event for particular partnering middle schools, in time it came to be offered on weekends and mornings as well. The event was designed to involve both students and their parents (who are at times together and at times apart). While attendance varies based on the partnering school size, time of year, etc., a typical event has 15-30 students, 15-30 parents, 15-20 college students, and 3-7 STEM professionals. A representative timeline for a morning event is sketched below:

<u>Student Program</u>

9:00 Registration, Pre-survey
9:30 Demonstrations/Activities
10:30 Panel discussion on STEM
11:00 Interactive Presentation
11:55 Post-survey
12:00 Liquid Nitrogen Ice Cream, Dismissal

<u>Parent Program</u>

9:00 Registration, Pre-survey
9:30 Demonstrations/Activities
10:00 Discussion/Q&A on STEM Careers
11:00 Interactive Presentation
11:55 Post-survey
12:00 Liquid Nitrogen Ice Cream, Dismissal

The core components of the Spanish Night program include the demonstrations, the panel discussion, and the interactive presentation. The demonstrations are run by trained college students who are members of local Hispanic science/engineering societies and are designed to introduce participants to ideas from a variety of STEM fields: centrifugal forces, acoustic and mechanical resonance, chemical reactions, buoyancy, materials science, mathematics puzzles, aerodynamics, and energy. Students circulate through the various exhibits and, due to a low student to exhibit ratio, are able to spend significant time at each legitimately participating and engaging in the ideas behind the exhibit (Lave & Wenger, 1991). That is, the college students work to engage the middle school students in scientific exploration and questioning, rather than simply observing. While students are engaged with these demonstrations, parents learn about fiscal and human resources available to their children. Additionally, they spend time hearing from (usually) Hispanic college students and STEM professionals about their personal experiences of being Hispanic in a largely non-Hispanic field. These volunteers provide valuable proofs-of-concept to parents who often have doubts about the role of the Hispanic community in STEM disciplines. Finally, the interactive presentation brings parents and students together in an exploration of who a scientist/engineer really is, what one does each day, what thinking like a scientist often looks like, and why this work is important. These themes are interwoven with hands-on critical experiments from scientific history and mathematical puzzles.

It is important to note that the entire event is delivered in both English and Spanish so that native language is not a barrier to entry.

The Study

The major goal of the study below was to gauge the efficacy of the Spanish Night program with the hope of sharing this implementation with others. In order to do so, both students and their accompanying parents were given a pre-survey before beginning the morning of activities and a post-survey right before the conclusion. These surveys can be found in the Appendix. The student and parent pre-surveys, which contained some similar questions, each offered six prompts to which respondents were asked to choose from among nine possible options – from Strongly Disagree to Strong Agree. This extended-Likert scale was used in order to allow participants more freedom in reporting the precise nature of their ratings. To avoid any native language bias, the questionnaires were offered in both English and Spanish, and students and parents were told to choose whichever they were more comfortable with after being given both. The English versions of these questions are reproduced below. The notation SQ1 denotes (S)tudent (Q)uantitative prompt 1, while PQ4 means (P)arent (Q)uantitative prompt 4.

SQ1. I find engineering topics to be interesting.
SQ2. I would like to study engineering in school.
SQ3. I want to become an engineer when I grow up.
SQ4. I feel like engineers are hard to relate to.
SQ5. I see Hispanics/Latinos as leaders in engineering.
SQ6. I have a good sense for what an engineer does each day.

PQ1. I have an appreciation for engineering.
PQ2. I know what path my child should take in order to become an engineer.
PQ3. I consider engineering as a possible career path for my child.
PQ4. I feel like engineers are hard to relate to.
PQ5. I see Hispanics/Latinos as leaders in engineering.
PQ6. I have a good sense for what an engineer does each day.

Three things are worthy of note based on these prompts (sometimes referred to ‘questions’ below). First, while these questions use the term engineer/engineering throughout, this language was chosen to simplify the survey (as opposed to scientist/engineer). Throughout the intervention, scientists, technologists, engineers, and mathematicians were all viewed as STEM professionals, and these terms began to be used as roughly synonymous for ease of discussion. Second, of the prompts above, SQ1-SQ3 and PQ1-PQ3 are unique to their respective surveys, while SQ4-SQ6 are identical to PQ4-PQ6. This overlap will be important later in the across-group analysis. Finally, SQ4 and PQ4 were worded with negative affect in order to jostle the respondent and disassociate the right side of the Likert scale as always meaning positive.

After completing the event, the students and parents were given the post-survey which included these same questions as above. In order to mitigate the possibility of respondents easily reproducing their responses from the pre-survey, the question order was shuffled. In addition, each respondent was asked to provide written responses to two open-ended questions and some basic demographic data (age, grade in school, gender, racial identity, and primary language(s) spoken at home). Below, SW2 stands for (S)tudent (W)ritten question 2.

SW1. Has this program changed your view of Hispanics/Latinos in engineering? [Choose Yes or No] If so, how? If not, why not?
SW2. Has this program changed your view of engineering? [Choose Yes or No]. If so, why? If not, why not?

PW1. Has this program changed your view of Hispanics/Latinos in engineering? [Choose Yes or No] If so, how? If not, why not?
PW2. Has this program changed how you will encourage your child to continue exploring engineering topics? [Choose Yes or No] If so, how? If not, why not?

In order to gather more honest responses, the surveys were anonymous and random ID numbers were used to link pre- and post-surveys. A typical number scheme for a family might look like: 104 for the parent, 104 for child 1, and 104A for child 2. Most parents brought only one child, and most children came with only one parent. This ID system also allowed student responses to be linked back to parent responses in the across-group analysis below.

Some limitations are immediately evident upon seeing the study in its totality. First, the participants that attend a Spanish Night event are not a random sample. Indeed, they are intentionally chosen not to be, for the intervention is targeted at the Hispanic community. Nor are members of the school randomly assigned to attend or not attend. While this is a limitation when compared to the "gold-standard" in research design, it does not nullify the work to follow. Indeed, any conclusions from this paper generalize only to individuals in similar Hispanic communities that are curious enough to attend such an event. Thus, this study does not aim to make claims which generalize to the American populace at large (a *global* inference). As a paper focused on the *local* level, its results naturally generalize to similar settings at the same local level. Second, the interpretation of Likert response items is complex, for respondents may interpret the intermediate, unlabeled numbers differently (and even phrases like 'Strongly Agree'). On top of this, such scales may be viewed as ordinal measures by some and interval measures by others. These distinctions have important implications for the types of statistical tests one may employ in analyzing these data. Below, data from the Likert scales are viewed as an interval measure, and the same numerical score on different surveys is viewed as showing the same level of agreement/disagreement, despite the possibility that respondents were not viewing their responses as such.

Before turning to the results section, it is important to mention that this study is both quantitative *and* qualitative in nature. Each arm of the research apparatus brings something different to the reader – the former tends to show *that* something is occurring (with a certain level of statistical significance) while the latter can add important texture and show *how* or *why* something is occurring. Each is valuable for improving the research community's goal of fixing the STEM crisis in America: the first suggests whether something is a valuable use of time and resources, while the latter uncovers what types of processes realize the change educators hope to see in the world.

Results

This extended section will begin by presenting the quantitative results, followed by the qualitative results. The key methodological constructs used in this section are described as *across-time* and *across-group* analyses. The first of these works to capture how a fixed group (say, parents) changes over time (from the pre-survey to the post-survey). The second studies how at a fixed time (say, during the pre-survey) the different groups (students and parents) are correlated. Many traditional studies focus on across-time comparisons – they want to know what happens before and after an intervention. This study takes things a step further and also looks at how views of students and parents are linked. These across-group linkages are valuable in that they can answer questions such as: Do students roughly share their parents' beliefs about engineering walking in the door? What about when they leave? Does this type of intervention create the same kind of affective change in children and adults? Figure 1 (from Deckard et al., 2014) below organizes this idea for future reference.

Quantitative Across-Time Analysis

In the discussion to follow, the Likert-style response items (SQ1-SQ6 and PQ1-PQ6) were converted to numbers (1 = Strongly Disagree, 5 = Neutral, 9 = Strongly Agree). Given that question 4 was worded with negative affect while the others were positively voiced, one would hope to see a decrease in score for question 4 and an increase in the other five questions when moving from the pre-survey to the post-survey. The average results for both students and parents (pre and post) are seen in Figures 2 and 3 below. These Figures reveal that student and parent self-reported scores rose for all questions worded with positive affect, and the student scores on question 4, worded with negative affect, declined. Strangely, parent averages on question 4 rose, rather than declined; this was unexpected and may have been the result of confusion about the question, carelessness in responding, or a legitimate worsening of opinion on the relatability of engineers as a result of the intervention. This is a topic for further research.

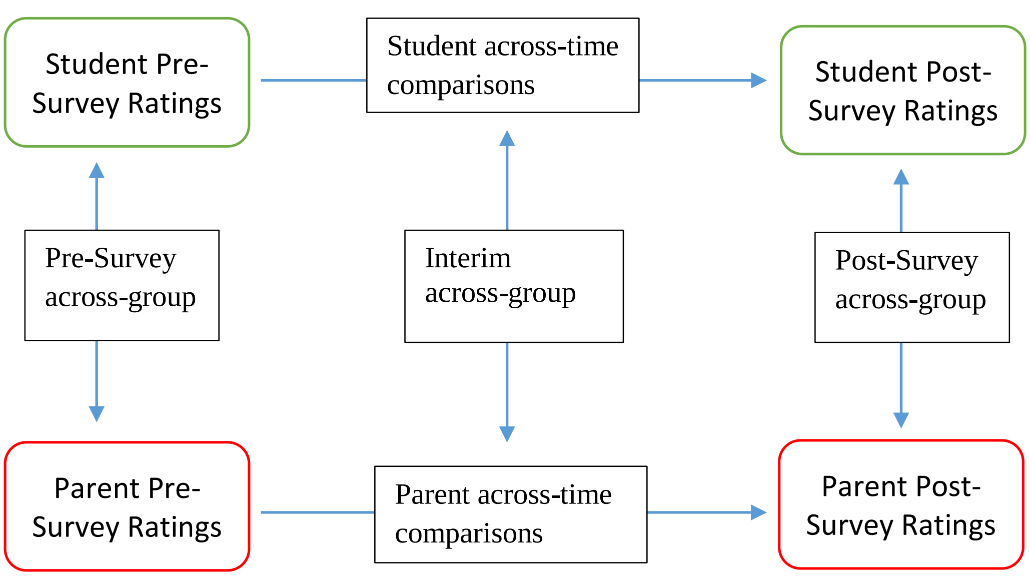
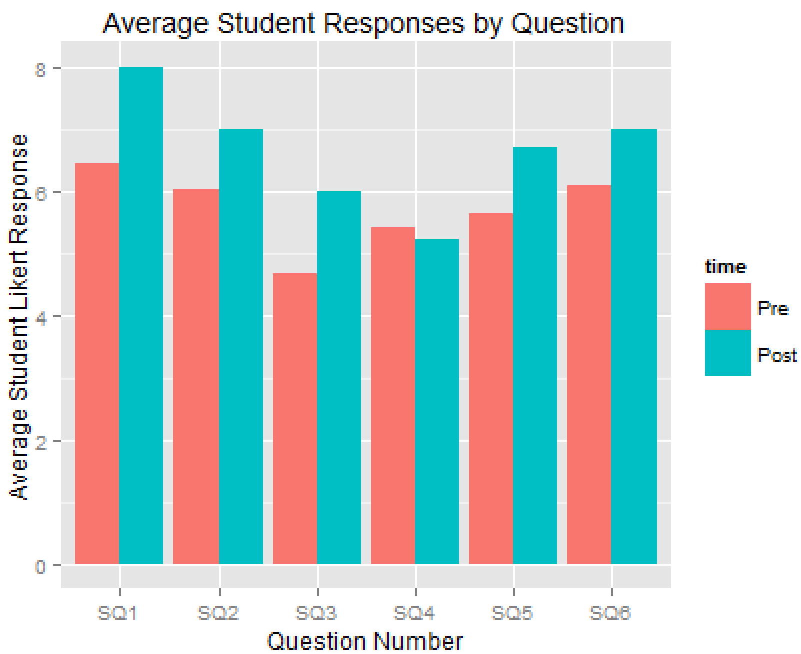


Figure 1. Methodological overview



p-values from the Wilcoxon Signed-Rank Test

SQ1: 0.0000524

SQ2: 0.00449

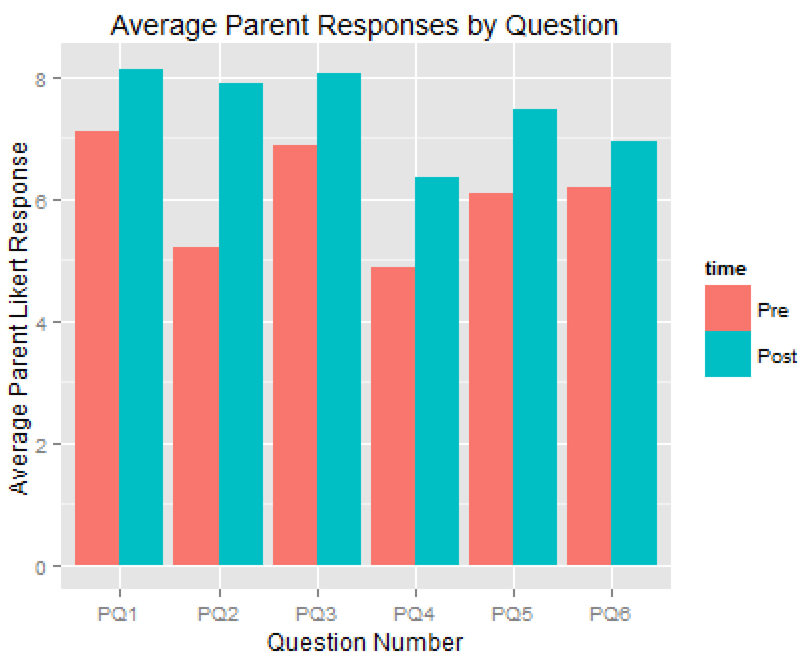
SQ3: 0.000953

SQ4: 0.389

SQ5: 0.000482

SQ6: 0.0141

Figure 2. Student (n = 30) across-time averages by question



p-values from the Wilcoxon Signed-Rank Test

PQ1: 0.00572

PQ2: 0.0000129

PQ3: 0.00210

PQ4: 0.993

PQ5: 0.00190

PQ6: 0.0372

Figure 3. Parent (n= 30) across-time averages by question

One natural question to ask about these data is whether they are statistically significant. In order to check for this, the Wilcoxon Signed-Rank Test was used. It compares paired samples (here, pre-scores and post-scores for a specific group and a specific question), and looks for shift in the pre- and post-distributions. The null hypothesis is that no shift occurs (i.e., the intervention has no effect on the given question). For the p-value reported above, a one sided alternative hypothesis was used – that the intervention cause an upward shift in the post-distribution (or downward in the case of question 4). This test produces statistically significant p-values (at the 0.05 level) for both parents and students on all questions except SQ4 and PQ4.

Another way of parsing these data is to use a switcher table (Deckard et al., 2014). The critical idea here is that while an upward shift in self-reported scores may seem valuable, these positive gains may actually mean very little if the movement happens on the low end (e.g., if a student reports moving from a 3 to a 4) or high end of the scale (e.g., a move from 8 to 9). In both of these cases, the participant is unlikely to have turned the STEM corner – in the former case, a negative view is still largely maintained, and in the latter case, the participant was likely already quite interested in STEM topics to begin with. A switcher table, therefore, sets a threshold that, if crossed, could symbolize a student or parent actually turning the STEM corner (i.e., someone who leaves the intervention with a critically different view on the subject and that might, someday, become a STEM professional). Naturally, the choice of threshold is debatable, but for the analysis below, two different thresholds will be studied (at $T = 6.5$ and $T = 7.5$). Once a particular threshold is chosen, participants can be dichotomized using their pre- and post-scores on a given question. These two labels place the student in one of the four boxes of the below switcher table (from Deckard et al., 2014). Note that participants whose pre- and post-scores remain on the same side of the threshold are labelled "Maintainers" while those that cross over are "Switchers". The (+) and (-) notation suggests which side of the threshold the participant ended up on, where (+) denotes a desirable ending spot.

Summary of Pre/Post-Surveys	Post-survey < threshold level	Post-survey >= threshold level
Pre-survey < threshold level	Maintainers (-)	Switchers (+)
Pre-survey >= threshold level	Switchers (-)	Maintainers (+)

Figure 5. Structure of the 2x2 dichotomized-response switcher table

If the goal is to change participants' views about STEM in a dramatic and career-altering way, then one would hope to see a large value in the "Switcher (+)" cell. Figures 6-9 below show the counts for each group (students or parents), each question, and each of the two threshold levels ($T = 6.5$ or 7.5). As above, one might ask whether the observed cell counts have any statistical significance. Under a null hypothesis in which the intervention has no effect, one would expect to see all counts in the two Maintainer cells (modulo statistical variation). Deviation from this state begins to erode the null hypothesis and suggest, to the contrary, that the intervention does have an effect. McNemar's test may be used to evaluate statistical significance in this case (Adedokun & Burgess, 2011). This test has advantages compared to other tests typically used on matrix data: it is non-parametric (so no assumptions must be made about the underlying distributions) and exact (so there are no minimums that must be met for cell counts). As with Wilcoxon's test above, a one-sided alternative hypothesis was studied which stated that the proportion of participants above the threshold should be higher in the post-scores than in the pre-scores. Finally, note that for the below analysis, the question 4 scores (SQ4 and PQ4) scores were symmetrically flipped about 5 so that the notion of "Switcher (+)" remained the desirable cell.

Quantitative Across-Group Analysis

We turn now to the vertical arrows in Figure 1, or the across-group analysis. In this section, a time is chosen from three possible times: before the intervention (pre-survey), after the intervention (post-survey), or the stretch of time between the surveys (interim). Once a time is chosen, student and parent responses are compared for the three questions (Q4-Q6) that were identical in the two groups. In the case of the interim time period, the pre-scores were subtracted from the post-scores and these differences were the objects of comparison; they represent the self-reported change engendered by the intervention. In order to study the correlation (or lack thereof) of students with their parents, dotplots were created. See Figures 10-12 for the three different fixed times – Figure 10 for pre-surveys, 11 for interim results, and 12 for post-surveys. On each, a student's rating is matched with his or her parent's rating to create a point (Student Rating, Parent Rating) on a given dotplot. In the event multiple student-parent pair ratings fell at the same place on the plot, larger-sized dots were used to indicate overlap.

After creating these visualizations, two types of correlation statistics were calculated. The Pearson correlation is a parametric measure of the relationship between two variables – here, students' ratings and their associated parents' ratings. It is parametric because it assumes a *linear* relationship between these inputs, and a score of -1 or 1 represents a perfect (negative or positive) linear relationship. A score of 0 suggests no linear relationship whatsoever. In contrast, the Spearman rank correlation coefficient is a nonparametric measure of the relationship between two inputs. Because it is nonparametric, it does not assume a *linear* relationship, and hence is valuable for finding any type of monotonic relationship between data that are continuous, discrete, or even ordinal (hence, it relaxes assumptions both about the nature of the relationship and the type of the variables involved).

SQ1	Post < T	Post >= T
Pre < T	6	9
Pre >= T	0	15
McNemar’s Test p-value: 0.00195		

SQ2	Post < T	Post >= T
Pre < T	11	5
Pre >= T	1	13
McNemar’s Test p-value: 0.109		

SQ3	Post < T	Post >= T
Pre < T	15	9
Pre >= T	1	5
McNemar’s Test p-value: 0.0107		

SQ4	Post < T	Post >= T
Pre < T	21	4
Pre >= T	3	2
McNemar’s Test p-value: 0.5		

SQ5	Post < T	Post >= T
Pre < T	15	10
Pre >= T	0	5
McNemar’s Test p-value: 0.000977		

SQ6	Post < T	Post >= T
Pre < T	9	7
Pre >= T	4	10
McNemar’s Test p-value: 0.274		

Figure 6. Table for: **Students**; Threshold Level: **T = 6.5** (lower level = 1-6, upper level = 7-9)

PQ1	Post < T	Post >= T
Pre < T	3	8
Pre >= T	1	18
McNemar’s Test p-value: 0.0195		

PQ2	Post < T	Post >= T
Pre < T	3	20
Pre >= T	0	7
McNemar’s Test p-value: 9.5e-7		

PQ3	Post < T	Post >= T
Pre < T	2	7
Pre >= T	2	19
McNemar’s Test p-value: 0.0898		

PQ4	Post < T	Post >= T
Pre < T	21	2
Pre >= T	5	2
McNemar’s Test p-value: .9375		

PQ5	Post < T	Post >= T
Pre < T	4	15
Pre >= T	2	9
McNemar’s Test p-value: 0.00117		

PQ6	Post < T	Post >= T
Pre < T	5	9
Pre >= T	4	12
McNemar’s Test p-value: 0.133		

Figure 7. Table for: **Parents**; Threshold Level: **T = 6.5** (lower level = 1-6, upper level = 7-9)

SQ1	Post < T	Post >= T
Pre < T	6	14
Pre >= T	1	9
McNemar’s Test p-value: 0.000488		

SQ2	Post < T	Post >= T
Pre < T	14	8
Pre >= T	2	6
McNemar’s Test p-value: 0.0547		

SQ3	Post < T	Post >= T
Pre < T	22	6
Pre >= T	0	2
McNemar’s Test p-value: 0.0156		

SQ4	Post < T	Post >= T
Pre < T	27	1
Pre >= T	1	1
McNemar’s Test p-value: 0.75		

SQ5	Post < T	Post >= T
Pre < T	21	4
Pre >= T	0	5
McNemar’s Test p-value: 0.0625		

SQ6	Post < T	Post >= T
Pre < T	14	8
Pre >= T	2	6
McNemar’s Test p-value: 0.0549		

Figure 8. Table for: **Students**; Threshold Level: **T = 7.5** (lower level = 1-7, upper level = 8-9)

PQ1	Post < T	Post >= T
Pre < T	4	7
Pre >= T	3	16
McNemar’s Test p-value: 0.172		

PQ2	Post < T	Post >= T
Pre < T	11	17
Pre >= T	0	2
McNemar’s Test p-value: 7.63e-6		

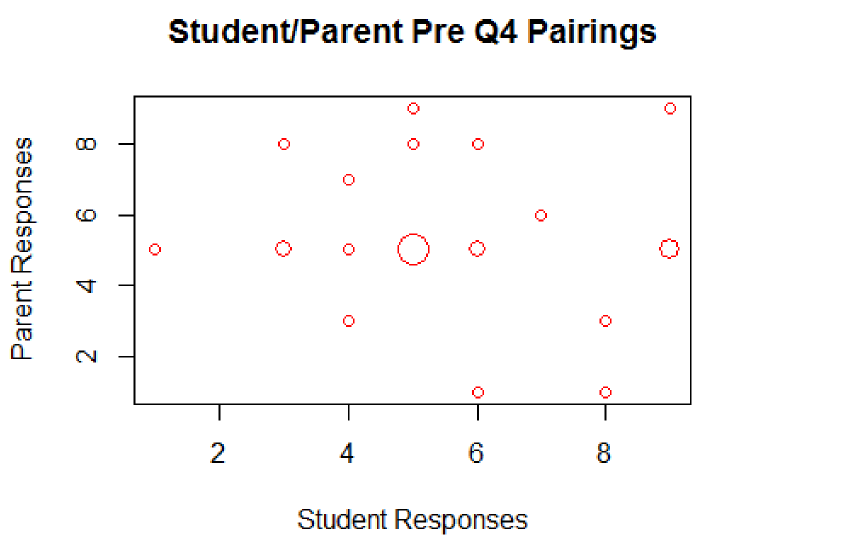
PQ3	Post < T	Post >= T
Pre < T	6	10
Pre >= T	2	12
McNemar’s Test p-value: 0.0193		

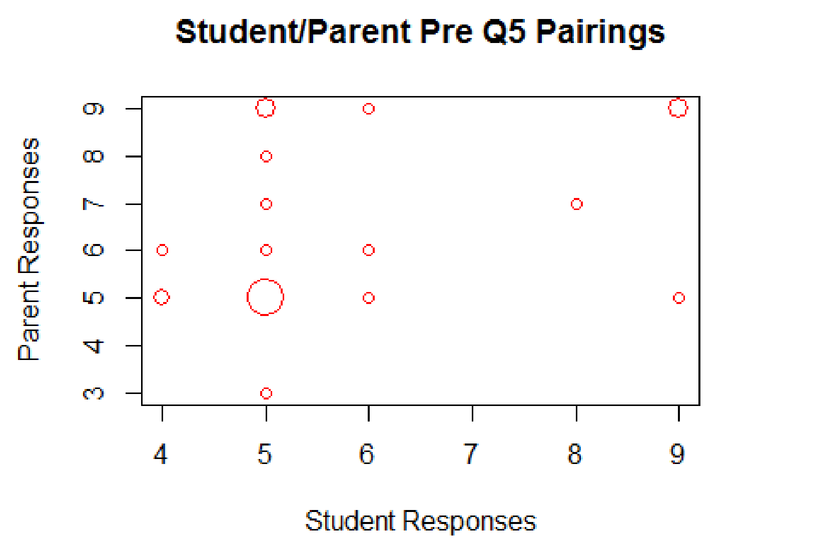
PQ4	Post < T	Post >= T
Pre < T	23	2
Pre >= T	4	1
McNemar’s Test p-value: 0.891		

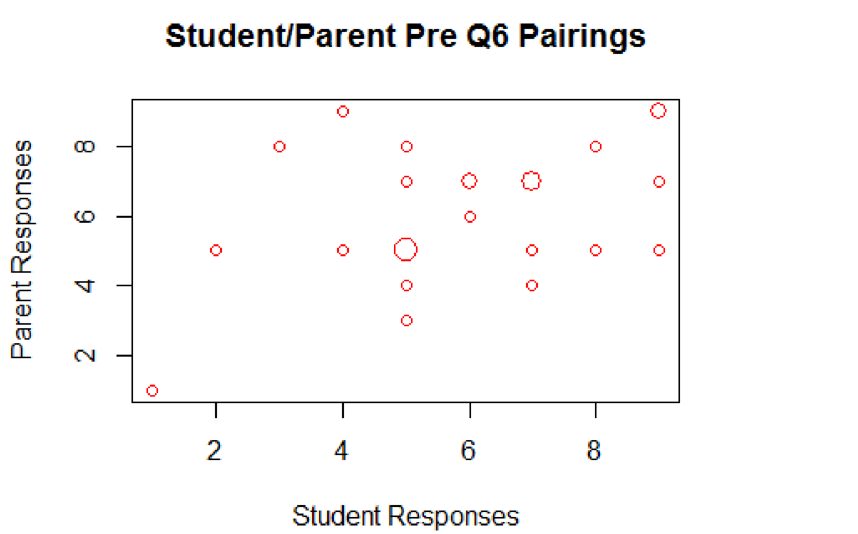
PQ5	Post < T	Post >= T
Pre < T	10	13
Pre >= T	2	5
McNemar’s Test p-value: 0.00369		

PQ6	Post < T	Post >= T
Pre < T	13	8
Pre >= T	3	6
McNemar’s Test p-value: 0.113		

Figure 9. Table for: **Parents**; Threshold Level: **T = 7.5** (lower level = 1-7, upper level = 8-9)

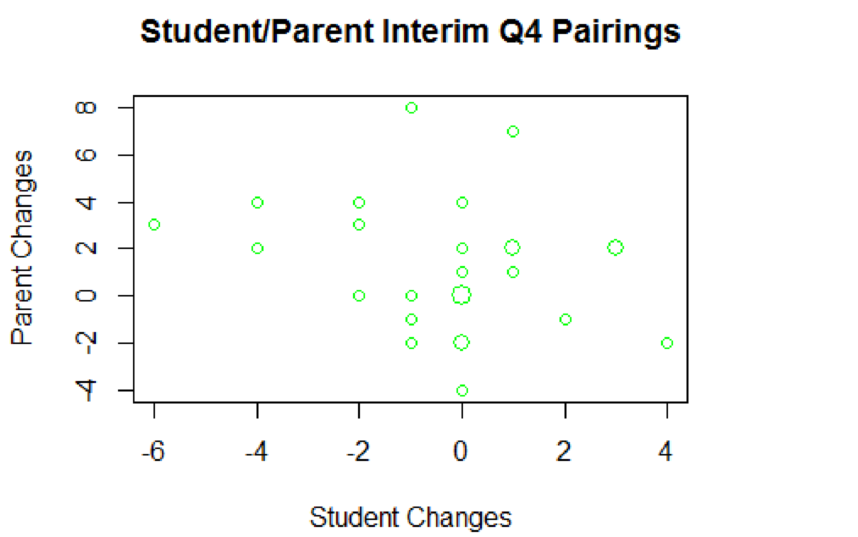


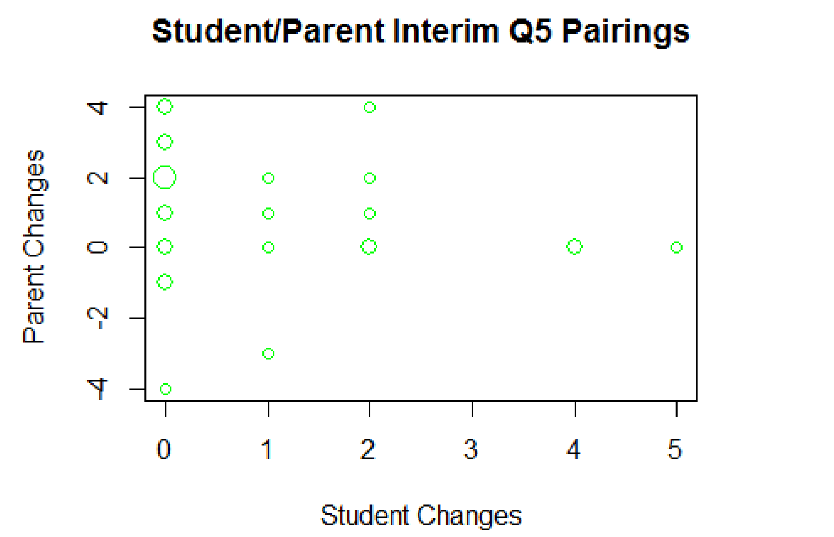


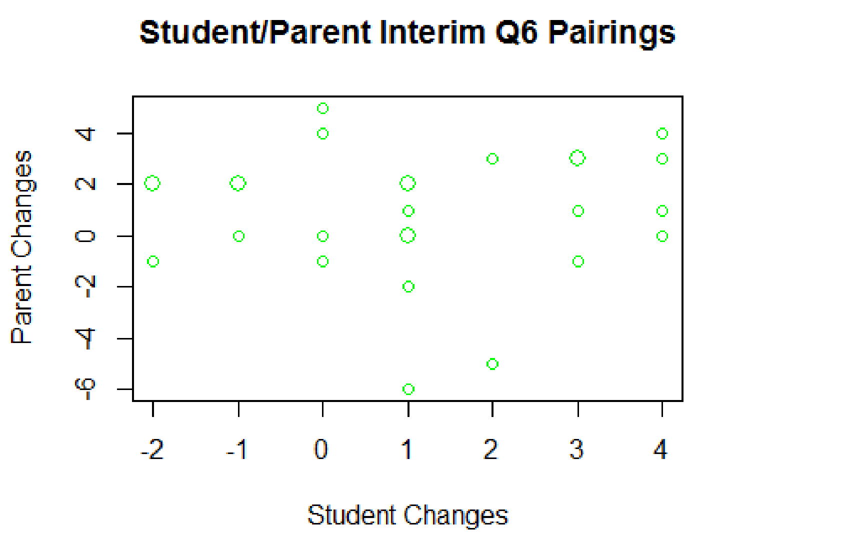


	Pearson correlation coefficient	Spearman correlation coefficient
Pre-survey Q4	-0.107	-0.090
Pre-survey Q5	0.430	0.398
Pre-survey Q6	0.428	0.311

Figure 10. Dotplots and correlation coefficients for Q4-Q6 on the pre-surveys

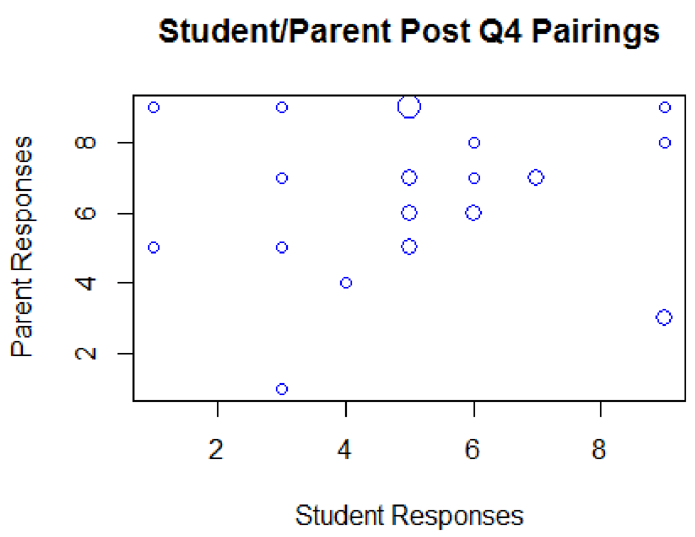


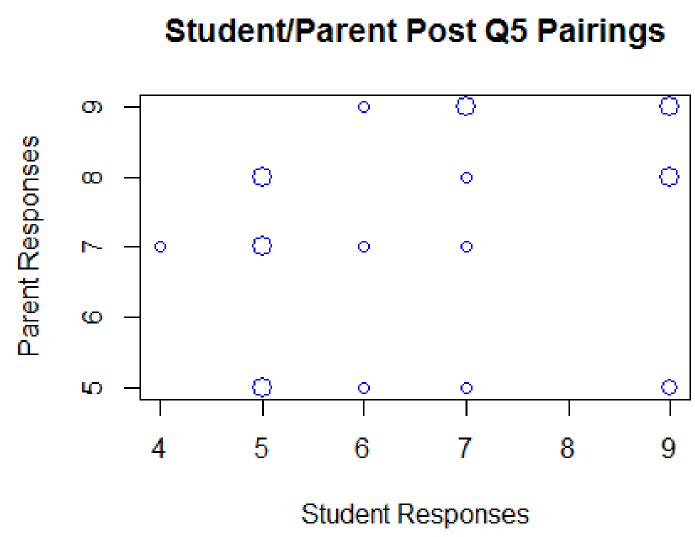


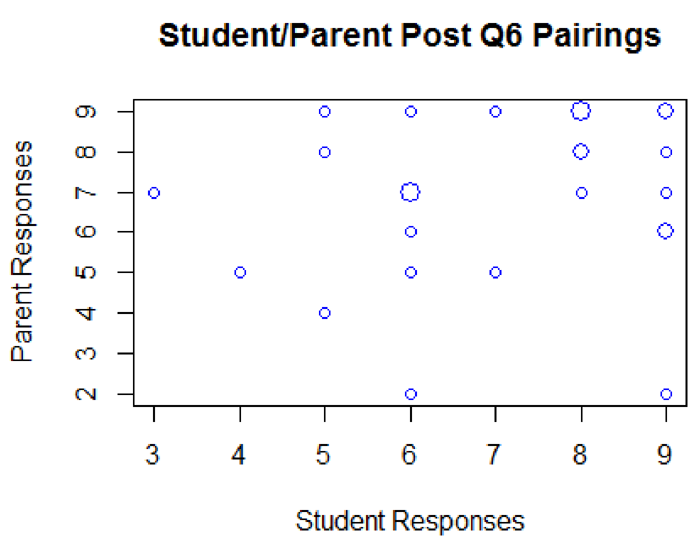


	Pearson correlation coefficient	Spearman correlation coefficient
Interim Q4	-0.238	-0.221
Interim Q5	-0.151	-0.212
Interim Q6	0.050	0.091

Figure 11. Dotplots and correlation coefficients for Q4-Q6 as a change in pre- and post-surveys







	Pearson correlation coefficient	Spearman correlation coefficient
Post-survey Q4	-0.022	0.021
Post-survey Q5	0.262	0.350
Post-survey Q6	0.173	0.194

Figure 12. Dotplots and correlation coefficients for Q4-Q6 on the post-surveys

Figures 10-12 reveal a few trends in student/parent attitudes. First, given the relatively low correlations found in the pre- and post-timeframes, it appears as if students and their parents arrive with different ideas about STEM fields and leave with different opinions. Indeed, even in the case of the pre-timeframe Q5 with a correlation of 0.43 (the highest seen above), a student's score can only explain $0.43^2 = 0.1849$, or 18.49%, or the variation seen in his or her parent's rating (assuming a linear model is appropriate). Furthermore, in looking at the interim timeframe, or how the intervention affects students and their parents, it appears as if no clear correlation exists. That is, the event may work wonders for one family member and not the other (or vice versa). Thus, maxims like "Like father, like son" or "Like mother, like daughter" should be viewed with extreme caution when planning events of this type. This result is somewhat surprising and was also found in Deckard et al. (2014).

Taken together, the across-time and across-group analyses suggest that real changes can be created in students and parents even in a short-term intervention like Spanish Night. Furthermore, the degree and direction of these changes may differ from student to student and between a student and his or her parent. This raises the natural question of how the changes differ when viewed through the three-part objective lens articulated in the Theoretical Framework section above. As mentioned, these goals (STEM Awareness, Pathway, and Philosophy) were specifically mapped to the survey questions, and so it is possible to further parse the above quantitative results with these goals in mind. The explicit mappings were:

STEM Awareness: SQ1, SQ6, PQ1, PQ6
Pathway: SQ2, SQ3, PQ2, PQ3
Philosophy: SQ4, SQ5, PQ4, PQ5

Below, we tally the number of p-values that reached statistical significance ($p < 0.05$) for Wilcoxon (shifts in central tendency) and McNemar's (switcher tables) tests:

Objective	Linked Questions	Significant **Student** p-values	Significant **Parent** p-values	*Total* Significant p-values
STEM Awareness	SQ1, SQ6, PQ1, PQ6	4	3	7
Pathway	SQ2, SQ3, PQ2, PQ3	4	5	9
Philosophy	SQ4, SQ5, PQ4, PQ5	2	3	5

Figure 13. Tallies of significant p-values by objective and group

As Figure 13 suggests, when viewed in its totality, the Spanish Night program seems most effective at remapping beliefs around STEM pathways, followed by Awareness and then Philosophy. The challenge in reshaping students' and parents' philosophies was also found in Deckard et al. (2014) and remains an important area for further research. This finding is somewhat intuitive: reshaping deep-seated views on one's relationship to a career and its content seems difficult in comparison to simply providing awareness of career pathways or the various branches of engineering. Indeed, the Philosophy goal was designed to target the *affective* plane, rather than the *informational* plane. In order to make better sense of the changes that do seem to be occurring in these two spaces, a qualitative analysis was performed using student and parent responses to questions SW1, SW2, PW1, and PW2 (listed above).

Qualitative Analysis

The goal of the qualitative analysis was to uncover *how* participant beliefs were changing (not simply that they *were* changing). To do this, the technique of Ground Theory (Corbin & Strauss, 1990; Strauss & Corbin, 1994) was employed. In brief, this approach uses iterative cycles of exploration and coding to find patterns across diverse participant response sets. As theories slowly emerge, these are constantly compared to the data in a search for the highest degree of perceived consistency between the data and their interpretation. In the current analysis, separate coding schemes were used for students and parents, and then a combined scheme was created to explore the totality of the data, in the event that participants were forming beliefs not as isolated cognizing agents, but as members of a community. In the end, this coding scheme meshed most naturally with the data, for it realized the sociocultural nature of the human experience (Brown, Collins, & Duguid, 1989; Forman, 2003; Vygotsky, 1987). As an example, while parents often wrote about gaining a clearer vision of the career opportunities within the STEM landscape, they usually mentioned the importance of this *relative to* educating and guiding their children in the future. Thus, their growth was typically not cast as personal growth, but as growth that provided additional mediating capacity in their children's futures.

The Piagetian notion of a scheme is valuable in the discussion below. In brief, a scheme is a collection of ideas and experiences concerning a given construct. These are slowly developed over time through the constructivist processes of assimilation and accommodation (von Glasersfeld, 1995). For example, a young child may have a scheme for what it means to be an engineer. This might contain personal facts (e.g., mom is an engineer), experiences (e.g., going to a chemical engineering plant on a field trip), socially-constructed ideas (e.g., engineers are white males who are good at math), etc. For Piaget, people hold schemes for a variety of constructs: what an engineer does, what an Italian restaurant looks like, who may become President, etc. Work from the Grounded Theory analysis revealed that students were adapting three types of schemes as a result of the Spanish Night intervention and that parents were improving in their abilities to mediate their children's schemes.

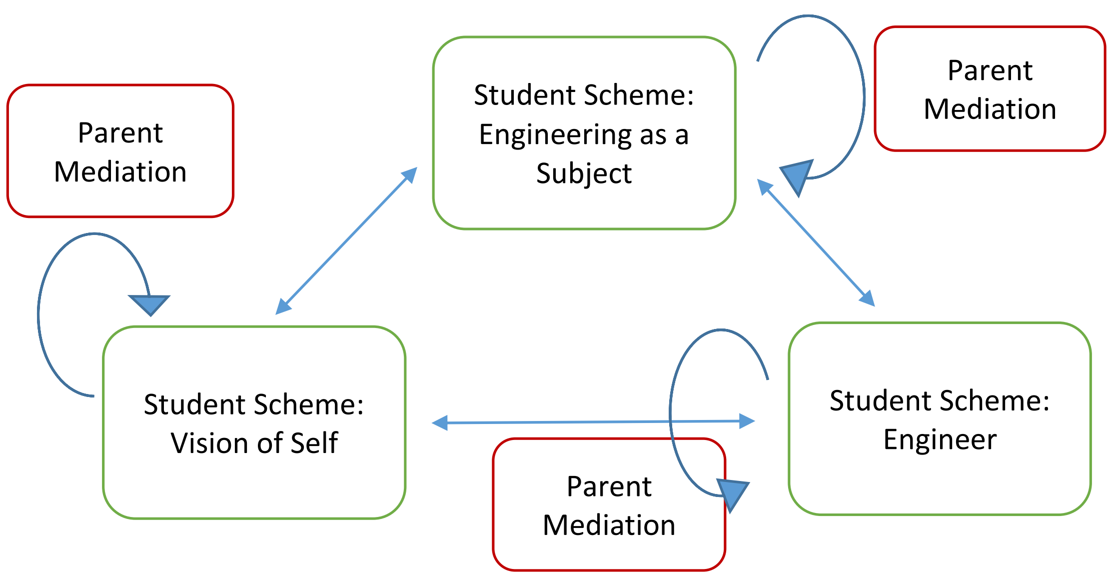


Figure 14. Overview of scheme organization from qualitative analysis

Figure 14 above gives an overview of the qualitative analysis. We begin by looking at the category "Student Scheme: Engineer". This idea captures those opinions, conceptions, misconceptions, and imagery a student holds for an engineer (or, more generally, a STEM professional). While a statistically significant change in SQ6 ("I have a good sense for what an engineer does each day") suggests that students are altering their schemes of an engineer, it does not reveal precisely how (or even if these changes are positive). The qualitative analysis, however, reveals the nature of these attitudinal changes (misspellings are corrected below):

- "I learned that engineers are always working on inventions to make the world a better place." (female, age 10)
- "I used to think they [engineers] just built things, but now I realized that it involves science which is interesting." (male, age 11)
- "Engineering is a good source for your life and uses a lot of creativity." (female, age 10)
- "I thought engineers only build buildings, but now I know that they build everything." (female, age 11)
- "Engineers do real cool stuff." (female, age 11)
- "Hispanics can become engineers." (male, age 10)

Taken together, these views suggest an image of an engineer as a creator, guided by scientific fields, who does "cool" work that serves an important social purpose ("make[s] the world a better place"). This scheme is far richer than one in which an engineer simply "build[s] buildings", or in the words of other students: "I thought engineering was for cars" (female, age 9) and "I thought it [being an engineer] would be like taking apart an engine's motor" (male, age 10). The bulleted quotes above were not unique in their messaging; students frequently wrote of changed views by noting similar ideas: "Engineers can discover cool stuff." (male, age 12) and "I want to be one of the people who makes a great change on the United States." (male, age 12).

At the top of Figure 14 is the student scheme for engineering as a subject. Certainly this is influenced by a child's evolving scheme for an engineer, for the latter is a practitioner of the former. Many student comments, however, reached beyond the space of the practitioner to the field itself. Some of these include:

- "I now know that Hispanics/Latinos are great at engineering." (male, age 11)
- "It [engineering] is interesting, and it is a lot of fun projects." (male, age 11)
- "It is harder, but at the end it pays off." (male, age 13)
- "There is a lot to discover." (female, age 12)
- "Engineering is hard, but fun." (male, age 12)
- "It looks fun, and if you do a mistake, you can try different stuff." (female, age 11)
- "We need more Hispanics/Latinos to represent us in engineering." (female, age 14)

These quotes demonstrate ways in which students' schemes were changing outside of those changes that results from updated views on what being an engineer means. Some students spoke of the need for and success of Hispanics/Latinos in the engineering community; others wrote about the nature of the subject ("hard, but fun", discovery-oriented). Some even spoke of the type of engagement they would expect in the field ("fun projects" and the ability to return to the drawing board when initial ideas failed). As a whole, these ideas nicely complemented those seen in the Engineer scheme above. Said simply, students appeared to be developing rich narratives around the life of a STEM professional.

Finally, on the left of Figure 14 is the student's scheme of himself or herself. The type of changes seen here centered around the student beginning to see himself/herself as a STEM professional. There are many reasons students might fail to see themselves in this role: lack of confidence in one's abilities, being unaware of certain STEM careers, affiliation with a certain racial/ethnic group and the societal biases that come with such an identification, etc. This last reason came across quite powerfully on the surveys; many students suggested that positive role models from the intervention changed their opinions of long-standing social biases, and in doing so, remapped their self-views (in relation to STEM fields). Evidence related to this area includes:

- "I learned that anyone could become an engineer." (male, age 12)
- "It [engineering] lets me think outside the box." (male, age 12)
- "No matter what you are, you can do anything." (mage, age 10)
- "Maybe one day I can try to be an engineer." (male, age 11)
- "They [Hispanics/Latinos] can do the same thing as people who speak English." (female, age 11)
- "Not only Americans can do that kind of stuff [engineering]." (male, age 11)
- "I thought that few Latinas would be able to be engineers. But this changed my mind." (female, age 11)

This type of sentiment recurred on survey after survey. It appeared as if freeing the Hispanic identity from society's anti-STEM bias allowed students who self-identified as Hispanic/Latino to begin considering a set of career options that they had previously seen as non- or infrequently-Hispanic.

In addition to students reforming their schemes (as represented by the curved arrows in Figure 14) and the cascading effects these changes had on other schemes (as represented by the straight arrows between schemes), parents frequently wrote of their desire to be involved in changing their children's views of self, engineers, and engineering. Because these were comments about affecting *others'* opinions and paths, they took on a different feel than the comments offered by students. For example, when thinking about their children and engineering, parents wrote about increasing awareness, leveraging new resources, and pursuing certain subjects in school:

- "I have a better understanding on how engineering has many possibilities for everyone."
- "[I will influence my child] by encouraging him to tackle math and science."
- "There are more programs than I knew about."
- "It gave me a view of how they [Hispanic/Latino children] will be successful in engineering and become leaders."
- "With more information, one can help their children do things."
- "Explaining to them all the opportunities that would be at their disposal, should they choose to pursue a career in engineering."
- "I'll inspire him to study more math and science, and search for more ways to support him."

- “[I’ll] try to take them to more fairs and expose them to science so as to provide our children with opportunities to practice engineering and motivate them to attend a university.”

Parents’ views on what makes an engineer also appeared to shift. In the process, they suggested a number of ways they might shape this new vision in their children:

- “I think being an engineer can be color blind. Any nationality can be an engineer.”
- “[I’ll] talk to our children about how important it is to create things that make daily life easier and better.”
- “[I plan on] giving them more information about this career and what it entails.”
- “Before attending this event, I had no idea that there was an association of Hispanic Engineers.”

This last quote shows the importance of designing interventions at the ‘local’ level. Here, college students from Hispanic engineering societies were recruited as exhibit presenters and Q&A panel members. These *authentic* examples, who were only five to ten years removed from the student participants, provided parents a proof of concept, and in doing so, gave them a vision to strive for with their own children.

Finally, parents also provided evidence of their desire to continue shaping their children’s self-images (particularly in relation to ethnic identity):

- “I will support whatever makes her interested and happy.”
- “I understand that regardless of your origin anything can be accomplished through preservation and dedication.”
- “Latinos have the knowledge, will power, and mental capacity to accomplish their goals and being bilingual gives them a better chance of success.”
- “Hispanics have as much of a chance of succeeding in an engineering career as any other person in society, even when it comes to occupying important positions in the community.”
- “I now understand the great advantage Hispanics have when studying these subjects and the importance that engineering has in daily life.”
- “I now want to motivate my child to put in the work to attain their goals.”

These quotes suggest a newfound desire of parents to work with their children, seeing ethnic identity as an asset and leveraging tool, rather than as a hindrance to getting involved in STEM fields or even becoming an engineer. Here, one hopes that these more sophisticated parental schemes will trickle down and mediate their children’s schemes. Parents’ comments suggested this possibility, speaking of attending science fairs with their children, gathering information about STEM opportunities, and working to see past the biases currently found within the scientific community.

Conclusion

The overarching goal of this paper has been to explore, using both quantitative and qualitative techniques, the effects of a half-day STEM intervention on the Hispanic/Latino community through three important lenses: STEM Awareness, Pathway, and Philosophy. The Spanish Night program was designed with these overarching themes in mind and crafted at the local level, meaning that it tried to present ideas, leverage resources, and use a style based completely on the audience it served. As such, the event was bilingually offered, recruited college students from Hispanic engineering societies, went directly to the communities in question, and offered convincing, near-to-home examples of successful Hispanic STEM professionals. Furthermore, the assessment of the program was also built around the three goals above.

The statistical-significance summary results from Figure 13 suggest that Awareness and Pathway objectives are more easily realized than those involving student and parent Philosophy. This result is interesting, and perhaps intuitive, for the Awareness and Pathway objectives exist primarily in the informational plane, while Philosophy is more affective in nature. Indeed, when we speak here about Philosophy, we really are referring to what some in the research literature refer to as “dispositions”. Melissa Gresalfi describes these as “ways of being in the world that involve ideas about, perspectives on, and engagement with information that can be seen both in moments of interaction and in more enduring patterns over time” (2009, p. 329). Because of the complex personal-societal-historical nature of these philosophies, they can be recalcitrant to change, and creating this change requires identifying and enacting transformation in those dispositional areas of highest intransigence. For some students in the Spanish Night program, a STEM career seems improbable because of poor past experiences in science and mathematics courses. For others, cultural biases or lack of knowledge about STEM fields may be the root cause of negative dispositions. Gresalfi notes that “the dispositions that students enact are not simply inherent capabilities, or learned responses, but rather are the result of both what happens in moments (e.g., the strength of an opportunity to participate) and how the accrual of those moments shapes the kinds of opportunities that are subsequently offered (e.g., emergent expectations of students)” (2009, p. 366). For this reason, students must continue to be exposed to STEM experiences that will serve as positive dispositional moments of accrual, particularly those that encourage participation from all students. In looking to the future, this goal, and questions about how to best achieve it, will be at the fore of our continued efforts.

Three other points are worth reiterating based on the results above. First, the across-group analysis showed very little linear or monotonic correlation between student and parent self-reported scores at any of the time periods studied. These findings are both a blessing and a curse: while the lack of correlation suggests that students of parents with negative views can still be swayed to a career in STEM, it simultaneously implies that students of parents with very positive views may not necessarily share those pro-STEM sentiments. As such, each student must be approached as his or her own person, with his or her own disposition toward STEM, which, while perhaps *influenced* by parental dispositions, is certainly not *determined* by them. Second, the qualitative findings suggest that significant scheme reformation may occur in students even in a short-term intervention. This result should inspire those to action who have only limited resources or time, for even half-day events can have an effect on changing student and parent attitudes. Finally, it is hoped that the methodological framework followed in this paper might provide a model for others moving forward. More specifically, this paper aimed to leverage more powerful statistical techniques than are usually brought to the table in similar studies. It also used both quantitative and qualitative analyses to show both that changes were occurring and what those changes looked like, and it organized the structuring and assessment of a local-level program around a set of three clearly-articulated objectives: STEM Awareness, Pathway, and Philosophy. It is also important to note that three goals jointly speak to the timeline of the human experience: Philosophy is largely a construction of past experiences (with some current shaping); Awareness concerns a student's understanding of a subject in the present; and Pathway refers to future-directed activity (goals, dreams, imagery, progressions – and how to achieve these). Using a set of objectives that recognized the *totality* of the human temporal experience was seen as crucial in answering the call to assuage the STEM crisis in America. That is, to ignore any of these components seems especially foolhardy, for while capturing a student's interest in the moment (Awareness) is important, any positive gains will dissipate over time if not paired with an understanding of how to realize such interest in later career work (Pathway). In addition, generating this interest (Awareness) is difficult if not presented in a way that speaks to the dispositions of those that are targeted (Philosophy). Finally, it makes little sense to craft a productive vision of the future (Pathway) without first recognizing and leveraging the important past experiences (Philosophy) upon which this vision will rest. Taken together, these three objectives fully sample from the temporal aspect of students' experiences and realize important synergies for enacting change.

Many questions remain for further study. For example: will the quantitative and qualitative results seen above continue to hold for larger sample sizes? In addition, what value can be leveraged from the demographic data collected (but not analyzed for this paper)? Another topic for exploration concerns the local nature of this intervention. While many of these design choices were articulated above, what additional resources and approaches could be invoked to better connect with middle school Hispanic/Latino students in the San Diego area? Perhaps most critically, further work must be done to understand the long-term effects of short-term interventions. Laursen, Liston, Thiry, and Graf (2007) have noted the challenges inherent in such longitudinal efforts citing the logistical complexities of tracking students over decade-long stretches as well as parsing the large number of factors ultimately responsible for shaping a person's career trajectory.

On a final note, both authors sincerely hope that the results, the methodological framework, or even some of the future questions above will inspire other educators to create their own STEM outreach programs or to do research on these in an effort to better inspire America's children to careers in science, technology, engineering, and mathematics. While the Spanish Night program touches only a small sector of San Diego, its influence is dramatically felt by its participants, as evidenced in the qualitative analysis above. With additional efforts of this nature, issues of equity will begin to be backgrounded (Gutiérrez, 2007), and the million-scientist shortfall discussed in the 2012 PCAST Report will fade into distant memory.

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