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Board 434: Work in Progress: Building a Sustainable Institutional Structure to Support STEM Scholars

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Building a Sustainable Institutional Structure to Support STEM Scholars – Work-in-Progress

Introduction

This paper describes preliminary findings and outcomes 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 [1]. 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.

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 was awarded an NSF grant—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 [2]. 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% [3]; at PFW that rate was 37% [4]. Improving graduation rates and reducing time-to-completion are priorities for the Indiana Commission of Higher Education [2].

This paper describes data from surveys of students in the College of ETCS taken over a three-year period that shows that a typical ETCS student receives financial aid, commutes, attends full time (at least when starting), and works. In addition, typical students report not being well connected with faculty, mentors, or student study groups. And, despite most students receiving financial aid, many still have financial difficulties. Data from grant-funded students [5] and institutional research [4] is also presented to complement the college-wide survey data.

Based on these findings, three tools to enhance student success were created, designed by a faculty learning community: 1. **Success Assessment Tool** – a Qualtrics-based risk assessment as means for self-evaluation of barriers (academic, time, or financial) to success and collaborative evaluation of students' status and needs with their faculty mentor; 2. **Risk Indicator Survey** – a Qualtrics instrument to flag students who are struggling in a particular class. Students who are flagged will be advised of support services and encouraged to develop a personalized improvement plan; 3. **Engineer Your Success** – a worksheet activity given to students to (a) monitor progress in a specific class, (b) assist students in self-identification of barriers to success that might exist in a specific class, and (c) provide a process for students to develop a personalized improvement plan. These three tools and college-wide efforts to increase mentoring, tutoring, and career development are discussed.

Description of the Project

Funding from the grant was primarily used to support twenty-six (26) junior- and senior-level students [1,6]. Students were recruited as rising juniors in three cohorts consisting of eight, eight, and ten students from 2017-2019. These students comprised the core of a Student Learning Community (SLC). The SLC met to every two-weeks with activities designed to promote successful academic habits and professional development as well as foster a sense-of-belonging and provide opportunity for both peer and faculty mentorship. Learning communities, especially for first-year students, have proven to be effective at improving retention [7,8].

A Faculty Learning Community (FLC) was also 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, expert and peer mentoring, and cooperative learning. Six to eight members of the FLC met regularly to discuss data collected and develop tools and recommendations to promote student success.

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.

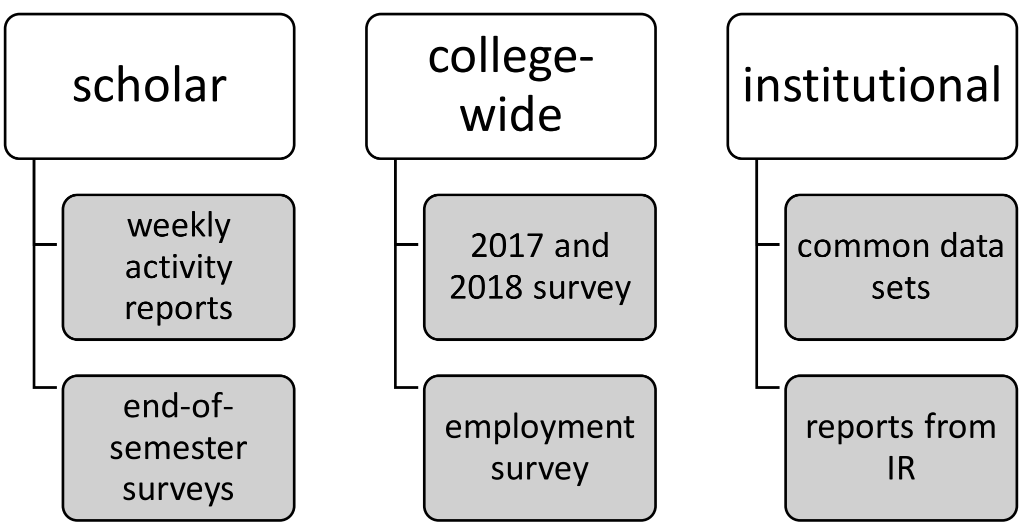

Figure 1. Types of data collection

College-Wide Survey

A survey was conducted of students (N = 304) in the College of Engineering, Technology, and Computer Science at Purdue University Fort Wayne. The purpose of the survey is to learn from experiences and perceptions of enrolled ETCS students over a period of four years (2017-2020) and seek students' feedback and advice on what helped or did not help them succeed.

The Center for Social Research, a Center of Excellence at Purdue University Fort Wayne, administered the survey. The survey was designed to gather information about respondents' experiences at Purdue University Fort Wayne.

The survey consisted of an introduction and 135 survey questions of which any given respondent saw a maximum of 70. Qualifying parameters for participation were determined by one initial screening question: Are you currently enrolled in the College of Engineering, Technology, and Computer Science? Only students of the College of Engineering, Technology, and Computer Science at Purdue University Fort Wayne were permitted to complete the survey. No incentives were offered for completion. Survey questions were designed to gather information on students' educational background, program information, and satisfaction with the ETCS department.

Surveys were distributed in a link to students in specific ETCS classes by email during the period November 2017-May 2019. Year 1 surveys were given to students in first-year courses, while year 2 surveys were given to students in second-year courses. Respondents were given instructions on how to take the survey by one of the Center for Social Research employees and completed their surveys in class.

Respondents were asked questions about their study habits, educational background, program information, employment information, financial aid, and personal opinions about the College of ETCS. Respondents were also asked about their engagements at Purdue University Fort Wayne, and their typical 24-hour day. In addition, the survey included questions about commuter students and mentors. The purpose of the research is to learn from experiences and perceptions of enrolled ETCS students and seek students' feedback and advice on what helped or did not help them succeed.

Key findings from the survey are summarized in Table 1. A typical student in the College of ETCS attends full time (at least when starting), receives financial aid, commutes, and works.

According to the survey, nearly 60% of first-year students are employed and that number increases to 68% for second-year students—data for the college overall is typically around 75%. Working students reported time management challenges and difficulty achieving a healthy work/school/life balance. Other themes associated with work are stress and financial concerns. Comments from students who work include:

> *Thanks to flexibility in my work schedule, I have been able to adequately balance work and school. Most of my time spent on the job takes place over the weekends. This may create difficulties with completing large assignments over the weekend. A lack of time off from work and school has also led to some episodes of stress over the past couple years.*

and

> *Not enough time outside of work to prepare for exams, do homework, work on projects, and sleep. I only get approximately 4 hours per night.*

Figure 2 shows a word cloud generated from working students' comments from the fall 2018 survey.

Table 1. Key findings from surveys of ETCS students.

Survey question	**Year 1** (n = 168)	**Year 2** (n = 136)
enrolled in more than 12 credits	90%	88%
currently employed	59%	68%
commuter student	60%	66%
applied for financial aid	84%	66%
receiving financial aid	65%	54%
drop to part time or temporarily stop out	10%	19%
primary reason to stop	40% academic 40% financial 20% other	30% academic 30% financial 20% work 10% family obligation
additional reason to stop	43% work 43% financial 14% other	43% financial 29% academic 14% work 14% family obligation
primary reason to attend part time	30% work 20% academic 10% financial 30% other	38% academic 25% work 13% financial 19% family obligation
additional reason to attend part time	31% work 23% financial 15% academic 23% family obligation	22% financial 22% work 11% academic 44% family obligation
have a mentor	9%	11%
interested in working with a mentor	37%	33%
study primarily by yourself	67%	64%
study primarily at home	58%	42%

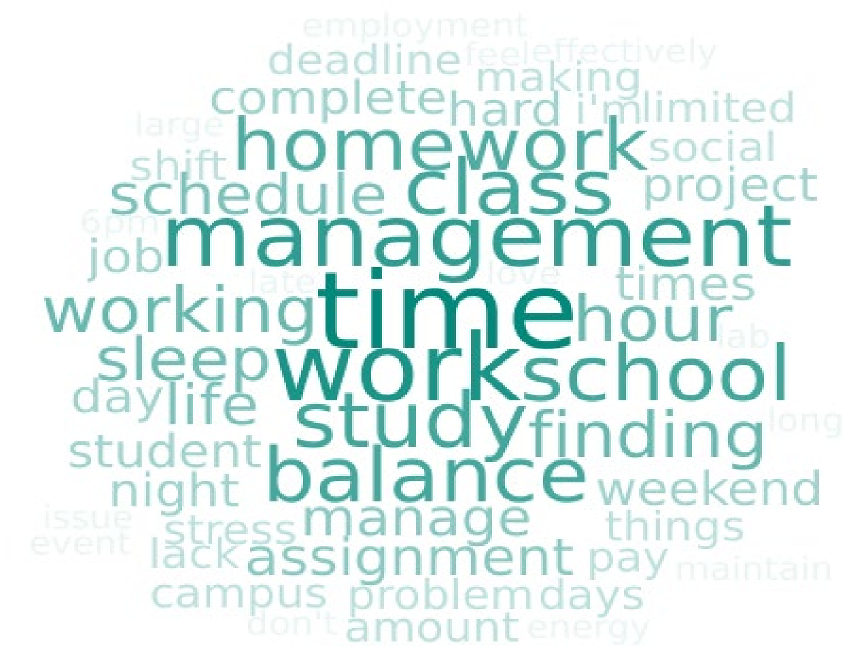

Figure 2. A word cloud created from comments by students who reported working from the fall 2018 survey.

Sixty percent of the students in the year 1 survey reported commuting, while that percentage increased to 66% for the second-year students. The average distance of commute reported is 18.7 miles with a maximum of 66 miles and a minimum of 1 mile. The average time spent on the commute is 41 minutes.

Despite most students receiving financial aid, many still have financial difficulties. In addition, typical students are independent (study by themselves) and report not being well connected with faculty, mentors, or student study groups.

In year 1, 10% of the students reported dropping to part time or temporarily stopping out. In year 2, that percentage rose to 19%. The primary reason that students reported stopping out is academic with a secondary reason financial. The primary reason that students in the first-year courses drop to part time is work, while the primary reason for students taking second-year courses drop to part time is academic.

Students reported the following helped them to succeed: helpful faculty, good study habits, hands-on-teaching, good planning and time management. Students also made the following comments: campus parking can be improved, more tutoring and help forming study groups would be beneficial, and banded tuition actually makes school more expensive for students that take less than 15 credit hours.

Institutional Data

Data from the PFW's Office of Institutional Research and Analysis was collected and processed. This data was presented to the FLC several times a year, and it was analyzed and discussed.

Categories of the data include demographic data, financial aid, retention, progress-in-degree, time-to-degree, and number of degrees. Comparisons were made between the College of ETCS and the entire PFW campus as well as other STEM programs offered on the PFW campus. The purpose of this paper is not to analyze the comprehensive institutional data related to PFW STEM programs. However, some general observations are evident from the data and are discussed.

One key metric that was analyzed is the *% stop out*. Percent stop out is defined as the percentage of students in a specific group that left the university—the remainder of the students in that group were enrolled in the university or graduated. There are many reasons (see Table 1) that students might stop out, e.g. insufficient academic preparation, unreasonable expectations of college rigors, insufficient resources (financial and time) to stay enrolled, and misperception of the program or major.

Figure 3 shows the *% stop out* over a four-year period. From Figure 3, it is evident that the data is relatively consistent, with a slight uptick in the polytechnic numbers for the fall 2020. However, the overall program data masks interesting trends.

Figure 4 and Table 2 show the *% stop out* for each program based on the student level for the year 2020-2021. The student level is based on credit hours within the university, i.e., B1 denotes less than 30 credit hours, B2 denotes 30 to 60 credit hours, B3 denotes 60 to 90 credit hours, and B4 denotes over 90 credit hours. Thus, transfer students, students switching majors, and students pursuing a second degree might not be accurately tracked for progress-to-degree. Hours within a specific program curriculum could also be used, but the data is more difficult to obtain and requires interpretation.

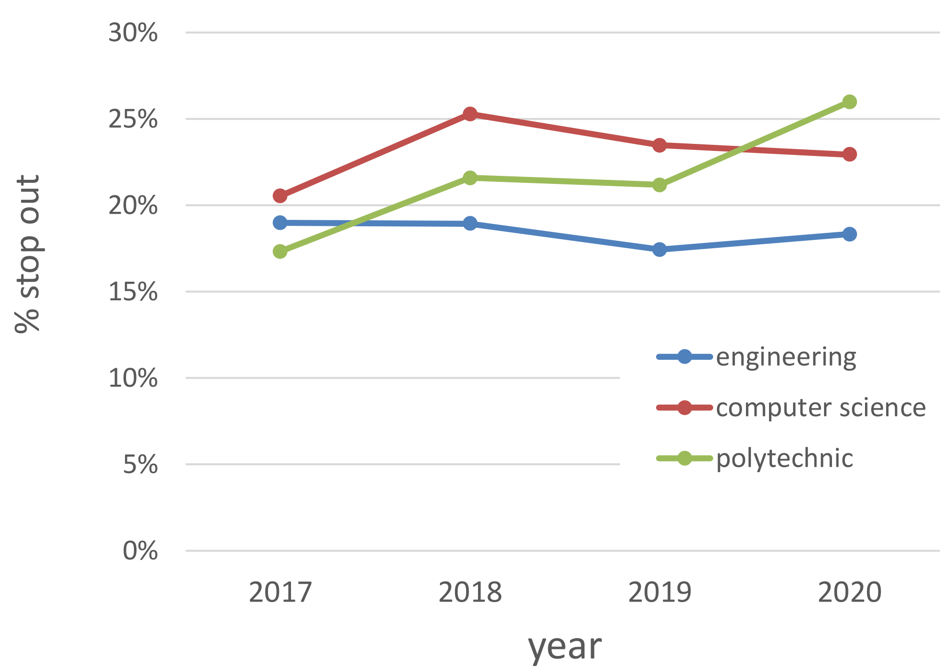

Figure 3. Percent stop out data for engineering, polytechnic, and computer science for the years 2017-2021.

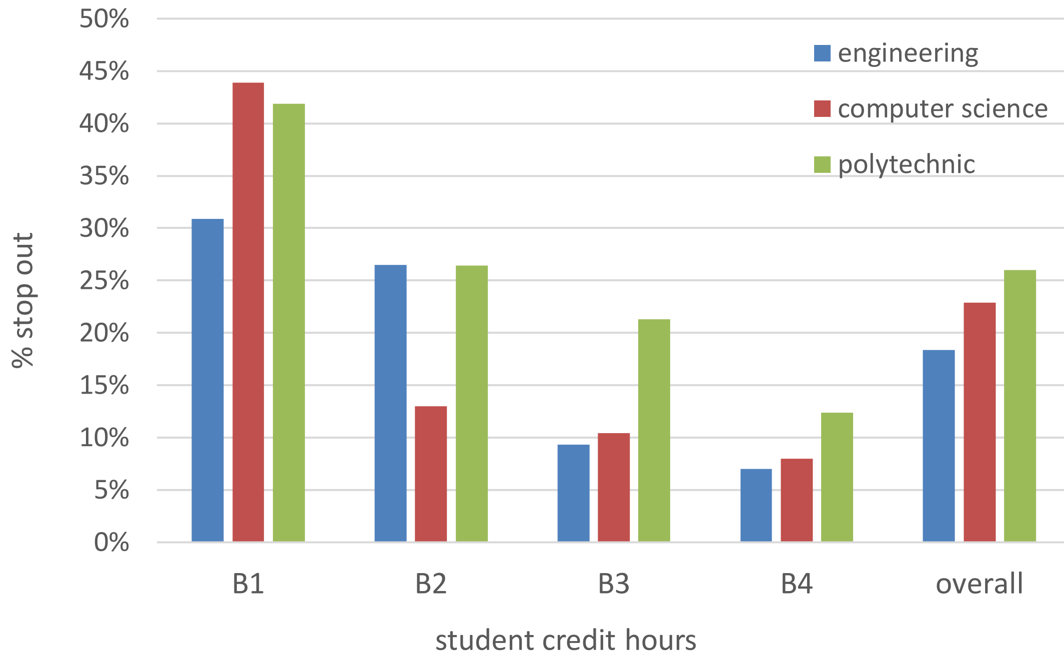

Figure 4. Percent stop out data for engineering, polytechnic, and computer science students at various levels for the year 2020-2021.

Table 2. Percent student success for the year 2020-2021

	ENGR	CS	POLY
first-year (B1)	30.9%	43.9%	41.9%
sophomore (B2)	26.5%	13.0%	26.4%
junior (B3)	9.3%	10.4%	21.3%
senior (B4)	7.0%	8.0%	12.4%
overall	18.4%	22.9%	26.0%

Separating the data by student level reveals interesting differences between the programs. Initially, the *% stop out* for first-year engineering students is much lower than that for first-year computer science or polytechnic students. This could imply that first-year engineering students are better prepared academically, have reasonable expectations of college rigors, have sufficient resources to stay enrolled, and have a good understanding of the selected major compared with polytechnic and computer science students.

For the B2 students, the computer science numbers drop significantly and stay consistently low until graduation. This suggests that after the first-year, the computer science students are well-equipped to move through the program. The polytechnic numbers drop also, but more gradually and consistently. This implies that polytechnic students continue to encounter challenges as they progress through the program.

In the second year, the percentage of engineering students that stop out decreases slightly, but the number is much higher than the percentage of computer science students. This suggests that a more careful examination of the data, program-by-program may be warranted. As an example, in 2020, 18 ME students switched to MET and 13 CE students switched to CET. Similar numbers were observed in other years. Thus, a typical scenario is that when engineering students encounter academic difficulties, usually after completing approximately 30 credit hours, they struggle and may switch to the related polytechnic program.

Figure 5 presents the data in slightly different format showing *% student success*. Percent student success is defined as the percentage of students that remain at the university plus the students who graduate; thus, this data is complementary to *% stop out* data. Initially, the *% success* is highest for engineering students. The *% success* for computer science students increases significantly from B1 to B2 and then remains high until graduation. The *% success* for polytechnic students displays a steady increase from one student level to the next.

Figure 6 shows the percentage of students transitioning from one level to the next (a measure of academic progression). Numbers were not available to compute overall program values, so a simple average of the four-year data is shown for each program. The *% level transitions* follows a similar trend the *% success* data with a few exceptions. Most notably, the transition from B4 to graduation. Engineering students exhibit a significantly lower rate of transition from senior to graduate. One reason for this is the senior design program in engineering is two semesters. Thus, engineering students often take an extra semester to graduate either due to pre-requisite requirements or due to a planned reduction in credit hours during their last year.

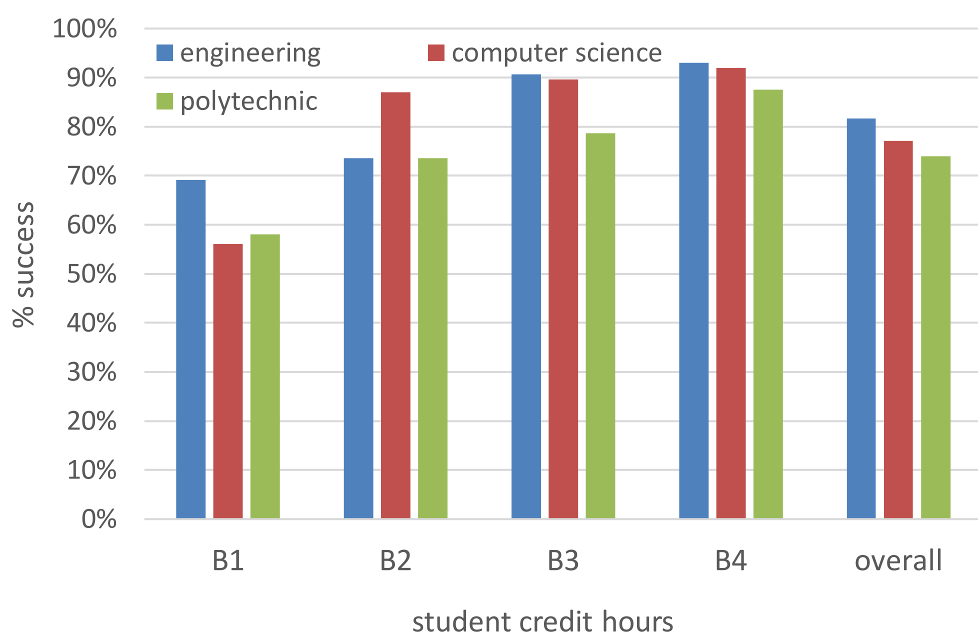

Figure 5. Percent success data for engineering, polytechnic, and computer science students at various levels for the year 2020-2021.

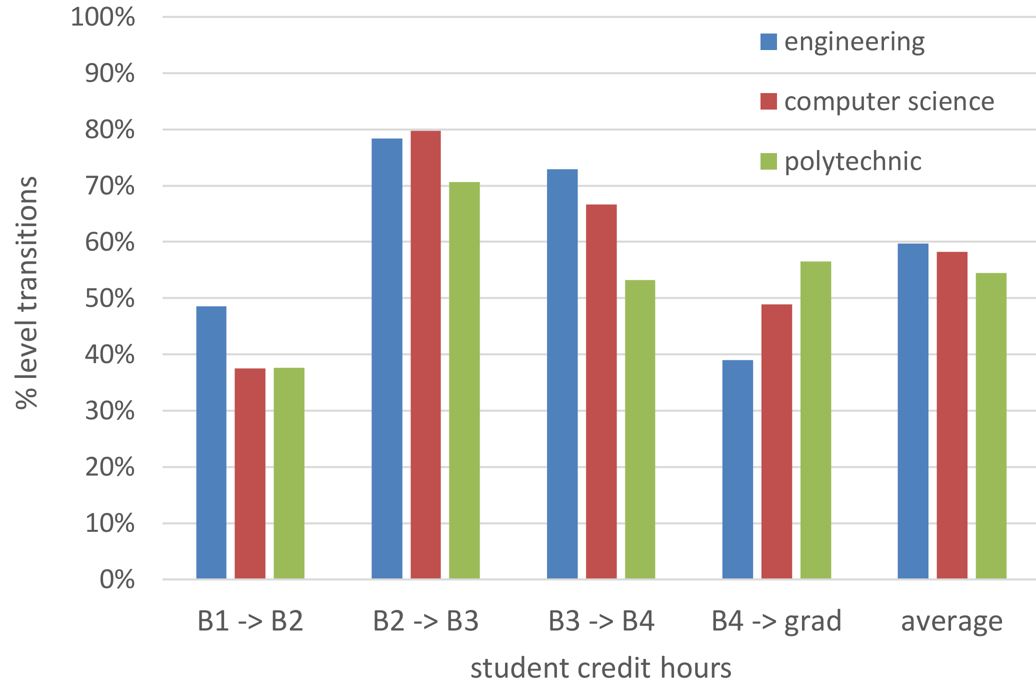

Figure 6. Percent level transitions for engineering, polytechnic, and computer science students the year 2020-2021.

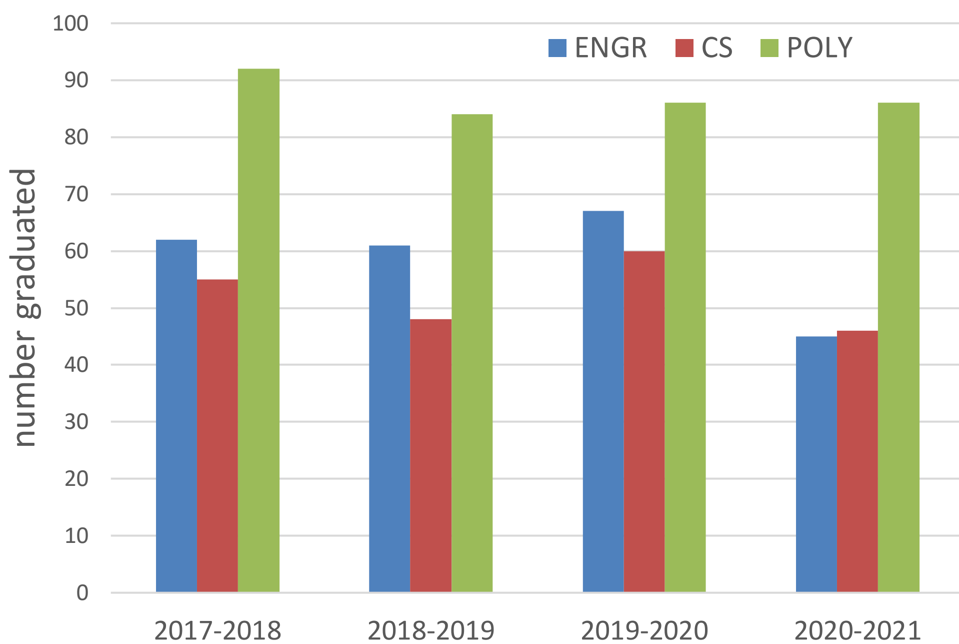

Figure 7. Number of BS graduates from engineering, polytechnic, and computer science.

To given an idea of the size of the programs, the number of students graduating each year is shown in Figure 7. Over the four-year period presented, the graduation rate is fairly steady.

Student Scholar Data

An additional source of data came from members of the STEM Scholars Program (SSP). Members of the program were required to fill 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 reports describing how they spent their stipend from grant. The monthly data was complied, analyzed, translated to semester data, and reported to the S-STEM Scholarship Reporting Site (www.s-stem.org).

Key findings from the activity reports [5] include:

- A common theme related to financial aspects of the grant is that scholarship money greatly reduced ***stress***. Stress effects students and support structures such as learning communities and mentoring give students structure and advice to help cope with stress. Learning communities also help students ***interact with other students***, especially those outside of their discipline.
- Students in the SSP benefited greatly from ***internships***, as well 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 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 (81%) of the students that participated in the grant also work. According to the data [5], 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.

The overarching goal of this project is to the increase the graduation rates and decrease the time-to-graduate for students 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. Figure 8 shows the number of semesters-to-graduate plotted versus GPA for the 25 students in the program who graduated. (Note, students entered the program as rising juniors and ideally, rising junior students should graduate in two years or four semesters.) Seventeen of the rising junior students or 65% graduated in four semesters or fewer and after five semesters that percentage rose to 73%.

The data in Figure 8 reveals a negative correlation of 0.40 between semesters-to-graduation and GPA (Pearson correlation $r(23) = -.40$, $p < 0.001$). The dashed line on the graph is an indication of the negative relationship. Academic success as indicated by graduation GPA correlates with on-time graduation. On average, computer science students in the program graduated in 4.3 (SD = 0.29) semesters, polytechnic students graduated in 4.8 (SD = 0.62) semesters, and engineering students graduated in 5.1 (SD = 0.55) semesters. More details about the student scholar data are given in Ref. [5].

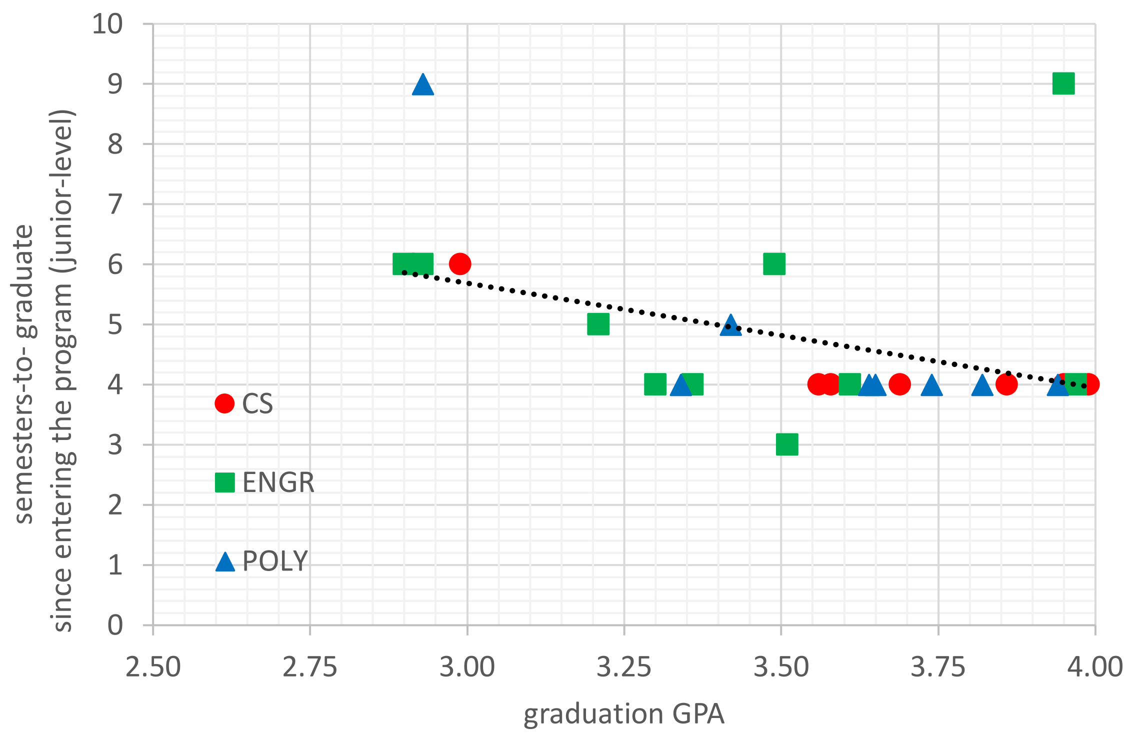

Figure 8. Relationship between semesters-to-graduate and GPA for S-STEM scholars. (From Ref. [5].)

Discussion of Results

Student success is dependent on many factors, e.g. student intellect, background, motivation, personal circumstance, etc. The overarching goal of this project is to improve student success and ultimately improve graduation rates. Supporting goals of this project are to identify impediments to success and to suggest strategies to reduce or eliminate the impediments.

Results of the survey indicate three primary challenges impact student success, viz. *academic*, *time* (work, family obligations, or commute), and *financial*. A schematic is shown in Figure 9.

Survey results indicate that the frequency and severity of these factors is dependent on the individual student's characteristics, chosen academic program, and personal circumstance.

In addition, the relationship between the factors is complex. One factor can cause or exacerbate another factor, thus compounding a student's situation. For example, some students lack sufficient time to study due to work or family obligations. This causes academic issues and necessitates dropping a class that can lead to financial issues. Other students have academic difficulties that cause them to drop and repeat a class that leads to financial issues and thus a need to increase hours at work. Still other students have financial issues, which causes a need to work, reducing study hours, leading to academic problems.

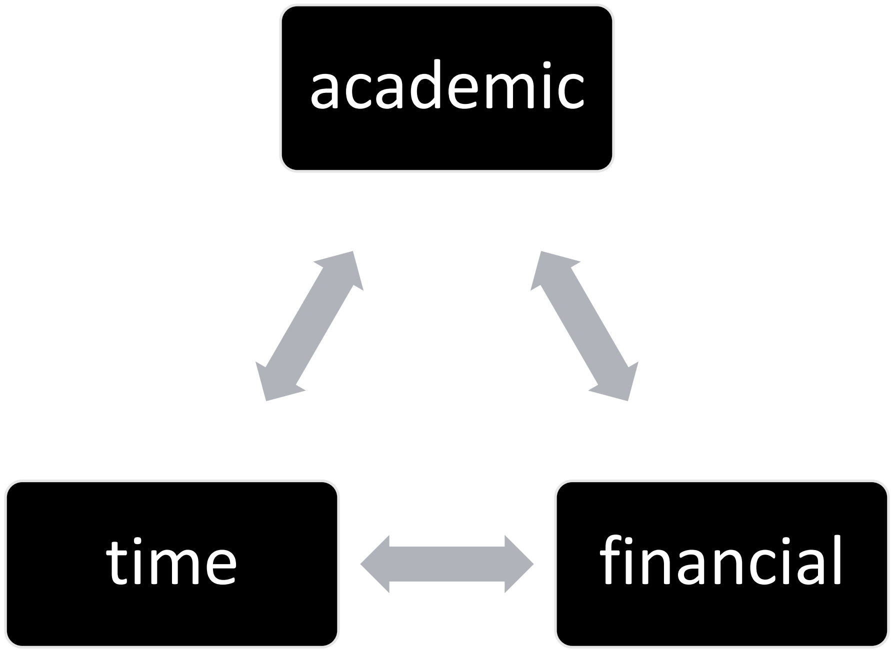

Figure 9. Factors that challenge student academic success.

It is critical that student success advisors identify the primary challenge for the individual student before it becomes a serious issue, compounds, and impacts student success. Success advisors need to connect students with the proper university resources to reduce or eliminate barriers quickly and decisively.

Products Developed

Based on the findings from the three data sources, the FLC developed three student success tools.

1. Success Assessment Tool

A Qualtrics risk assessment has been created as means for self-evaluation of barriers (academic, time, or financial) to success and collaborative evaluation of students' status and needs with their faculty mentor or advisor. This tool is comprised of 30 questions with some sub-questions. The assessment takes approximately 10 minutes to complete.

This assessment tool aims to help students understand how much or how little additional support they need from faculty and the university to facilitate the successful and timely completion of their degree program. The goal is to further assist the student by identifying needs for additional supports and how the faculty mentor and the university services can be helpful to the student. Students who complete the survey will be better informed about the risks they face failing or succeeding at the university and the various options that exist to minimize the risk of failure in their degree program.

The results from this tool can be used by the student when meeting with the faculty mentor who can then guide the student to the resources on campus, detail the degree program, and outline a program completion plan. Using this tool is voluntary—students are not required to complete this assessment tool.

The survey begins with an introduction of the assessment tool, its purpose, and how it can be used. The next section evaluates the academic level of the student. Then, there is a block of four questions assessing student motivation. The largest section on the survey has 11 questions and focuses on ability and performance. The next section has seven questions and includes self-appraisals of coping and stress management. There are three questions in the openness and approachability section with two final questions regarding completion plan and advising needs.

2. Risk Indicator Survey

A Qualtrics risk indicator has been created to identify students who are struggling in a particular class. Students who are "flagged" by an instructor will be advised of support services and encouraged to develop a personalized improvement plan.

This risk indicator tool is used by faculty to flag students in their courses who they believe are at risk of failing. At-risk students are connected with an advisor in the student success center, who will follow up with the student when appropriate. Survey results are monitored by the student success center, thus allowing the student success center staff to potentially view information from multiple faculty members and determine if the student is struggling with one class or in the multiple classes. With the use of this tool, students can be connected to support services prior to actually failing the course or failing out of their degree program.

This assessment tool consists of seven questions—the first identifies the student and the course in which the student is struggling. Then, in a matrix style, the faculty member indicates areas that the student is at risk at such as a high number of missed classes, not submitting assigned work, or low grades.

Another question allows faculty members to indicate if they believe the student requires immediate intervention with a simple yes or no. A write-in section allows the faculty member to share what they are concerned about and to more specifically identify why they believe the student is at risk of failure. A final question is for the faculty member to indicate whether or not they have already spoken to the student about these issues and concerns. The last question allows the student success advisor to understand the degree to which others have already tried to intervene and to provide support.

3. Engineer Your Success

Engineering Your Success is an activity and worksheet given to students to (a) monitor progress in a specific class, (b) assist students in self-identification of barriers to success that might exist in a specific class, and (c) provide a process for students to develop a personalized improvement plan. A copy of this activity is given in the Appendix. The activity is designed to be reviewed by a student success advisor for input and advice.

Due to changes in the undergraduate advising structure at PFW in general and personnel changes within the ETCS student success center, adoption of the success tools has been slow.

Concluding Remarks

Most studies, e.g. [9] – [10], of retention and persistence in STEM majors conclude that academic ability and academic preparation are the biggest factors for success, while interactions such as learning communities and mentoring play a smaller role. This study confirms that finding.

This study shows that rates of academic progress and retention are different for different programs, i.e. engineering, polytechnic, and computer science. Specific interventions designed for targeted groups should be explored. For example, attention should be given to entering computer science students to make them aware of the focus of the program and the demands of the major. Engineering students may struggle academically their second year, and certain groups of engineering students may benefit from help transitioning to polytechnic programs. In addition, engineering students often slow their rate of progress in their senior year taking an extra semester to graduate—these students can benefit from additional academic programs such as certificate programs or the combined BS/MS degree program, or they may choose to work more hours. Polytechnic students encounter challenges throughout the program that need to be addressed to maintain enrollment—consistent monitoring may be beneficial.

Current efforts are ongoing by the College of ETCS to help students with academics, interaction, and engagement. The Help Corner offers tutoring services for ETCS students by ETCS students. Tutors have proven academic success inside the classroom and are trained to provide a quality service to their peers. In-person tutoring is a drop-in process. An online option is also available, although most students prefer in-person. The current program has nine tutors in a wide range of topics. The LEAD Peer Mentor Program connects students with industry mentors, their peers, and their faculty through a variety of academic, career development, and social activities and events. The current program has nine student peers servicing over 90 students. Programs at the college-level are structured with resources so that they are sustainable and maintainable.

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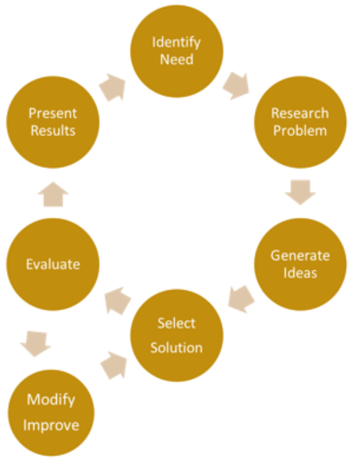
Appendix

Engineer Your Success

The engineering design process is a systematic procedure that engineers follow to develop innovative solutions to complex and challenging problems. A chart illustrating seven steps of the process is shown in the figure below.



We are going to apply this process to the "need" of achieving success in a class.

Identify a Need

Well maybe "need" is a little strong, but as students you are striving for success in your classes. Success can be defined in a lot of ways—you certainly want to master the material, but "master" is a little vague. To define a measureable, quantifiable objective we are going to define success as a grade of A or B.

Research the Problem

Next, you need to do some research. Refer to the syllabus to determine how your average will be computed and your grade will be assigned. Then, talk to other students, professors, peer mentors, and draw on your previous academic experiences to determine ideas as to what it takes to be successful in this class.

Generate Ideas

In this step, you want to imagine as many different ideas as possible to help you achieve your goal. Don't worry about whether the idea is practical. Examples of possible solutions might include attend every class, submitted every assignment, bribe your professor, etc.

Select Solution

After generating a list of ideas, select the best or most promising ideas to implement. In this case, you need to eliminate all illegal (and unethical) ideas, so bribing your professor and cheating should be crossed off the list.

Evaluate

Next, evaluate your progress. We suggest computing your grade at least once a week. Are you achieving your goal of an A or B? If not, go to the step of modify to improve your solution plan.

Modify to Improve

If you are not meeting your goal, **MAKE A CHANGE,** before it is too late! Maybe attend the Help Corner, devote more time to the class, study with other students in the class, go to faculty office hours?

Present Results

Discuss your progress and final grade with others. Talk with your advisor or peer mentor. Is your plan sound? Are you on the right path? Did you achieve your desired result? If appropriate, let your parents, spouse, family, or friends know how you are doing along the way, but be honest. Finally, you should be proud of hard work that results in success.

Summary

This exercise is designed to make you aware that ***you are responsible for your success.*** You need to develop a plan, monitor your progress, make changes if needed, and reflect on the outcome to see if you are in the right program and headed in the right direction.

A sheet to record your plan, your progress, and any modifications is included. This sheet is only an example—it can be adapted for other courses. The sheet should updated at least weekly and shared with your advisor periodically. At the end of the semester, we would like get a copy of the completed worksheet to see if this exercise was helpful to you.

Engineer Your Success

Identifier: ______________________

Need: Success in ___________________ as indicated by a grade of A or B in the class.

Possible Ideas:

1. Attend all class meetings.
2. Submit all assignments
3.
4.
5.
6.
7.

Selected Ideas

1. Attend all class meetings.
2. Submit all assignments
3.
4.

Modifications to the plan to improve:

1. Date implemented ________
2. Date implemented ________

Evaluate Progress:

Week	Classes Missed	Assignments Missed	Homework Average	Quiz Average	Exam Average	Class Grade	Notes
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							