The Role of STEM Society Scholarships in Supporting the Retention and Persistence of Women in Engineering and Computer Science

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Introduction

Progress and innovation in STEM (Science, Technology, Engineering, and Mathematics) fields rely heavily on their ability to promote gender equality in all aspects of society [1]. Although strides have been made toward achieving gender equality, there remains a noticeable gap when it comes to the representation of genders in STEM (Science, Technology, Engineering, and Mathematics) fields – women constitute less than 30% of the graduates in these fields [2]. Research indicates that, between 2015 and 2018, the global average percentage of female students in higher education enrolled in engineering, manufacturing, and construction programs ranged between 6% and 7%, whereas in comparison, males accounted for 20-21% of enrollments [1], [2]. Moreover, there are several points where the trajectory path for females in STEM significantly decreases: when they enter higher education, when they enter the workforce, and when advancing to higher professional positions [3].

Chen [4] sheds light on the significant differences in the rates at which college groups tend to depart from STEM degree programs. Among those entering STEM fields at the bachelor's degree level, females had a higher likelihood to switch to a non-STEM field than males (32% and 26%, respectively), despite the fact that the dropout rate among males was higher than females (24% and 14% respectively). Statistics about education pipelines are not optimistic. The National Science Foundation (NSF) indicates that by the time students enroll in college, there is an imbalance between genders in STEM majors [5].

Data on doctoral recipients in STEM show that women are still underrepresented in most areas of STEM, aside from life sciences [6]. Women accounted for only 33.1%, 25.4%, and 24.9% of those majoring in physical and earth science, mathematics and computer sciences, and engineering, respectively [6]. The Pew Research Center found that fewer women compared to men in computer-related fields end up working directly in computer-related occupations – among women, 38% end up working in computer-related fields compared to 53% of males [7]. In terms of annual salaries, men working in STEM industries make, on average, $15,000 more annually than women in the same fields, with men earning around $85,000 per year while women earn $60,828 [8], [9]. Moreover, Latina and Black women in STEM face larger pay gaps as they earn an average of around $52,000 per year, which is roughly $33,000 less than their male counterparts [8]. Research has also shown that completing STEM degree requirements takes significantly more time compared to other fields of study, making financial support even more important for STEM student retention [10]. Women of color represent only 5% of all science and engineering doctorates and face many barriers that significantly impact their representation in STEM faculty positions – such statistics highlight the fact that women have yet to achieve gender equality across STEM disciplines [11], [12].

To bridge this gap, professional STEM societies have increasingly recognized the importance of supporting women in pursuing STEM education, often through scholarships [3]. Recognizing the need to recruit, retain, and advance a diverse workforce, professional organizations value

women's contributions to STEM fields [3]. Further, researchers note that scholarships are "transformational for female students of color pursuing careers in computer science" and a "crucial financial support encourage and assist women in their junior year to persist and complete their degrees" [13]. However, private STEM scholarships have recently faced criticism for potentially utilizing reverse sexism to boost women in a minority field [13]. Some argue that sex-based scholarships are "dirty money" and claim "reverse discrimination" on the basis of violating Title IX, a law that prohibits discrimination based on sex in educational programs and activities that receive federal funding [13].

Much of the existing literature on female engagement in STEM fields has primarily examined earlier stages of the pipeline via K12 school grade levels when students tend to be forming their career identities [14]. Scholars note that while research on early time points is critical to understanding the mechanisms that predict initial interest in STEM, mechanisms that potentially predict sustained engagement following initial career investment and demonstrated skill at the graduate level may also vary and should be explored [14]. Additionally, much of the literature on women in the STEM workforce compares women's employment trajectories to those of men and examines potential variations in women's retention relative to men's rather than generally what stimulates field commitment [15].

Thus, considering these two arguments – recognizing that more practical research is needed to better understand the ways that various mechanisms potentially predict sustained engagement and commitment in STEM [3] and the impact, use, and funding of scholarships [13], [14] – this study was undertaken to better understand the impact of scholarships offered through the Society of Women Engineers (SWE) on the academic trajectories of women in STEM. This research explores the educational pathways SWE scholarship recipients take and whether their scholarships influence their persistence and degree completion in STEM fields. The overarching research question is: What is the return on investment for SWE scholarships awarded to female STEM students, particularly students in engineering and computer science programs when considering the academic outcomes of recipients?

Literature Review

Chilly Climate

A "chilly climate" describes a situation where everyday inequalities, which may seem small or go unnoticed, have the potential to accumulate and negatively affect women's participation, making them doubt the value of their contributions [16]. Existing research indicates that "women often confront an unwelcoming environment, a cold campus or "chilly climate" and encounter gender bias on a regular basis, leading to women's dissatisfaction with their discipline's culture and lowering their confidence in relation to pursuing degrees in STEM fields." [17].

These circumstances can result in dissatisfaction, decreased confidence, and ultimately lower rates of degree completion [17]. For instance, Weinberger [18] surveyed college students majoring in non-IT degrees about their decision to avoid pursuing STEM majors. The findings showed that about one-third of women expressed their concerns about the classroom culture in

IT courses.

Furthermore, Margolis and Fisher [19] found that female computer science students at Carnegie Mellon University expressed dissatisfaction with their program culture, often indicating that women felt it overly perpetuated stereotypes associated with being a "computer geek," disregarding broader applications of the field that aligned more with their interests. The consequences of such chilly climates include underrepresentation of engineering faculty members and professionals within the field [16], gender pay gap [20], limited opportunities for career advancement when compared to men [16], and generally exhibit higher retention disparities when compared to other STEM fields – women leave the engineering profession at a disproportionately higher rate than men [21].

STEM Retention via Scholarships

Scholarships play a pivotal role in promoting diversity in STEM fields and addressing the gender disparity that has affected STEM disciplines [22]. At its core, scholarships provide equal opportunity through financial support to students who are pursuing STEM education [22]. These financial resources help alleviate the burdens that often discourage women from entering or continuing their studies in these fields. By removing barriers, scholarships ensure that aspiring female scientists and engineers can access quality education [22]. Moreover, research shows that scholarships act as a strategy to not only provide that pathway to access higher educational opportunities but also to narrow the gender gap disparity in STEM fields [23], [24] – specifically instances for every dollar earned by a man in STEM, a woman earns 14 cents less. According to the U.S. Government Accountability Office (GAO), women's interest in STEM is substantially affected by the presence of role models, having a sense of belonging, and access to resources, one being financial [25]. Research shows that efforts to recruit women through STEM scholarships show to be positive – gradually reducing feelings of isolation and discrimination – and STEM scholarship incentives ultimately increase the overall representation of women entering the STEM field [23], [24]. Furthermore, research into the retention of women in STEM indicates that elements such as a nurturing learning atmosphere, mentorship options, and financial assistance, can greatly impact women's determination to stay in these areas [24]. Scholarships offered by established STEM organizations like SWE can also help to tackle these factors, creating an environment that supports the retention of female expertise [8].

Methodology

For this study, researchers analyzed data from the National Student Clearinghouse (NSC) dataset [26]. The NSC dataset is maintained by an organization founded by the higher education community and contains voluntarily provided data from 97 percent of colleges and universities in the United States. It serves as a resource for understanding the college student population nationwide. This dataset was analyzed using Excel to examine information about women's educational pathways and outcomes, focusing on recipients of SWE scholarships and their academic progress and achievements from 2017 to 2023.

In line with other scholars, incomplete participant degree information and duplicate entries were encountered. For instance, for students who have been identified as completing a degree at a

given college, the field for the name of the degree completed was often duplicated or missing in the NSC data [27]. Furthermore, in line with other scholars, students may not be included in the NSC data often due to unreported enrollments that are indistinguishable from non-enrollments [27].

To mitigate and reduce potential margins of errors, the researchers (i) conducted data cleaning and preparation prior to data manipulation for each step of the data transformation process and (ii) utilized pivot tables in Excel for data manipulation [28]. This allowed for data combining between the NSC data and the demographic data on SWE scholarship recipients. Gender was not a variable in this analysis, as all the records in the dataset were women who had received SWE scholarships. Interactions and relationships between the two sets of data were examined. For example, scholarship recipients were matched with intended degrees from the scholarship data with NSC records on their educational pathways, including whether they switched to non-STEM fields or remained in STEM through graduation.

There were 1,209 scholarship recipients who had received at least one SWE scholarship between 2017 and 2022. Recipients who had received SWE scholarships in 2023 were not included because the students would have received those funds in fall 2023, which was the cutoff enrollment semester for analysis. NSC requires first and last names and birthdates to match student records. To ease records matching, each SWE scholarship recipient was assigned a unique identifier prior to the data request to NSC. Of the 1,209 SWE scholarship recipients, 482 had provided birthdates. NSC was able to match more than 80% of these records, resulting in 418 SWE scholarship recipients in the final dataset.

All SWE scholarship recipients were women who intended to pursue a degree in Engineering, Engineering Technology, or Computer Science (ECS) when they applied for the scholarship. When analyzing the NSC data, students who enrolled in or received a degree in ECS or STEM were categorized using the CIP codes listed in Table 1, which align with the NSF STEM CIP codes used for the LSAMP program. Most SWE scholarship recipients (359, or 85.9%) were intending to pursue an ECS bachelor's degree when they received their scholarship.

This paper focuses on these undergraduate SWE scholarship recipients. Table 2 provides the racial/ethnic breakdown of the 359 scholarship recipients and the SWE scholarship amounts awarded over the course of their undergraduate studies between 2017 and 2023.

Table 1: CIP Codes to Determine STEM and ECS Majors

CIP Code	**Instructional Program**	**ECS/STEM**
01	Agriculture, Agriculture Operations, and Related Sciences	STEM
03	Natural Resources and Conservation	STEM
04	Architecture and Related Services	STEM
11	Computer and Information Sciences and Support Services	ECS and STEM
14	Engineering	ECS and STEM

15	Engineering Technologies/Technicians	ECS and STEM
26	Biological and Biomedical Sciences	STEM
27	Mathematics and Statistics	STEM
30	Multi/Interdisciplinary Studies	STEM
40	Physical Sciences	STEM

Table 2: Profile of Undergraduate SWE Scholarship Recipients, 2017 to 2023

Race/Ethnicity	% Representation
Asian or Pacific Islander	5.1%
Black or African American	12%
Hispanic or Latino/a/x	9.2%
Indigenous/Native/Aboriginal	1.1%
Multiracial (Two or More Races)	4.5%
White	47.1%
Other, including No Response	20.9%
Scholarship Amounts*	
$1,000 to $2,499	25.8%
$2,500 to $4,999	20.1%
$5,000 to $7,499	50.1%
$7,500+	4.0%

* Some recipients received multiple SWE scholarships between 2017 and 2023.

Findings

To evaluate the return on investment of scholarships for women in STEM, particularly in ECS, the undergraduate SWE scholarship recipients' graduation and retention pathways from 2017 to 2023 were analyzed. Those who had not graduated and were still enrolled in an undergraduate degree program in Fall 2023 were considered to still be pursuing their degrees - a positive finding, particularly if they were still enrolled in an ECS or STEM program. Table 3 provides the results of this analysis.

Table 3: Retention and Graduation Results for Undergraduate SWE Scholarship Recipients

	% (count)
Bachelor's Degree Earned	58.2% (209)
Earned an ECS Degree	93.3% (195)
Earned a non-ECS STEM Degree	2.4% (5)
Earned a non-STEM Degree	4.3% (9)

Still Pursuing a Bachelor's Degree in Fall 2023	35.9% (129)
Still Pursuing an ECS Degree	84.5% (109)
Pursuing a non-ECS STEM Degree	4.7% (6)
Pursuing a non-STEM Degree	10.9% (14)
Not Enrolled in Fall 2023 and No Degree	5.8% (21)

Findings reveal that among the 359 undergraduate SWE scholarship recipients, 58.2% had completed a bachelor's degree by Fall 2023. Of these graduates, 95.7% had earned a degree in a STEM discipline, and 93.3% had earned an ECS degree.

Of the remaining 150 students, 86% were still enrolled in a bachelor's degree program in Fall 2023. The majority (84.5%) were still enrolled in an ECS program, with 4.7% having switched majors to another STEM program and 10.9% switching to a non-STEM major. Out of the 359 SWE scholarship recipients in this study, 5.8% were not enrolled in Fall 2023 and had not earned a bachelor's degree. It is unknown if these students have left higher education completely or have taken a break and intend to return to complete their degrees.

When examining the relationship between intended and actual degree achievements in ECS among SWE scholarship recipients, the analysis revealed that there is a relatively small gap that exists between intended and actual degree outcomes for undergraduate SWE scholarship recipients. Specifically, 304 of the 359 scholarship recipients (or 84.7%) either earned or are still pursuing an ECS degree. In STEM (including ECS and non-ECS STEM), 315 of the 359 SWE scholarship recipients (or 87.7%) either earned or are still pursuing a STEM degree. In comparison, researchers have found that only 48% of women persist in their bachelor's STEM degree programs [29].

When considering the return on investment, researchers also looked at the dollar amount that SWE scholarship recipients received. Scholarship amounts for undergraduate students ranged from $1,000 to $17,000, with the most awarded amount being $5,000 (approximately 46% of scholarship recipients) and the average amount being just under $4,000. Less than 10% of scholarship recipients received more than $5,000 for any single award. While a handful of recipients received more than one SWE scholarship over the course of their studies, most recipients received a SWE scholarship only once.

Conclusion

The research findings indicate that financial support via scholarship funding could potentially serve as one mechanism that potentially increases the likelihood of women's retention in undergraduate STEM programs. Specifically, women pursuing a STEM degree and who receive scholarships to support their education are more likely to graduate with a STEM degree when compared against women's retention rates in STEM programs [4], [29]. This connection highlights the importance of financially supporting women pursuing STEM degrees as a means

of increasing the diversity in STEM professions. Organizations that invest in scholarships as a means of supporting diverse STEM students can see a return on investment through increased diversity among STEM graduates entering the workforce. This support does not only appear to benefit individual recipients but also contributes to the overall growth and advancement of STEM fields.

Limitations

As with any research endeavor, this study is not without its limitations. Researchers encountered limitations using the NSC dataset, including incomplete degree information for participants and duplicate entries across the data. For example, (i) some students who were identified as having completed a degree at a college had duplicated or missing information regarding the name of their degree, (ii) students may not be included in the NSC data for multiple reasons, and it can be difficult to determine whether these students were enrolled or not, (iii) matching errors can occur when locating students' college records based on name and birthdate, and (iv) other variables in the dataset could inadvertently produce a small amount of error during the matching process [27]. Dynarski, Hemelt, and Hyman [30] found "that the NSC matching algorithm did not add appreciable measurement error when identifying students – the NSC reports having a match rate that is approximately 94 percent accurate, accounting for the 2.4 percent of student enrollment files for institutions that are not participating with NSC and approximately 3.6 percent matching errors." According to NSC, matching errors can be caused by several factors, including duplicate student records, missing SSNs, and enrollment reporting submission errors [27]. While NSC data is generally reliable, institutions and students have the option to opt out of reporting data to NSC –and the accuracy and completeness of the results from analyzing this data depends on the reporting practices of individual institutions [27].

Future research

Future research has a lot to gain by studying the factors that influence women's pathways in STEM fields over time. Longitudinal studies play a role in tracking women's progress from their education to joining the workforce. To this end, it would be beneficial to combine methods such as interviews or focus groups with quantitative data from the National Student Clearinghouse. This approach can shed light on social and institutional factors that impact women's choices and experiences in STEM. It is especially important to identify moments when women are more likely to leave STEM fields and develop targeted interventions that encourage their continued participation in these areas.

Further analysis to understand whether the scholarship amount received has any impact on ECS or STEM degree completion would offer additional insights. As SWE revises its data collection tactics to encourage more students to provide racial/ethnic demographic information and expands its efforts to increase the racial/ethnic diversity of its applicants, future research offers the opportunity to better understand the impact of SWE scholarships on women of color in ECS and STEM programs.

Effectively utilizing the information in the NSC database for future research holds great promise despite the current limitations of this data. It has the potential to contribute significantly towards

creating policies and practices that promote diversity, innovation, and gender parity in STEM disciplines.

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