2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #37704

Examining the impact of a summer engineering program on academic self-efficacy

Dr. Edward Collins, National Society of Black Engineers

Edward Collins serves as Director, Programs and Research for the National Society of Black Engineers (NSBE). He has experience and research interests in student learning and assessment, and college student choice. Edward obtained his doctoral from the University of Nevada, Las Vegas, master's from the University of New Orleans, and bachelor's from Louisiana State University.

Dr. Rochelle L Williams, National Society of Black Engineers

Rochelle L. Williams, Ph.D. is the Chief Programs Officer at the National Society of Black Engineers.

Examining the impact of a summer engineering program on academic self-efficacy

Introduction

The economic future of the U.S. will depend on engineers, as they are critical in providing solutions to the world's environmental, medical, and technological challenges. However, fulfilling these roles will be challenging due to the lack of early access, STEM inspired education for underrepresented students, and the growing lack of interest in STEM careers [1], [2]. Thus, it becomes immensely important to introduce students to these fields during their elementary and secondary education, to develop their understanding of what individuals in these fields do and demonstrate pathways that can lead to their future pursuit and success in STEM occupations [1].

Building students curiosity in science and engineering often begins with their own capabilities. Students who believe in their abilities also tend to be more engaged and find the topics more interesting [3]. Increasing students' confidence in themselves and their academic ability helps them realize that their goals are achievable. Students' perception about their own capability of achievement affects their aspirations, fascination, and how well they prepare themselves for careers. When students have a high sense of self-efficacy—the belief in one's ability—they become motivated to act in ways that make their success more likely [4].

In engineering, there are different ways in which self-efficacy is measured. Three categories of self-efficacy measures used are: 1) general academic self-efficacy, 2) domain-general self-efficacy, and 3) self-efficacy measures for specific engineering tasks or skills [5]. General academic self-efficacy scales broadly assess engineering students' beliefs in their capabilities to perform academically or perception of their competence to do the work [5]. The second, adapted from general academic self-efficacy, domain-general self-efficacy asks students to rate their general confidence within a particular subject area of engineering [5]. Third, task- or skill-specific self-efficacy asks students to evaluate their confidence for performing specific engineering tasks [5].

This paper presents an evaluation of the 2021 Summer Engineering Experience for Kids program (SEEK), a summer program hosted by the National Society of Black Engineers (NSBE) designed to offer underrepresented students, not only access to a STEM curriculum, but to cultivate their academic self-efficacy in these fields. To determine the impact of the program, this paper examines the following research questions:

> RQ1. Does participation in SEEK improve students' academic self-efficacy? How does impact compare across gender?
>
> RQ2. How well does academic self-efficacy predict students' aspirations of becoming an engineer? For boys? For girls?

Background

NSBE created the SEEK program to inspire Black students through the many diverse opportunities and wonders of the STEM fields. SEEK is a free, three-week summer program that offers a fun and engaging educational experience for students in grades 3–5 that aims to provide high-quality learning opportunities to students from groups underrepresented in STEM.

Designed to be an engaging SEEK, traditionally an in-person program in communities across the country, completed its second year as a digital learning opportunity. SEEK has been called to reimagine how hands-on, virtual experiences can be scaled to accelerate student participation and cultivate science, technology, engineering and mathematics (STEM) engagement via curricula delivered remotely because of safety concerns related to the COVID-19 pandemic. With momentum from the 2020 Summer Engineering Experience for Kids (SEEK) program year, NSBE was able to secure funding that enabled the program to grow participation, create new partnerships that allowed expansion to middle school, and integrate the SEEK program into the summer school curriculum of a large public school system. SEEK is generally the first touchpoint participants have to the National Society of Black Engineers and, for many, their first exposure to engineering concepts.

Since 2007, the program has served more than 24,000 students. In Summer 2021, the virtual format created the opportunity for students all over the world to benefit from the program, and students from 42 U.S. states and six other countries — including Mexico, Canada, Germany, Nigeria, Kenya and Bermuda — did so. The pandemic and the continued racial unrest reinforced our vision for SEEK to: 1) offer participants greater exposure to STEM at an early age; 2) engage them daily in hands-on engineering design activities with mentor/teachers; and 3) fulfill NSBE's mission, *to increase the number of culturally responsible Black engineers who excel academically, succeed professionally and positively impact the community.*

Despite the distance, SEEK leaders continued to connect with students virtually and prioritize one-on-one conversations and outreach. To ensure students would be able to access the virtual curriculum, thousands of tablet computers were provided to the participants and their families, who were offered a free, downloadable curriculum for the hybrid learning experience. A hands-on design process and curriculum packet encompassing core engineering concepts provided guidance.

Facilitated by 89 mentors via Zoom, the curriculum promoted an active learning experience where students completed drone, robotics, and coding challenges. These mentors, many of whom are engineering majors and collegiate members of NSBE, are dedicated to pursuing professional excellence and giving back to the community through their work with the children.

Methods

Instrument

Items for this evaluation were developed and implemented by researchers in engineering education from Virginia Tech University and Purdue University. Items for the evaluations allowed researchers to study the effectiveness of SEEK and its organizational features. Multiple sources were consulted including Assessing Women & Men in Engineering, and the Friday Institute for Educational Innovation. The evaluation tool also draws on an instrument which determines how elementary students develop an engineering identity [6]. The Engineering Identity Development Scale (EIDS) is comprised of four factors: 1) academic self-efficacy, 2) school identity, 3) occupational identity, and 4) engineering aspirations [6]. For the purpose of this paper, only the first factor, general academic efficacy, is examined in SEEK participants.

To examine the influence SEEK had on participants, the EIDS was distributed as a pre and post-test survey. The EIDS was to be conducted once at the beginning and at the end of the program. The parents of students registered for the program received an email with the EIDS instrument, requesting that their student complete the evaluation. The pre-test was disseminated on the first day of the program and the post-test was disseminated on the last day.

Students were asked to rate themselves across 10 items, which are used as proxies for academic self-efficacy (see Table 1). They were asked to respond by selecting 'yes', 'sometime', or 'no'. The same question items and scale were used in both the pre and post-test.

Table 1. Academic Self-Efficacy

Question Item	Yes	Sometimes	No
I am a good listener.			
I am good at following instructions.			
I am good at working independently.			
I am smart.			
I believe I can be an engineer.			
I can do hard things.			
I can do well in math.			
I can do well in science.			
If I don't understand something, I ask a question about it.			
If something is hard, I try and try until I get it.			

3 = Yes; 2 = Sometimes; 1 = No

Participants

Of the 4000 plus registered SEEK participants, 1397 completed the pre-test and 836 completed the post-test. The table below shows the breakdown of participation by gender and grade. In both the pre and post-test groups, majority of the sample were comprised of boys (55%) and 5th graders (49% and 37% respectively).

Table 2. Survey completion by category

	Pre		Post	
Gender	**Count**	**Percent**	**Count**	**Percent**
Boys	770	55.3%	463	55.5%
Girls	622	44.7%	371	44.5%
Total	1392	100.0%	834	100%
Grade				
3rd Grade	264	18.9%	249	29.8%
4th Grade	450	32.2%	280	33.5%
5th Grade	683	48.9%	306	36.6%
Total	1397	100.0%	835	100.0%

Data Analysis

To answer RQ1, independent t-tests were used to compare the mean ratings of academic self-efficacy. This evaluation examined the full sample as not all participants completed the pre and post-test survey. The first t-test examined if there was a significant difference in the pre and post-test results of academic self-efficacy. Additionally, a second series of t-tests were conducted by gender to determine if SEEK impacted boys similarly to girls. The analysis was conducted for those identifying boys and a separate analysis for those identifying as girls. Cases where gender were not reported or disclosed were not included in the analysis.

To answer RQ2, standard multiple regressions were performed to determine how well the independent variables of the academic efficacy scale explain the variance of the dependent variable (i.e., students' desire of becoming an engineer). The same 3-point rating scale that was applied to the independent variables were also applied to the dependent variable – "When I grow up, I want to be an engineer."

Results

An independent t-test was conducted to compare the academic self-efficacy pre and post-test ratings of SEEK participants, for the overall sample, boys, and girls. Though small, there was only one significant difference in the pre-post scores for the overall sample where after the program students believed they could do well in science ($M = 2.788$, $SD = 0.429$; $t\ (1919) = 2.886$). Likewise, for boys, their belief that they could do well in science was also the only significant change ($M = 2.806$, $SD = .422$; $t\ (1077) = 2.536$) from the pre and post-test responses. However, for girls, there were no significant change across any areas of their academic self-efficacy.

Table 3. Overall Sample Independent t-test

Item	Test	n	Mean	SD	t
I can do well in math	Pre	1393	2.731	0.480	1.462
	Post	836	2.761	0.462	
I can do well in science	Pre	1393	2.732	0.482	2.886*
	Post	836	2.788	0.429	
I am good at working independently	Pre	1393	2.555	0.564	1.466
	Post	836	2.590	0.530	
I believe I can be an engineer	Pre	1393	2.791	0.484	-0.302
	Post	836	2.785	0.486	
I am a good listener	Pre	1393	2.605	0.515	0.459
	Post	836	2.615	0.520	
I am good at following instructions	Pre	1393	2.683	0.485	-1.141
	Post	836	2.658	0.504	
I can do hard things	Pre	1393	2.608	0.516	1.438
	Post	836	2.640	0.502	
If I do not understand something I ask question about it	Pre	1393	2.711	0.478	-0.1
	Post	836	2.709	0.477	
If something is hard I try and try until I get it	Pre	1393	2.671	0.510	-0.029
	Post	836	2.670	0.493	
I am smart	Pre	1393	2.942	0.249	0.642
	Post	836	2.949	0.221	

*p-value < .05

Lastly, this paper examines what areas of academic self-efficacy leads to students' desire of becoming an engineer as an adult. After entry of academic self-efficacy items as independent variables in the standard multiple regression model, findings show that the overall model explains 33% of the variance in aspirations to be an engineer ($F(10, 828)= 25.44$, $p < .001$). When considered together, the variables contributing the most predictive influence are gender, as boys show a greater likelihood of wanting to become an engineer ($\beta = .132$, $p<.001$), and if a student believed they could be an engineer, they had a greater likelihood of wanting to be an engineer ($\beta =.376$, $p <.001$).

In addition, multiple regressions also show that the greatest predictor for boys wanting to become an engineer "when they grow up", was the *belief* that they could become an engineer ($\beta= .375$, $p<.001$), and their persistence at continually trying something even though it may be difficult ($\beta= .095$, $p = .05$). The multiple regression model for boys explained 19% of the variance in the desires to become an engineer ($F(9, 454) = 13.38$, $p < .001$). Likewise, for girls, believing that they can be engineers ($\beta= .395$, $p<.001$) as well as asking questions when they do not understand something ($\beta= .018$, $p< .001$) were significant contributors in their desire of becoming an engineer. The overall model for girls explained 21% of variance of the desire to become an engineer ($F(9, 362) = 12.16$, $p <.001$).

Table 4. Overall Multiple Regression Model

Model	B	Std. Error	Standardized Coefficients β	t	Sig.
(Constant)	-.968	.258		-3.753	<.001
Gender	.212	.050	.132	4.217	<.001
I can do well in math	.018	.058	.010	.303	.762
I can do well in science	.058	.058	.031	.992	.322
I am good at working independently	.072	.051	.048	1.418	.157
I believe I can be an engineer	.612	.052	.376	11.686	<.001
I am a good listener	.068	.061	.044	1.107	.269
I am good at following instructions	.063	.063	.040	.994	.321
I can do hard things	.064	.056	.040	1.136	.256
If I do not understand something I ask question about it	.074	.056	.045	1.333	.183
If something is hard I try and try until I get it	.088	.058	.054	1.518	.130

Adjusted R Square = .226; $F(10, 828)= 25.44$, $p < .001$

Discussion

To increase the number of students entering engineering and science careers, it is necessary to provide opportunity and to stimulate interests in these fields at an early age. This paper shares an evaluation of NSBE's SEEK program that took place in 2021 and sought to determine the program's impact on academic self-efficacy. Results from the post-test show that there was modest growth within one area of students' belief that they could do well in science, however, this is perhaps mostly contributed to boys as they represented a majority of the sample. Identifying minimum and/or insignificant growth will allow NSBE leaders to focus on parts of the curriculum where measures can best be improved. However, because of the virtual format it is difficult to determine whether the modality contributed to the lack of growth. Authors have shared that there are a limited opportunities for vicarious experiences in online environments, and these learning comparisons can serve as a valuable means to form self-efficacy [7].

The findings of the multiple regression analysis indicate that student's efficacy that they can be an engineer is the greatest predictor for their aspirations of pursing engineering later in life. These findings further substantiate Bandura's work that by improving students' perception of their capabilities will lead to them pursuing their career goals [8]. Moreover, self-efficacy shapes academic and career preferences [9], and these preferences can wane if individuals do not perceive themselves capable of success in science and engineering courses [10].

.

References

[1] Kennedy, B., Hefferon, M. & Funk, C. (2018). Half of Americans think young people don't pursue STEM because it is too hard. Retrieved from https://policycommons.net/artifacts/617503/half-of-americans-think-young-people-dont-pursue-stem-because-it-is-too-hard/1598308/ on 04 Feb 2023.

[2] London, J. S., Lee, W. C., & Hawkins Ash, C. D. (2021). Potential engineers: A systematic literature review exploring Black children's access to and experiences with STEM. *Journal of Engineering Education*, 110(4), 1003– 1026. https://doi.org/10.1002/jee.20426

[3] Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2013). Motivation in education: Theory, research and applications (3rd ed.). Upper Saddle River, NJ: Pearson Education.

[4] Bandura, A. (1997). Self-efficacy in changing societies. Cambridge, England: Cambridge University Press.

[5] Mamaril, N.A., Usher, E.L., Li, C.R., Economy, D.R. & Kennedy, M.S. (2016), Measuring Undergraduate Students' Engineering Self-Efficacy: A Validation Study. J. Eng. Educ., 105: 366-395. https://doi.org/10.1002/jee.20121

[6] Capobianco, B.M., French, B.F., & Diefes-DU, H.A. (2012), Engineering Identity Development Among Pre-Adolescent Learners. Journal of Engineering Education, 101: 698-716. https://doi.org/10.1002/j.2168-9830.2012.tb01125.x

[7] Hodges, C.B. (2008), Self-efficacy in the context of online learning environments: A review of the literature and directions for research. Perf. Improvement Qrtly, 20: 7-25. https://doi.org/10.1002/piq.20001

[8] Bandura, A. (1997). Self-efficacy in changing societies. Cambridge, England: Cambridge University Press.

[9] Robnett, R.D., Chemers, M.M. and Zurbriggen, E.L. (2015), Longitudinal associations among undergraduates' research experience, self-efficacy, and identity. J Res Sci Teach, 52: 847-867. https://doi.org/10.1002/tea.21221

[10] Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities,participation, and aspirations in science, engineering, and medicine. Journal of Research in ScienceTeaching,47,564–582.doi: 10.1002/tea.20353

[11] National Research Council. (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics.* Committee on Highly Successful Science Programs for K-12 Science Education. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Table 5. Correlation table

	When I grow up I want to be an engineer	I can do well in math	I can do well in science	I am good at working independently	I believe I can be an engineer	I am a good listener	I am good at following instructions	I can do hard things	If I do not understand something I ask question about it	If something is hard I try and try until I get it
When I grow up I want to be an engineer	1.000	.186	.133	.143	.433	.153	.142	.159	.161	.186
I can do well in math	.186	1.000	.191	.208	.265	.223	.204	.289	.143	.184
I can do well in science	.133	.191	1.000	.100	.161	.124	.059	.177	.108	.139
I am good at working independently	.143	.208	.100	1.000	.096	.334	.320	.347	.141	.164
I believe I can be an engineer	.433	.265	.161	.096	1.000	.098	.085	.103	.158	.151
I am a good listener	.153	.223	.124	.334	.098	1.000	.612	.300	.255	.284
I am good at following instructions	.142	.204	.059	.320	.085	.612	1.000	.253	.221	.329
I can do hard things	.159	.289	.177	.347	.103	.300	.253	1.000	.174	.352
If I do not understand something I ask question about it	.161	.143	.108	.141	.158	.255	.221	.174	1.000	.380
If something is hard I try and try until I get it	.186	.184	.139	.164	.151	.284	.329	.352	.380	1.000