Building a Sustainable Institutional Structure to Support STEM Scholars – Scholar Survey Data

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Abstract

This paper describes activities and preliminary findings from a five-year, NSF-sponsored project (Award #1565066) at Purdue University Fort Wayne to increase the number of students who complete engineering, engineering technology, and computer science degrees. Purdue University Fort Wayne is a metropolitan, non-selective, public institution with a high percentage of under-prepared, first-generation, low-income, commuter students, many of whom work. The objectives of this project are to (a) increase graduation rates of the STEM cohorts; (b) build the foundation for a sustainable institutional structure and support STEM scholars and other students; (c) carry out research designed to advance understanding of the factors, practices, and curricular and co-curricular activities that affect the retention of students and their degree completion; and (d) integrate the best practices into the educational culture of the institution.

Funding from this grant was primarily used to support twenty-six (26) junior- and senior-level students. Students were recruited in three cohorts consisting of eight, eight, and ten students from 2017-2019. The topic of this paper is the personal data, survey responses, completion rates, and student success from the grant-funded students. Areas of focus for which data are collected include: (a) learning how commuters prioritize the three aspects of their lives (home, work, and school); (b) understanding how commuters use the financial assistance that they receive and its impact on the progress they make towards completing their degrees; (c) identifying the support practices and interventions that enhance the academic success of commuter students from among the many that are provided by universities and colleges; and (d) identifying the challenges that commuters face with juggling responsibilities and obligations from home, work, and school. Significant findings from the first two cohort groups indicate that grant funds and activities reduce financial stress, give students hope and structure, and shorten time-to-degree. High-performing commuters, a majority that are employed, have developed efficiencies in the use of their time and how to they do their academic work.

Introduction

Nationwide, engineers, technologists, and computer scientists are needed to meet the demands of the current economy, and even more will be needed to meet the demands of the economy of the

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future. According to the Bureau of Labor Statistics [1], the job outlook for engineering and computer scientists is growing, e.g.

- employment of software developers, quality assurance analysts, and testers is projected to grow 25% from 2021 to 2031, much faster than the average for all occupations;
- employment in computer and information technology occupations is projected to grow 15% from 2021 to 2031, much faster than the average for all occupations;
- employment in architecture and engineering occupations is projected to grow 4 percent from 2021 to 2031, with some areas of engineering, such as industrial and biomedical growing at rates of 10%.

In northeast Indiana [2], engineering and computer science graduates support economic development in the broad sectors of manufacturing and health care, as well as specifically targeted, growth industries such as defense & aerospace, distribution & e-commerce, medical devices, specialty insurance, and vehicles. A continuous and steady supply of engineers, technologists, and computer scientists is necessary to sustain economic growth [3].

Purdue University Fort Wayne (PFW) is a public institution serving northeast Indiana. PFW is a metropolitan, non-selective, institution with a high percentage of under-prepared, first-generation, low-income, commuter students, many of whom work. The mission of the PFW College of Engineering, Technology, and Computer Science (ETCS) is to provide a comprehensive education that will prepare career-ready graduates for a variety of roles in engineering, polytechnic, computer science, and leadership, serving the needs of northeast Indiana and beyond.

In 2016, PFW (then IPWF) was awarded an NSF grant (Award #1565066)—the overarching goal of the project is to increase the number of students who complete degrees in engineering, technology, and computer science. Like many similar institutions, PFW struggles with graduation rates [4]. For example, in 2020, the overall 6-year graduation rate for first-time, full-time undergraduate students who began seeking a bachelor's degree at 4-year degree-granting institutions in fall 2014 was 64% [5]; at PFW that rate was 37% [6]. Improving graduation rates and reducing time-to-completion is a priority for the Indiana Commission of Higher Education [4].

This paper briefly describes some of the activities associated with the NSF project [7] with a focus on the personal data, survey responses, completion rates, and student success of the grant-funded students. Areas of attention for which data are collected include: (a) learning how commuters prioritize the three aspects of their lives (home, work, and school); (b) understanding how commuters use the financial assistance that they receive and its impact on the progress they make towards completing their degrees; (c) identifying the support practices and interventions that enhance the academic success of commuter students from among the many that are provided by universities and colleges; and (d) identifying the challenges that commuters face with juggling responsibilities and obligations from home, work, and school.

Rationale and Approach of the Project

The objectives of this project are to (a) increase graduation rates of the STEM cohorts; (b) build the foundation for a sustainable institutional structure and support STEM scholars and other students; (c) carry out research designed to advance understanding of the factors, practices, and curricular and co-curricular activities that affect the retention of students and their degree

completion; and (d) integrate the best practices into the educational culture of the institution. More details on the overall structure of the project are given in [7].

Most programs to enhance retention in the STEM fields focus on first- and second-year students [8,9]. Many retention-enhancement programs [10,11] form communities of learning to support first- and second-year students academically, socially, and professionally.

This project focuses on rising juniors; there are two reasons for this. First, the nature of nonselective institutions such as PFW is that a very wide variety of students is admitted. Their readiness for, interest in, and commitment to a given major vary widely as well. These issues are generally not sorted out until the end of their sophomore year. As juniors, these students will have demonstrated commitment to their ETCS majors as well as to satisfactory levels of academic performance. Financial aid at this point rewards them for what they have achieved—making it to the halfway mark. Second, beyond the stipend, this project also encourages, supports, and assists STEM scholars to complete their degrees earlier than they would otherwise. On residential campuses of very selective universities, where graduation rates are very high (88-96%), once a student reaches the junior level of an undergraduate curriculum, it is practically a certainty that the student will graduate with a bachelor's degree. Unfortunately, that is not the case at PFW. A review of institutional data regarding the graduation rates of rising juniors in the College of ETCS from 2006 to 2015 reveals that only 27.5% of new juniors completed their degrees in two years; 58% completed their degrees in three years; 64% in four years; 72% in five years; and 82% in six years. The ranges of percentages within the college and the corresponding weighted averages are shown in Table 1. Some of these students get discouraged and quit altogether. Therefore, the significance of this project is that it will shorten the time it takes students to graduate, thereby, increasing their graduation rates. With this project, the expectation is that rising junior-level students who would have taken three or four years to graduate will do so in two years. This would increase the two-year graduation rate of STEM scholars (rising juniors) from the current 27.5% to about 60% for each of the two cohorts of this project. The data in Table 1 is generated by considering all students who attained 60 credit hours in a given semester as juniors. Thus, it includes students with transfer credits fulfilling general education requirements and students who need to retake a single sophomore-level course to satisfy a pre-requisite requirement.

For this project, three types of data were collected and analyzed: (1) survey data from the scholars in the program that received funding, (2) college-wide surveys to ETCS students, primarily first- and second-year students, (3) institutional data such as retention, persistence (student success), progression-in-major, and graduation rates.

Table 1. Years taken by new juniors to graduate with bachelor's degrees in ETCS (2006-2015).

years to graduate once a junior	2 years	3 years	4 years	5 years	6 years
range (%)	18% - 32%	43% - 84%	50% - 86%	50% - 90%	67% - 92%
average (%)	27.5%	58%	64%	72%	82%

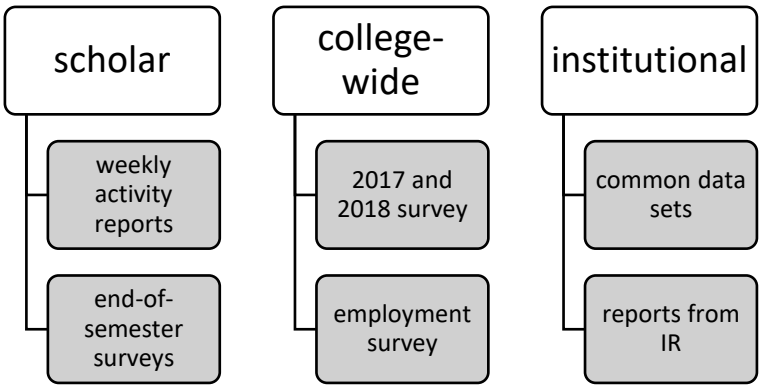

Figure 1. Types of data collection

Description of Grant Activities

Funding from this grant was primarily used to support twenty-six (26) junior- and senior-level students. Students were recruited in three cohorts consisting of eight, eight, and ten students from 2017-2019.

S-STEM Scholars Program

Twenty-six (26) rising junior-level students were selected to participate in the S-STEM Scholar Program (SSP). Demographic data is given in Table 2. The application process consisted of an application form, personal essay, and letter of support from a faculty member. Applicants also had to satisfy residency requirements in accordance with NSF guidelines and demonstrate financial need as determined by the office of financial aid. Students selected received $4166 per semester or $8332 per year. The period of funding was two years, although adjustments could be made. The scholars participated in a comprehensive program designed to improve student retention, promote academic success, and build preparedness for professional careers and graduate studies. The program was built upon student support structures that existed previously at PFW.

Table 2. Demographic information about the three cohorts.

cohort	number	engineering	computer science	polytechnic	male	female	white	not white
2017	8	4	1	3	7	1	5	3
2018	8	3	3	2	5	3	6	2
2019	10	4	3	3	9	1	7	3
total	26	11	7	8	21	5	18	8
total		42.3%	26.9%	30.8%	80.8%	19.2%	69.2%	30.8%
ETCS*		33.1%	27.1%	39.8%	87.6%	12.4%	76.3%	23.7%

*fall 2019 and includes computer science, engineering, and polytechnic majors (excludes non-resident)

The S-STEM Scholar Program consists of required elements and optional elements. The following elements are required: program orientation, Student Learning Communities (SLC), academic and professional development workshops, STEM colloquia series, reports of academic progress on a weekly basis (RAP), and exit interviews. A program orientation was given to the scholarship recipients in late August of the fall semester during which they received the award and the following fall. During this orientation, the students are given a timetable of activities and other program requirements. It was emphasized that the honor and recognition that they receive as STEM Scholars comes with distinct responsibilities and that the program requirements must be completed in a timely manner for each student to continue participation in the program.

A team consisting of teaching faculty, mentors, academic advisors, and peer mentors has been created to support the NSF S-STEM scholars. These teams are organized and do their work using the well-established concepts of faculty and student learning communities and follow the recommendations from the well-known study by the National Research Council (NRC): *How People Learn,* which identifies four interrelated perspectives of effective learning environments: *Learner-centered environments*, *Knowledge-centered environments*, *Assessment-centered environments*, and *Community-centered environments.* Together, these environments work to create and sustain the mutual support and encouragement of students and the active involvement of all faculty, staff, administrators, fellow students, and employers of the graduates of STEM academic programs [12].

Faculty Learning Community

A Faculty Learning Community (FLC) is a cross-disciplinary group of faculty that engages in an active, collaborative, multiyear program that focuses on sharing experiences, learning from the literature, other campuses, and each other.

An FLC was formed, and the group participated in a comprehensive program designed to increase interactions between faculty and students, support student retention, promote academic success, and build career preparedness through such activities as faculty advising and mentoring; and cooperative learning [12,13]. Six to eight members of the FLC met regularly to discuss the data collected and develop tools and recommendations to promote student success.

Student Learning Community

A Student Learning Community (SLC) was created to enhance academic achievement, personal growth, and career & employment success [10,11]. The SLC consists of a small group of students and a faculty member in the same, or closely related field, and a student assistant (peer mentor). The faculty member served as the top-tier mentor and liaison for the cluster and performed the following duties: advising (e.g., helping students with course selection and monitoring their academic progress); assisting them in identifying and evaluating academic and career opportunities; evaluating job offers or preparing for graduate school, whichever is appropriate; coordinating various activities for the cluster (e.g., research seminars, trips, etc.); and being the group's liaison with the FLC. The student assistant served as a "near-peer" mentor for the STEM Scholars, helping them with issues related to available resources and connecting them with a variety of services, professionals, and other students, as needed. Whereas some students find it intimidating to work with the faculty, in the mentoring cluster, when needed, the peer advisor provides a less intimidating resource. Three SLCs were formed: one for engineering majors,

another for polytechnic majors, and the third for computer science majors. Building such learning communities is a way to implement a research-proven and time-tested pedagogy on *How People Learn* [12].

Results: Weekly Activity Reports

Members of the STEM Scholars Program were required to fill out activity reports detailing their time use and academic progress (attendance, grades, etc.) The reports contained weekly data and were submitted monthly via email. In addition, students filled out reports describing how they spent their stipend from the grant. The monthly data was complied, analyzed, translated to semester data, and reported to the S-STEM scholarship reporting site (www.s-stem.org).

The topic of this section is personal data and survey responses from 15 scholars in the first two cohorts.[†] Results from the fall 2018 individual time use surveys are shown in Figure 2, while the average values are shown in Figure 3. The data indicates that the scholars spent the majority of their time sleeping or with home life. Twelve of the scholars worked, while three did not. For the students that worked, the average number of hours reported working per week is 17.1 (SD = 10.0). One student reported working 36 hours in a given week, while one student reported working only 2 hours per week.

The relationship between GPA and time use is investigated using Pearson's correlation coefficient. Despite the small sample size, three relationships stood out as potentially significant, viz., a 63% positive correlation between GPA and time spent on paid work, a 46% negative correlation between GPA and home life, and a 57% positive correlation between GPA and sleep. For all correlations, $r(13)$ and $p < 0.01$.

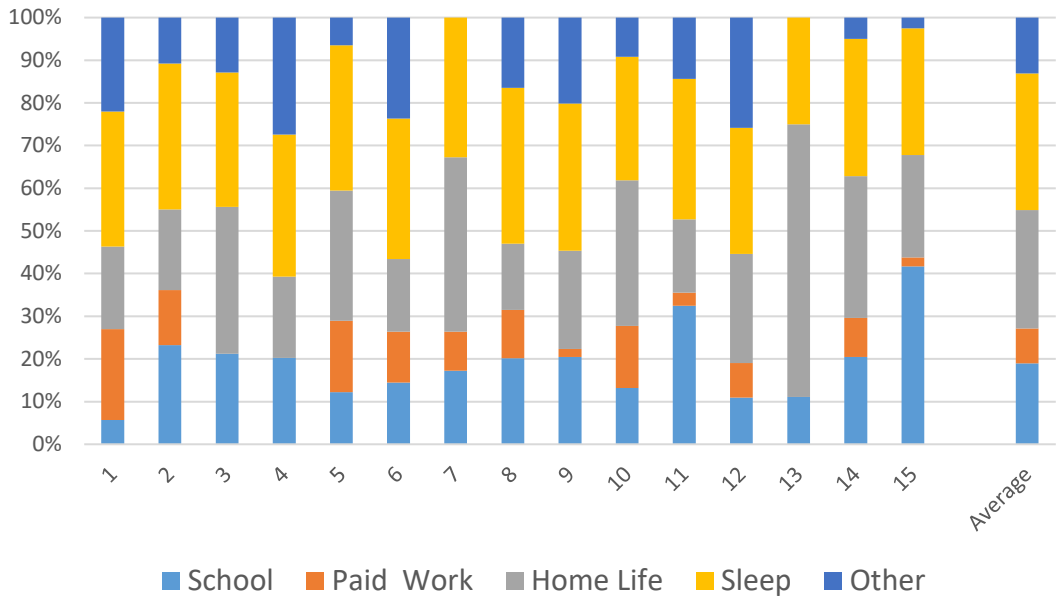

Figure 2. Allocation of time—individual student responses fall 2018.

[†] The data presented in this section is pre-COVID-19 pandemic disruption.

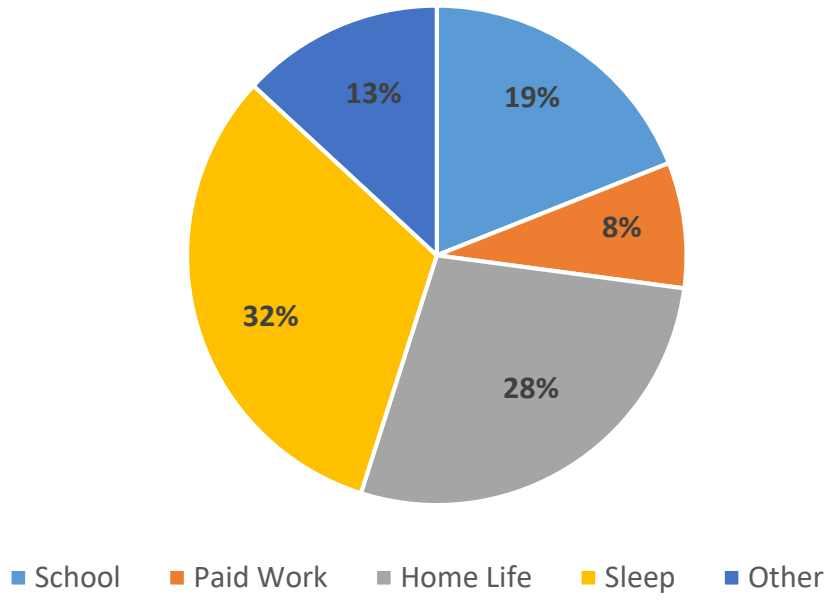

Figure 3. Allocation of time—average student responses fall 2018.

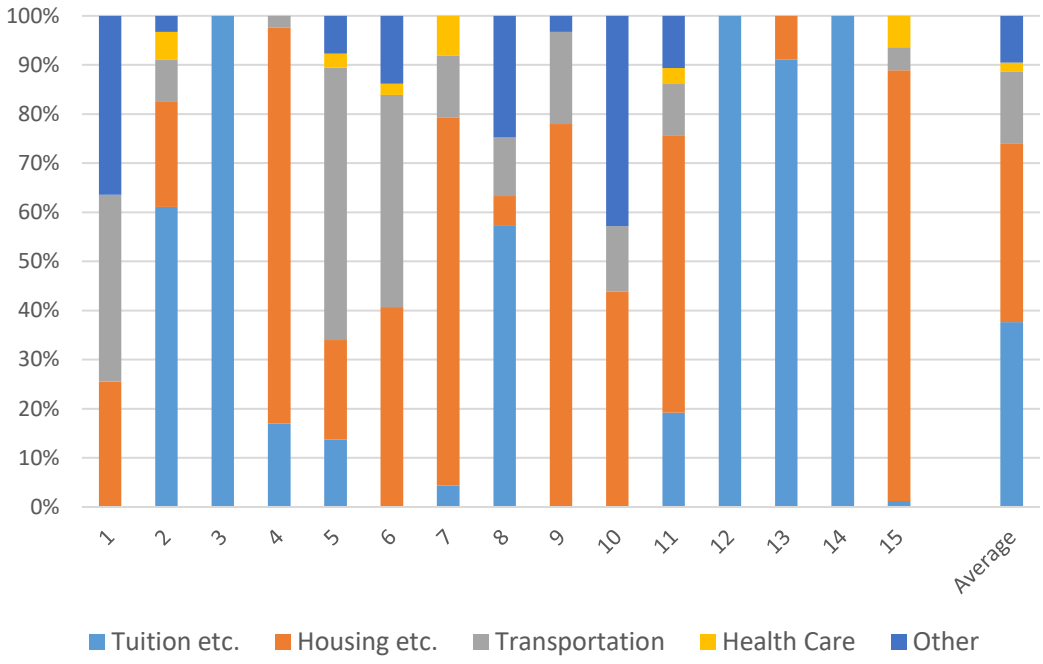

Figure 4. Allocation of funds—individual student responses fall 2018.

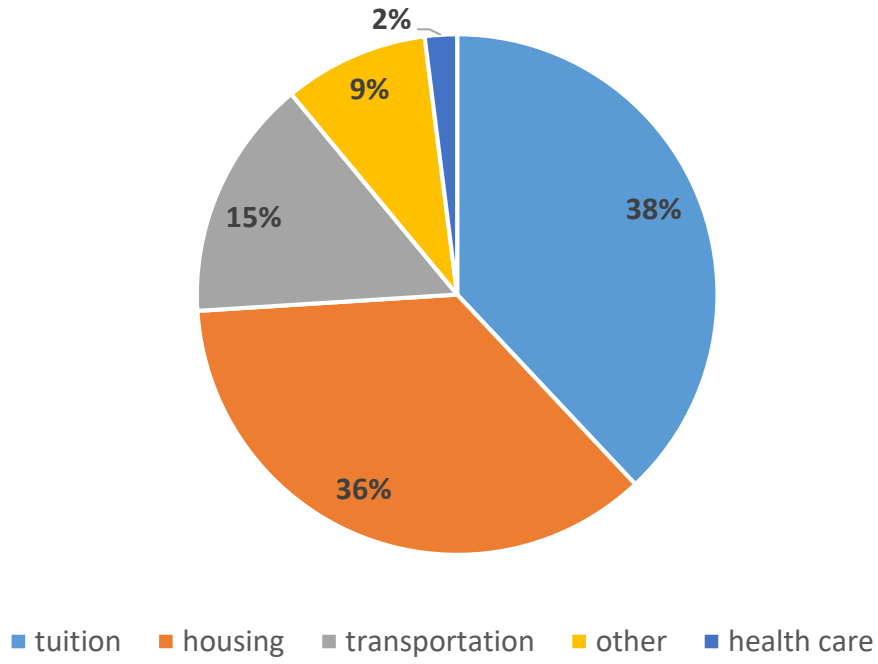

Figure 5. Allocation of funds—average student responses fall 2018.

Figures 4 and 5 show how the SPP participants spent their stipend. The majority of the funds were used for tuition and housing. Three scholars reported spending all of the funds on tuition, while two students reported not spending any of the funds on tuition.

Results: End-of-Semester Surveys

End-of semester Qualtric surveys were given to all S-STEM scholars in the program. The surveys consisted of 10 questions as shown in the Appendix. The survey was developed and administered at the end of each semester starting in the fall 2017 semester. To make sure that students provided complete and honest answers without any bias, the survey was conducted by the PFW Assessment Office. Results from the fall 2017 – spring 2019 were aggregated and analyzed by the assessment coordinator of the grant.

Students were asked to evaluate the extent to which participation in the S-STEM Scholars Program (SSP) helped them in the following areas:

a) Increased their interactions with other engineering students
b) Increased their interactions with faculty members
c) Increased their interaction with professionals in the community
d) Increased opportunities to participate in research projects

Students were asked to evaluate each element on a five-level Likert scale with responses of *none*, *not much*, *a little*, *quite a bit*, or *a lot*.

Students were asked to evaluate the extent to which participation in the S-STEM Scholars Program (SSP) helped them achieve learning gains in the following areas:

a) Participating in an externship
b) Participating in an internship
c) Participating in Fort Wayne Engineers' Club Tours
d) Retired Engineers and Engineering Managers Seminars
e) Immersion Excursions
f) Monthly Leadership Meetings
g) Monthly Seminar with Scholars

Students were asked to evaluate each element on a five-level Likert scale from *no gains*, *a little gain*, *moderate gains*, *good gains*, or *great gains*.

A summary of the results from the fall 2017 – spring 2019 is shown in Table 3. The fall 2017 and spring 2018 data are solely from the first cohort, while the fall 2018 and spring 2019 data are from cohorts 1 and 2. Table 3 contains the percentage of respondents, juniors and seniors, which selected the top two responses on the Likert scale, either *quite a bit* and *a lot* or *good gains* and *great gains*. Values greater than 50% are indicated with bold and are deemed to be significant.

Both junior and senior students felt that the SSP helped to increase interactions with other students. Junior-level students felt that the SPP helped to increase interactions with faculty, while senior-level students felt that the program helped to increase interaction with professionals in the community.

Participation in some SPP activities was optional and not required. Students, however, were encouraged to participate in these activities. In general, there were very few responses to some questions in this part of the survey. Due to the low participation in these areas, observations should be considered with caution.

Table 3 End-of-semester survey responses fall 2017 – spring 2019—% favorable responses.*

Extent SSP helped to…	junior (N = 16)	senior (N = 21)
Increase interactions with other engineering students	**75.0%**	**76.2%**
Increase interactions with faculty members	**56.3%**	42.9%
Increase interaction with professionals in the community	25.0%	**61.9%**
Increase opportunities to participate in research projects	12.3%	23.8%

Extent SSP helped to achieve learning gains by...	N	%	N	%
Externship Participation	2	0%	4	25%
Internship Participation	10	**80%**	13	**69%**
Fort Wayne Engineers' Club Tours	2	0%	3	0%
Retired Engineers and Engineering Managers Seminars	3	33%	5	40%
Immersion Excursions	3	33%	4	0%
Monthly Leadership Meetings	12	**67%**	10	**70%**
Monthly Seminar with Scholars	16	**69%**	20	**60%**

* top two favorable responses: *quite a bit* and *a lot* (top) or *good gains* and *great gains* (bottom)

With regards to SSP activities that helped achieve learning, both junior and senior students felt that internships contributed to their learning. In addition, both junior and senior students felt that monthly meetings and seminars were beneficial to learning.

Note the survey was also given each semester from fall 2019 to spring 2021, and subjects included the third cohort and members of the first two cohorts that were still in the program. Due to the COVID-19 pandemic, program activities were modified, priorities were shifted, and data collection was problematic. Before presenting the 2019 – 2021 data, further analysis and a nuanced interpretation are needed.

In addition to the rating of activities, students were asked to provide comments as to what they achieved over the course of a semester, e.g. one student commented:

> *Because of the scholarship assistance, I was able to achieve a good semester GPA while still being able to spend some quality time with my family. It is important to me that I be able to attend my step-children's events and activities, as well as help them with their homework and spend some free time with them, and the scholarship funds allowed me to discontinue one of my two jobs, allowing me extra time. In all, I achieved a balanced work, school, and family schedule.*

and another:

> *I divided my semester into four compartments: school, work, family, and personal life. I achieved enough of a balance to succeed in my courses and still have time to devote towards my professional development.*

These comments indicate that the SPP offers a healthy work-life balance for students that allows them to succeed academically. Another student commented:

> *I went to school full time and worked at Regal Beloit part time. At school, I was able to get great grades on tests while managing my time accordingly. At work, I've been developing a new product using skills I learned in school and experience from past co-op sessions.*

This comment indicates that the SPP allows students to make personal and professional changes to their lives that empower and equip them with new skill sets.

Students were also asked how the stipend helped, e.g.

> *The scholarship money helped tremendously with tuition payments and it gave me peace of mind when budgeting for food, bills, transportation, etc.*
>
> *The main way the scholarship money helped me was by allowing me to take time to focus on my academics and not have to stress much about fitting in time to work. Being able to concentrate so heavily on my academics allowed me to achieve very good grades and still maintain a healthy lifestyle i.e. time to exercise and sleep a healthy amount.*
>
> *Feeling more financially secure reduced tremendous amounts of stress that could have detracted from my ability to focus on my current goals and course completion. I feel that not having worries related to money allowed me to relax and approach university work with a clearer head and optimism. It also made affording materials for class much easier.*

Almost every student remarked how the provided funds reduced stress and allowed them focus on their schoolwork.

Results: Time-to-Graduate and Student Success

The overarching goal of this study is to increase the graduation rates or decrease the time to graduate for juniors in the College of ETCS. Twenty-six students received funding from the program—25 of the 26 students or 96% of students in the program graduated. One student from the 2017 program left the university. Seventeen of the students in the program or 65% graduated in 4 semesters or fewer and after five semesters, that percentage rose to 73%. The average number of semesters-to-graduate is 4.8 (SD = 1.51) and the average graduation GPA is 3.50 (SD = 0.37).

Two students graduated nine semesters after becoming a junior—both of those students changed majors. One student changed their major from mechanical engineering technology (polytechnic) to mechanical engineering and the other changed from mechanical engineering to mechanical engineering technology (polytechnic). These data points are included in the analysis.

The data reveals a negative correlation of 0.40 between semesters-to-graduation and GPA (Pearson's correlation $r(23) = -.40$, $p < 0.01$). Figures 6-8 present the semesters-to-graduate and GPA data highlighting three different aspects, i.e. program, cohort year, and work/no work. A linear regression analysis of the data, showing the general trend, is indicated on the graphs with a dotted line.

On average, computer science students in the program graduated in 4.3 (SD = 0.76) semesters, polytechnic students graduated in 4.8 (SD = 1.75) semesters, and engineering students graduated in 5.1 (SD = 1.73) semesters.

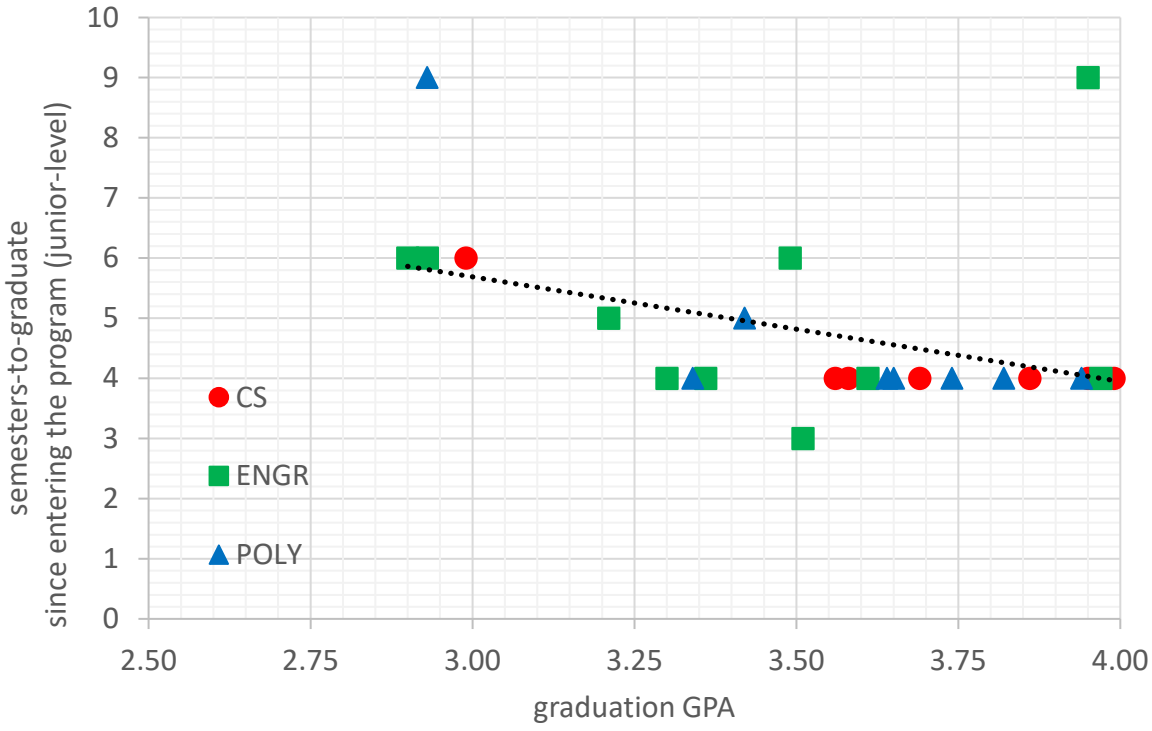

Figure 6. Relationship between semesters-to-graduate and GPA—effects of different programs.

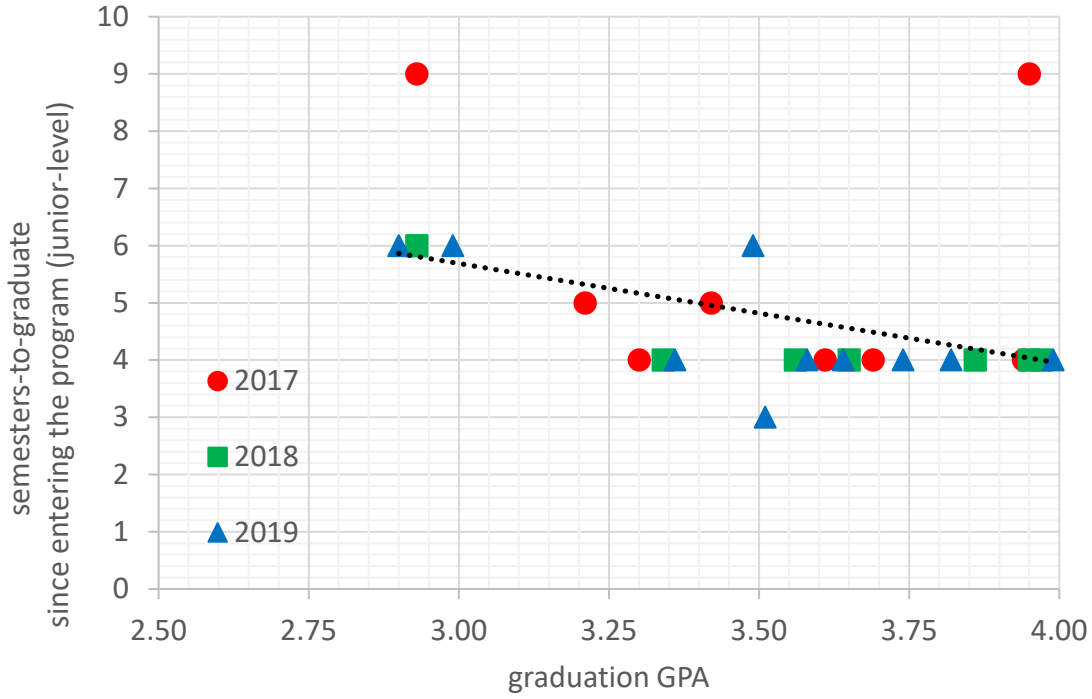

Figure 7. Relationship between semesters-to-graduate and GPA—effect of year entering the program.

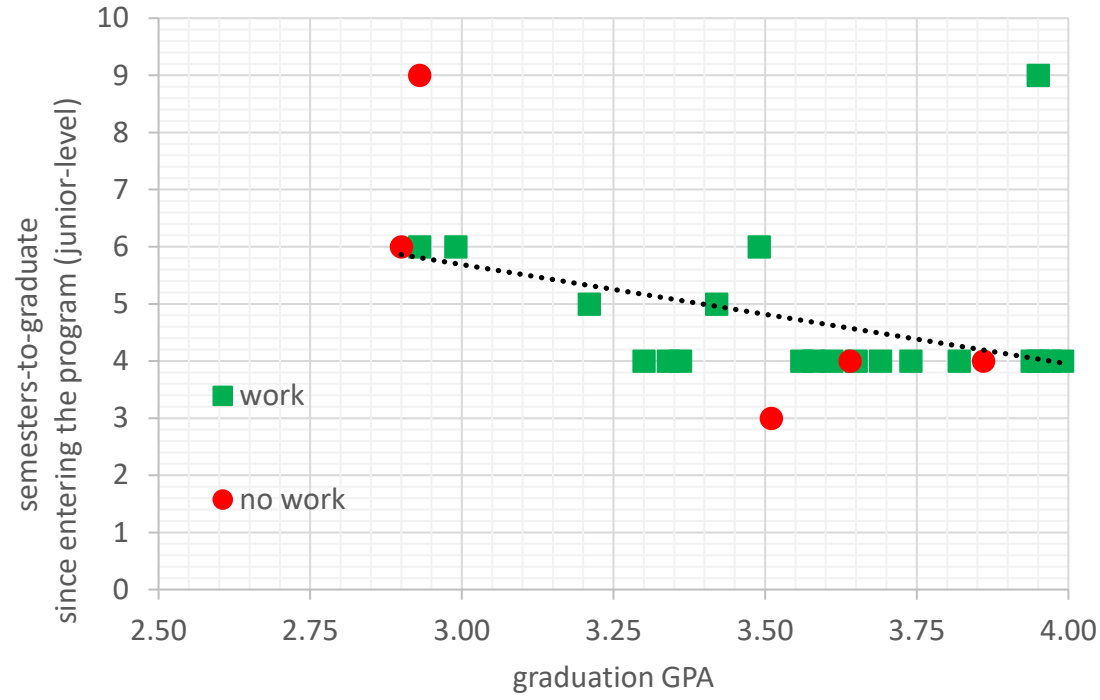

Figure 8. Relationship between semesters-to-graduate and GPA—effects of work or no work.

Students in the 2017 cohort took the longest to graduate—taking an average of 5.5 (SD = 2.20) semesters. However, note that two students in the first cohort changed majors and took 9 semesters after entering the program to graduate—without those two data points, the average number of semesters to graduate drops to 4.3 (SD = 0.52). Students in the second and third cohorts graduated in 4.3 (SD = 0.76) and 4.5 (SD = 1.08) semesters. It appears that there is no significant difference in time-to-graduate between the cohorts.

81% percent of the students reported that they work, while 19% reported no work. Over the entire reporting period, the average number of hours students reported working is 17.7 (SD = 7.86). Students who work had higher GPAs compared to students who reported not working (3.53 to 3.37), but, on average, took slightly longer to graduate than students that did not work (5.2 semesters to 4.7 semesters). Other studies found student work often results in a longer time to graduation and less academic success [14,15].

Lessons Learned

When you have met one PFW, ETCS student, you have met ***one*** PFW, ETCS student. Every student is different and every student has different interests and challenges to overcome. Time is limited and engineering programs do not allow much flexibility. A more flexible curriculum could potentially improve retention [16] and time-to-graduation.

A common theme related to the financial aspects of the grant is that scholarship money greatly reduces ***stress***. Stress affects students and learning communities and mentoring give student structure and advice to help them cope with stress.

The SSP helped students ***interact with other students***, especially those outside of their discipline.

Students in the SSP benefited greatly from ***internships***, as well as the ***meetings*** and ***seminars***. To make these aspects ***sustainable***, permanent structures need to be put in place. Programs to help students obtain internships should be continued by university career services. Student chapters of professional societies can help to sustain meetings and seminars, and the college has implemented a peer and alumni mentoring program.

A majority of PFW students ***work***. Surprisingly, a majority of the students that participated in the grant also worked. It appears that PFW ETCS students who work take slightly longer to graduate, but are slightly more successful academically. This appears to contradict other studies involving student employment.

While the COVID-19 pandemic disrupted many aspects of society including academia, it appears that the disruption did not affect timely graduation for upper-level ETCS students in good academic standing.

Future Work

Analysis of the other two data sources, i.e. ETCS student survey data and PFW institutional data [17], is ongoing and being used to complement and confirm the data and findings reported in this paper. Based on these findings, three tools to enhance student success were developed by a faculty learning community: (1) Success Assessment Tool, (2) Risk Indicator Survey, and (3) Engineer Your Success [17].

Acknowledgment

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Appendix

Exit Survey

Thank you for taking the time and effort to respond to this survey. Please feel free to give your most candid response to the following questions. Your response is confidential, will not affect your scholarship, and most importantly will help us to improve the university's NSF Scholarship Program.

Q1 **When did you enter the NSF Scholarship Program?**

- O Fall 2017
- O Fall 2018
- O Fall 2019
- O Fall 2020

Q2 **What is your current class standing?**

- O Freshman
- O Sophomore
- O Junior
- O Senior

Q3 **Please evaluate the extent to which participation in S-STEM Scholars helped you in the following areas:**

	N/A	None	Not Much	A Little	Quite a Bit	A Lot
Increased your interactions with other engineering students	O	O	O	O	O	O
Increased your interactions with faculty members	O	O	O	O	O	O
Increased your interaction with professionals in the community	O	O	O	O	O	O
Increased opportunities to participate in research projects	O	O	O	O	O	O

Q4 **Describe the learning gains you achieved as a result of participating in the following activities:**

	N/A	No Gains	A Little Gain	Moderate Gain	Good Gain	Great Gain
Participating in an externship	O	O	O	O	O	O
Participating in an internship	O	O	O	O	O	O
Fort Wayne Engineers' Club Tours	O	O	O	O	O	O
Retired Engineers and Engineering Managers Seminars	O	O	O	O	O	O
Immersion Excursions	O	O	O	O	O	O
Monthly Leadership Meetings	O	O	O	O	O	O
Monthly Seminar with Scholars	O	O	O	O	O	O

In the following section, describe your semester.

Q5 **What did you achieve?**

_____

Q6 **What did you hope to achieve but did not?**

_____

Q7 **What did you plan to achieve but did not?**

_____

Q8 **How did the scholarship money help you?**

_____

Q9 **How did the scholarship money not help you?**

_____

Q10 **Please share any additional information and questions.**

_____

Question added in fall 2020

Q11 **How has COVID-19 affected your studies?**

_____