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Effectiveness of a Precollege STEM Outreach Program

Bin (Brenda) Zhou

Abstract

Workforce shortages in the field of science, technology, engineering, and math (STEM) have led to an increasing need for STEM outreach programs for high school students. This article presents an integrated approach to such efforts; government agencies, the host university, and local professional associations play meaningful roles in program design and implementation. This article also evaluates program effectiveness in increasing high school students' likelihood of studying STEM in college. Opening and end-of-program surveys, coupled with demographic data, provided rich information on participants' backgrounds and their responses to STEM exposure and intervention. A discrete choice model discovered participants' differential valuation of program effectiveness and quantified the factors that influenced participants' pursuit of STEM college education due to program participation. In addition to demographics and family culture, overall program experience is critical to the perceived benefits of STEM exposure. Findings can help educators and outreach program directors develop appealing STEM outreach curriculum.

Keywords: STEM, precollege, high school students, discrete choice model, program evaluation

A well-educated STEM workforce is critical to maintaining U.S. competitiveness in today's global economy (National Academy of Sciences et al., 2007, 2010). Many precollege outreach programs have been developed and implemented nationwide to attract high school students to the STEM pipeline. This evidence-based practice article presents an integrated approach to this effort and evaluates the effectiveness of a 1-week, nonresidential summer program using various statistical analysis techniques.

The National Summer Transportation Institute (NSTI) program is one of the Federal Highway Administration's (FHWA) educational initiatives. It is "designed to introduce secondary school students to all modes of transportation careers anden-courage them to pursue transportation-related courses of study at the college and/or university level" (FHWA, 2016). The NSTI program presented in this article is fully funded by FHWA and is implemented with remarkable contributions from the state Department of Transportation (DOT), professional associations, and faculty at the host university. The host university is a regional, comprehensive public university, and has a tradition of serving a diverse student body. It conducts the NSTI program under the leadership of a project director who implements the day-to-day activities and ensures compliance with rules and regulations. Local chapters of the Women's Transportation Seminar and the National Society of Black Engineers are invited to deliver presentations, talk about real-life projects, and share insightful perspectives with young program participants. State DOT manages the program and offers field trip planning and coordination. This practice demonstrates an integrated approach to promoting STEM educational and career opportunities among high school students.

Precollege outreach activities promoting STEM disciplines among K-12 students are abundant. Jeffers et al. (2004) summarized over 50 engineering outreach programs with various scopes and diverse target groups. More recently, the effectiveness of precollege outreach programs in attracting high school students to the STEM pipeline has been measured and documented.

STEM outreach programs generally have positive impacts on participants' understanding of STEM and/or attitude toward STEM disciplines. For example, based on responses from about 250 high school students over several years, Crittenden et al. (2011) concluded that the "Launching Into Engineering" program helped over 75% of participants decide to pursue a STEM degree in college. Goonatilake and Bachnak (2012) found that participants in the "Engineering Summer Program" performed remarkably well on posttests compared to on the same pretests. A histogram showed that the majority of participants either strongly agreed or agreed that the program had encouraged them to go to college and/or to become an engineer. Boynton and Hossain (2010) also used pretests and posttests to show that a hands-on engineering class at a rural high school had a positive impact on students' understanding of the subject matter and the importance of STEM. In addition, a control class was used to demonstrate the effectiveness of a hands-on engineering curriculum. Christie (2012) used a percentage distribution and showed participants' improved understanding of what engineers do from 11 years of "Science and Engineering Community Outreach Program." Constan and Spicer (2015) also used percentage distributions to report participants' increased interest in science and influenced career plans or future course selections after attending the "Physics of Atomic Nuclei" program. Applying similar statistical analysis techniques, Kuhl et al. (2015) presented positive influence of both in-lab and online "Relevant Education in Math and Science" activities on participants' understanding of engineering and interest in math and science courses. Some studies took a further step and examined parental knowledge of engineering and/or attitudes, since parents play an important role in their children's education and career path decisions (Christie, 2012; Goodman & Cunningham, 2002; Klein-Gardner, 2014).

In terms of attitude shift, Nadelson and Callahan (2011) examined two engineering outreach programs for adolescents and applied a paired samples t-test using a repeated measure (e.g., pre- to postprogram) of participants' engineering perceptions and attitudes as well as their college attitudes. They discovered a significant change in engineering perceptions and attitudes but a marginally nonsignificant change in attitudes toward college education. Applying a similar analysis technique, Huang et al. (2015) found a moderate positive impact of STEM outreach activity on participants' attitudes toward STEM disciplines.

Many prior studies revealed positive impacts of precollege outreach programs in attracting high school students to the STEM pipeline, but very few analyzed multiple factors in young people's pursuit of STEM higher education. One notable study conducted by Constan and Spicer (2015) utilized a propensity-score matching technique to evaluate the effectiveness of outreach programs. Program participants were matched to students from the National Center for Education Statistics 2002 Educational Longitudinal Study. A logistic regression model suggested that the likelihood of program participants' pursuing STEM college education was nearly nine times greater than that of the comparison group (i.e., nonparticipants). However, only one explanatory variable, program participation, was included; other relevant variables were used in the propensity-score matching technique and therefore can't provide any insights on how they affected program participants' likelihood of studying STEM in college. Zhou et al. (2017) analyzed perceptions and preferences of high school students in STEM and used an ordered probit model to study likelihood of pursuing college education in STEM. They focused on probabilities of studying STEM in college among all program participants but didn't examine the impact of their outreach program on participants' pursuit of STEM college education or, in other words, the change in participants' probabilities of studying STEM in college due to program participation.

This article fills in this knowledge gap by examining multiple factors affecting a precollege outreach program's effectiveness at promoting STEM college education among participants. Opening and end-of-program surveys in two consecutive years of the NSTI program, as well as an alumni survey,

<table>
<tr><th colspan="6">Table 1. Sample NSTI Program Schedule</th></tr>
<tr><th>Time</th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>8:00–8:30</td><td rowspan="2">Welcome & Survey</td><td rowspan="2">SAT Preparation</td><td rowspan="2">SAT Preparation</td><td rowspan="2">Admissions & Career Services</td><td rowspan="4">Helicopter Simulation</td></tr>
<tr><td>8:30–9:00</td></tr>
<tr><td>9:00–9:30</td><td rowspan="2">Professional Organizations</td><td rowspan="2">Aircraft Operations</td><td rowspan="4">Spot Speed Study</td><td rowspan="6">Bridge Design & Lab</td></tr>
<tr><td>9:30–10:00</td></tr>
<tr><td>10:00–10:30</td><td rowspan="2">Team Building & Exercise</td><td rowspan="4">Aircraft Design & Wind Tunnel Test</td><td rowspan="4">Field Trip</td></tr>
<tr><td>10:30–11:00</td></tr>
<tr><td>11:00–11:30</td><td rowspan="2">Guest Speakers</td><td rowspan="2">Traffic Simulation & Operation</td></tr>
<tr><td>11:30–Noon</td></tr>
<tr><td>Noon–12:30</td><td rowspan="3">Orientation Luncheon</td><td rowspan="2">Lunch</td><td rowspan="2">Lunch</td><td rowspan="2">Lunch</td><td rowspan="2">Lunch</td></tr>
<tr><td>12:30–1:00</td></tr>
<tr><td>1:00–1:30</td><td rowspan="6">State Pier & Airport Field Trips</td><td rowspan="2">River Systems in the U.S.</td><td rowspan="4">Steel &Tensile Test Lab</td><td rowspan="6">DOT Visit & Graduation Ceremony</td></tr>
<tr><td>1:30–2:00</td><td>Livable Communities</td></tr>
<tr><td>2:00–2:30</td><td>Federal Aviation Admin.</td><td rowspan="4">Lock and Dam System</td></tr>
<tr><td>2:30–3:00</td><td>Transportation Safety</td></tr>
<tr><td>3:00–3:30</td><td rowspan="2">Campus & Lab Tour</td><td rowspan="2">Intelligent Transportation Systems</td></tr>
<tr><td>3:30–4:00</td></tr>
</table>

provided the primary data source. Discrete choice modeling and statistical analyses tools were used to discover and quantify the impacts of multiple influencing factors in program participants' pursuit of STEM higher education.

Program Summary

The NSTI program is a 1-week, nonresidential program for high school students (rising 9–12 graders). Program details undergo refinements and improvements each year, but the basic curriculum remains the same, including lectures led by professors, hands-on laboratory exercises tailored to engage teenagers, presentations by transportation practitioners, and field trips to state landmark projects. Three educational modules are designated as land, water, and air transportation modes, and are enriched by hands-on laboratory exercises. Depending on schedules, the NSTI program may include concrete and steel material labs, a spot speed study, an engineering surveying exercise, public speaking and presentations, and entrepreneurship. In addition, field trips, SAT preparation, and team-building exercises are vital components of the program. Table 1 shows a sample program schedule.

The NSTI program is well supported by government agencies, the host university, and local professional associations. Different entities play special and meaningful roles, presenting an integrated approach to stimulating high school students' interest in STEM. Notable features of the program are the orientation luncheon and the graduation ceremony. During the orientation luncheon, students mingle with established professionals who have a vested interest in the students' educational and career aspirations. Students officially "graduate" from the NSTI program at a graduation ceremony hosted at state Department of Transportation (DOT) headquarters. These two events have been well received by the students and their guests at the graduation ceremony.

A website dedicated to this NSTI program serves as a powerful tool in program marketing and student recruitment efforts. Pictures from previous years, as well as the current year's tentative schedule, program flyer, and application form, are posted on this website to showcase this fun and worthwhile program. Program participants are selected primarily based on teacher letters of recommendation and student essays. However, this NSTI program focuses on attracting historically underrepresented groups. Different strategies are utilized to ensure success in recruiting a group of high school students with diverse demographic backgrounds, such as seeking assistance from other educational programs that have similar missions.

This NSTI program has two surveys: an opening survey on the first day and an end-of-program survey on the last day. Coupled with demographic information collected at the student recruitment stage, these two surveys provide rich information on participants' perceptions and preferences in STEM college education. Findings from the surveys can help educators and summer program directors develop curriculum activities that match the preferences and learning styles of high school students, thus stimulating greater interest in STEM.

Data Description

The primary data sources for this study are the opening and end-of-program surveys conducted in two consecutive years. Survey instruments were developed based on assessment requirements and research hypotheses, and were tested 1 year before the data used in this article were collected. In these two surveys, students were asked to self-report their academic and family backgrounds, evaluate their STEM knowledge improvements, assess program educational instruments, and provide written comments.

A total of 41 high school students participated in this NSTI program over 2 years. In general, the program participants represent historically underrepresented groups, such as female, minority, and/or low-income households. For example, 31.7% of the students (13 out of 41) were female, and 65.8% (27 out of 41) reported themselves as not being Caucasian, with 36.6% self-reporting as African American and 7.3% as Hispanic. In addition, 24.4% of students (10 out of 41) reported their annual household income as less than $30,000.

In the following discussions, sample size is reduced from 41 to 35 because six students did not fully complete either the opening survey or the end-of-program survey. Among these six students, two voluntarily opted out of both surveys, one didn't complete the opening survey, and three missed the graduation ceremony when the end-of-program survey took place. The sample size is relatively small, but is believed to be sufficient for the distribution analyses in program assessment. A small sample size in discrete choice modeling, presented in the Methodology and Results section, normally reduces the number of significant explanatory variables in empirical studies. However, this effect is not detrimental here because the final model identifies proper influencing factors with expected effects and the results are meaningful to educators in the precollege outreach program community.

Educational and occupational information about participants' parents and relatives (e.g., siblings, grandparents, uncles, aunts) revealed the family culture of program participants. A remarkably high percentage of participants' parents graduated from college: 61.0% of the mothers graduated from college, as compared to a national average of 32.7% for females age 25 and over who have at least a bachelor's degree, and 58.5% of the fathers graduated from college, as compared to a national average of 32.3% (Ryan & Bauman, 2016). In addition, many participants were exposed to STEM in their early years because their parents or relatives worked in a STEM-related field. Of the 35 participants, 17.1% had mothers who worked in a STEM-related field; 42.9% had fathers in STEM-related fields; and 48.6% had relatives working in a STEM-related job. These numbers are significantly higher than the 6% figure provided by the U.S. Census Bureau for participation in STEM fields in the total civilian workforce aged 25 to 64 (Landivar, 2013). It is obvious that family culture played a critical role in these high school students' interest in STEM; parents' college attainment and early exposure to

STEM significantly increased high school students' participation in STEM outreach programs that could improve their readiness for a relatively challenging but rewarding STEM college education and career path. Table 2 summarizes the demographics and family background of program participants.

Overall, this NSTI program was well received and deemed helpful by program participants. Of the participants, 51% (18 out of 35) rated their satisfaction level with their overall experience as "highly satisfied," 46% (16 out of 35) responded that they were "satisfied," none were "partially satisfied," and 3% (1 out of 35) were "not satisfied." When asked whether they agreed that this program improved their knowledge of STEM, 66% (23 out of 35) responded that they "strongly agree," 31% (11 out of 35) said they "agree," one student (3%) chose "partially agree," and none of the participants selected "not agree." The single unsatisfied student in the overall experience "partially agreed" that this program improved the student's knowledge of STEM, indicating that the NSTI program has positive impacts on high school students even when they have already decided not to study STEM in the future. A close examination of participant written comments reveals the single unsatisfied student focused on the transportation theme of this program when reporting dissatisfaction; this student wrote, "I do think there were some aspects to this program that I did take away from but honestly, I wasn't completely drawn towards taking transportation engineering as a major in the future." Table 3 summarizes the assessment results.

Methodology and Results

One NSTI program goal set by FHWA is to encourage participants to "pursue transportation-related courses of study at the college and/or university level" (FHWA 2016). The end-of-program survey shows that 46% of the participants (16 out of 35) "strongly agree," 34% (12 out of 35) "agree," 17% (6 out of 35) "partially agree," and 3% (1 out of 35) do "not agree" that this NSTI program made them more likely to choose a STEM major in college. A key research objective is to discover and quantify the factors that influence participants' pursuit of college education in STEM as a result of program

Table 2: Demographics and Background of Program Participants

	Percentage
Female	32.0
African American	36.6
Hispanic	7.3
Mother graduated from college	61.0
Father graduated from college	58.5
Mother works in a STEM field	17.1
Father works in a STEM field	42.9
Relatives work in a STEM field	48.6

Table 3: Percentage Distributions of Program Participants' Responses

How would you rate your overall experience with this NSTI program?	**Highly Satisfied**	**Satisfied**	**Partially Satisfied**	**Not Satisfied**
	51%	46%	0%	3%
Do you agree that this NSTI program improved your knowledge of STEM?	**Strongly Agree**	**Agree**	**Partially Agree**	**Not Agree**
	66%	31%	3%	0%
Number of observations	35			

participation. Understanding these factors can help us evaluate the effectiveness of such interventions and design outreach activities to stimulate greater interest in STEM college education.

The responses to this survey question are offered in an ordered fashion. More specifically, when asked whether they agree that this NSTI program made them more likely to pursue college education in STEM, participants could choose from four ordered alternatives: "not agree," "partially agree," "agree," and "strongly agree." Because the data is based on rank ordering, an ordered probit model was selected to determine the influencing factors and to quantify their effects on the effectiveness of this precollege outreach program.

An ordered probit model is a member of a large family of discrete choice models that have been widely applied in economics, marketing, transportation planning, and similar fields. The model is built based on a random utility maximization framework and utility function for an individual Ui, defined as

$$U_i = \boldsymbol{x}_i \, \beta + \epsilon_i$$

where $\boldsymbol{x}_i$ is a row vector of explanatory variables for an individual *i*, β is a column vector of parameters to be estimated, and ϵ_i is the random component of individual *i*'s utility function. The error term ϵ_i is assumed to follow a normal distribution with zero mean and unit variance. Utility is unobserved, but based on the choice individual *i* made (assuming four ordinal alternatives, categorized into 1, 2, 3, and 4), the following can be derived:

Chosen alternative = 1 if $U_i < \mu_1$
Chosen alternative = 2 if $\mu_1 < U_i < \mu_2$
Chosen alternative = 3 if $\mu_2 < U_i < \mu_3$
Chosen alternative = 4 if $U_i > \mu_3$

where μ_1, μ_2, and μ_3 are unknown threshold values to be estimated. Because the error term (ϵ_i) is normally distributed, the probability of choosing each alternative can be represented as follows:

Probability (Chosen alternative = 1) = $\Phi(\mu_1 - x_i \beta)$
Probability (Chosen alternative = 2) = $\Phi(\mu_2 - x_i \beta) - \Phi(\mu_1 - x_i \beta)$
Probability (Chosen alternative = 3) = $\Phi(\mu_3 - x_i \beta) - \Phi(\mu_2 - x_i \beta)$
Probability (Chosen alternative = 4) = $1 - \Phi(\mu_3 - x_i \beta)$

where Φ() is a standard normal distribution function. These probabilities enter the log form of a likelihood function, and maximization of this likelihood function gives estimates of the parameter (β) and the threshold values (μ_1, μ_2, and μ_3). For more details on ordered probit model specifications, readers may wish to refer to Greene's (2000) econometrics textbook.

All relevant explanatory variables, including demographics (e.g., gender, race, household annual income, household size, and number of children), family background (e.g., parent educational attainment, parent and relative occupations), past participation in STEM-oriented programs, and overall program experience, were included from the start. Explanatory variables offering *p*-values of more than 0.10 were removed in a stepwise fashion because their impacts were statistically insignificant or their influences were not statistically different from zero. Many explanatory variables did not meet the test of statistical significance, but a few remained. The following paragraphs discuss the estimated model results.

In the end-of-program survey, participants were asked whether they agreed that this NSTI program made them more likely to pursue college education in STEM; the four ordered alternatives were "not agree," "partially agree," "agree," and "strongly agree." As explained above, all possible influencing factors were considered from the start, and some were categorized into groups before model estimation. For example, satisfaction with the program experience was also categorized into four groups: not satisfied, partially satisfied, satisfied, and highly satisfied, with a higher value meaning a higher level of satisfaction.

Final model results are shown in Table 4. A participant whose mother graduated from college was found more likely to pursue a college education in STEM after attending this NSTI program, as shown by the positive coefficients to the "mother graduated from college" explanatory variable. The explanatory variable "African American" has a negative coefficient, indicating the negative impact of this demographic factor on participants' perceived benefits from this STEM exposure. In other words, with all other factors being the same, African American participants were found less likely to pursue

Table 4: NSTI Program's Impacts on Likelihood of Pursuing College Education in STEM		
Explanatory Variables	**Coefficients**	***t*-statistics**
Mother graduated from college	0.833	1.94
African American	-0.966	-2.25
Satisfaction with the program	0.964	2.73
Threshold 1	0.871	
Threshold 2	2.47	
Threshold 3	3.66	
Number of observations	35	
Pseudo R^2	0.174	

college education in STEM due to program participation.

This model also discovers one important influencing factor: the overall program experience. The coefficient to "satisfaction with the program" is positive, indicating that participants who are more satisfied with their program experience are more likely to pursue a college education in STEM due to program participation than participants who are less satisfied. More importantly, this influencing factor is "external" to program participants' backgrounds, and therefore provides educators and outreach program directors with an opportunity to intervene. It is also worth noting that this influencing factor's coefficient is comparable to those of the family background factors discussed previously, meaning a small change in this factor can generate a relatively big change in the effectiveness of such interventions. For example, if a participant's program satisfaction increases by one level (e.g., from "partially satisfied" to "satisfied"), the impact on likelihood of pursuing college education in STEM is similar to that of a participant's mother being a college graduate. This finding has a significant implication: It is imperative that such outreach programs be designed with engaging activities that help participants better understand basic principles and exciting applications. Only when participants are both excited by and satisfied with their experience can these outreach programs achieve their goal of increasing the STEM pipeline.

The estimated model results also suggest that gender is statistically insignificant in participants' differential valuation of program effectiveness, indicating that this program offers essentially the same impact on both boys and girls when the other three explanatory variables—"mother graduated from college," "African American," and "satisfaction with the program"—are the same. It is worth noting that this NSTI program enjoys significant contributions from female professionals and associations targeting underrepresented minorities, such as the Women's Transportation Seminar. Their participation exposes underrepresented minority students to successful role models, which is believed to have positive impacts on their pursuit of STEM (Hill et al., 2010).

Like many other precollege outreach efforts, this NSTI program has limited space and therefore the sample size in this study is relatively small. Small sample sizes generally have a negative impact on significance level of explanatory variables in statistical models, meaning fewer influencing factors can be identified in empirical studies. This research includes many "potential" explanatory factors, such as demographics (e.g., gender, race, household annual income, household size, and number of children), family background (e.g., parent educational attainment, parent and relative occupations), and overall program experience. Many of these "potential" factors are eventually removed from the model specification due to low level of statistical significance. Only three factors in this study have been found statistically significant: "mother graduated from college," "African American," and "satisfaction with the program," indicating that any changes to these three variables will affect participants' likelihood of pursuing college education in STEM (or the effectiveness of this precollege outreach program).

The end-of-program survey collected written comments from participants. Consistent with the assessment results presented in the Data Description section, participant comments were remarkably positive. More significantly, these comments further support the model results discussed previously. For example, one student wrote:

> I really liked this program. It helped me better understand what different fields of engineering do and opened my eyes to how important transportation engineering is. It also helped me figure out that I want to pursue a career in civil engineering, and maybe more into a transportation-oriented career.

Another participant commented: "I love that this program exposed students to a wide range of engineering fields. This has definitely opened my horizons to engineering as a possible career!"

In addition, these written comments shed light on how to increase satisfaction with the program, which could increase participants' likelihood of pursuing college education in STEM, according to the model results. Apparently, high school students enjoy hands-on activities and embrace the idea of a competition when learning STEM concepts. Supporting comments from participants included the following: "I really enjoyed all of the hands-on experiences like with the lab and the competitions. It was fun working with others and/or doing our best to win, as well to use quick-thinking for when there was pressure with time" and "Labs building the lock & dam system and building a balsa wood bridge were extremely helpful in understanding and being able to apply the concepts we learned during presentations." Moreover, contributions from the professional associations were noted by participants. One student wrote: "I liked how the speakers made interesting conversation with the students in the program. The personal advice they provided was very helpful in developing my ideas for future choices for college and profession."

College Education of Program Alumni

In addition to better understanding of STEM, improved attitude toward STEM, and self-reported increased interest in STEM, many precollege outreach programs have been reported to result in encouraging outcomes in terms of program alumni's college pursuits. For example, a follow-up survey conducted by Kaye et al. (2011) found that all program alumni who responded to the survey attended college, with a high percentage (20 out of 24) studying science. Christie (2012) contacted 165 out of 206 program participants from a 10-year time span; among them, 164 attended college and 111 chose a STEM major. Zhe et al. (2010) surveyed all 33 program alumni. Of the 21 alumni who graduated from high school, all attended college and 18 chose a STEM major.

The NSTI program alumni were invited to complete a follow-up survey 1 year or 2 years after they finished the program. This survey was designed to determine the long-term effects of this outreach program on participants' STEM readiness and their actual college education choices. All 35 NSTI alumni who completed both the opening and end-of-program surveys were contacted to take an online survey in fall 2016. A total of 23 completed the survey, resulting in a response rate of 66%. Among the 10 alumni who were in a position to make a college decision, all had chosen to attend college and nine (or 90%) chose a STEM major. This finding is consistent with the findings in prior studies.

In addition, all 13 NSTI alumni who were still in high school reported the highest likelihood of pursuing college education from among the five response alternatives: "very likely" (> 80% chance), "probably" (80–60% chance), "decent chance" (59–40% chance), "maybe" (39–20% chance), and "probably not" (< 20% chance). When asked how likely it was that they would choose a major in STEM, 11 (out of 13) chose "very likely" and two chose "decent chance." Like the actual college education data, these self-reported responses by the NSTI program alumni demonstrate encouraging college education and field of study preferences.

Conclusions

The National Summer Transportation Institute (NSTI) program presented in this article takes an integrated approach to raising participants' awareness of STEM educational and career opportunities. Government agencies, the host university, and local professional associations make significant contributions to the program development and implementation. This integrated approach is effective at convincing students that a STEM college education is feasible and rewarding by providing them with diverse perspectives.

Many prior studies have examined the impacts of precollege outreach programs, but a quantitative approach to measuring the effectiveness of such programs for participants with diverse backgrounds and different program experiences is lacking. This article fills in this knowledge gap by examining multiple factors affecting a NSTI program's effectiveness at promoting STEM college education.

Program participants had diverse demographic and academic backgrounds, but offered consistent and positive program evaluations. About 97% of the participants (34 out of 35) rated their overall satisfaction level as "highly satisfied" or "satisfied," about 97% (34 out of 35) responded that they "strongly agree" or "agree" that this NSTI program improved their knowledge of STEM, and 80% (28 out of 35) responded that they "strongly agree" or "agree" that this NSTI program made them more likely to choose a STEM major in college. These statistics show that this precollege outreach program fulfilled its mission. However, the effectiveness of this program at increasing pursuit of college education in STEM fields varies, as demonstrated by the discrete choice model that is estimated using the same data set.

This study found that the effectiveness of this outreach program differed based on demographics and satisfaction with the program. Discrete choice model results reveal that family played a critical role in participants' perceived benefits from the intervention: Participants whose mothers graduated from college were more likely to pursue college education in STEM after attending this NSTI program, and African American participants were less likely to do so. This study identified at-risk groups in STEM education, such as African American students and high school students whose mother didn't graduate from college. Special strategies and/or techniques are warranted in order to promote STEM among these students. Exploring such strategies is beyond the scope of this study, but it is a topic that deserves more attention from educators and researchers in this field.

More importantly, this study discovered and quantified an "external" influencing factor, participant's overall satisfaction with the program, as compared to demographic factors that often take decades to change. This finding provides educators and outreach program directors an opportunity to intervene. Participants' satisfaction is estimated to have a relatively high impact on program effectiveness, which means a small change in this factor can generate a relatively big impact. This finding has an important implication: Outreach programs need to be designed with engaging curriculum activities that match high school students' preferences and learning styles. A challenging yet attractive STEM curriculum is critical to the effectiveness of a precollege outreach program. A close examination of the written comments from the participants reveals that high school students enjoy hands-on activities and embrace the idea of a competition. In addition, interactions with professionals inspire high school students and help them develop ideas for future education and career choices.

As discussed previously, this NSTI program generated a relatively small sample size in two consecutive years. Such limitation has a minimal impact on the overall program assessment using distribution analyses, but can result in a reduced number of significant explanatory variables in the discrete choice model. Even though many factors were initially considered, including demographics, family background, past participation in STEM-oriented programs, and overall program experience, only three factors remain in the final model specification. Identifying and quantifying these influencing factors has produced a meaningful result, but this study can be improved by using a larger sample size. One way to increase sample size is to collaborate with other NSTI host universities, which will require curriculum design coordination and survey questionnaire revision; another way is to cumulate more data over time, which will introduce time effects in the analyses. Both methods have advantages and disadvantages, and should be evaluated carefully before initiating the next stage of this research.

This study analyzed two state-preference surveys: the opening survey and end-of-program survey. Respondents tend to exaggerate potential benefits in a state-preference survey, resulting in optimism bias (e.g., Fifer et al., 2014; Hensher, 2010; List & Gallet, 2001; Murphy et al., 2005). Therefore, findings of benefits of the NSTI program are subject to such inherent bias. The alumni survey is designed to address this issue by examining alumni's actual college education and study area choices. This survey also includes questions on alumni's college education decision-making process and their long-term evaluations on the program effectiveness, which provide key data for future research efforts.

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About the Author

Bin (Brenda) Zhou *is a professor in the Department of Engineering at Central Connecticut State University. Her research interests include quantitative analyses, modeling techniques, and research in STEM education and precollege outreach. She received her PhD in civil engineering from the University of Texas at Austin.*

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