WIP: The effect of scholarships and community on graduation rates for STEM majors

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***Abstract*—This WIP research paper describes a key challenge faced by STEM disciplines, especially Engineering and Computing, namely the graduation rate of students. Many models that show a return on investment in higher education for individuals and the state work only when students graduate. However, graduation rates are strongly influenced by students' ability to focus on their studies. Anecdotally, faculty believe that when students must spend a significant time each week working in a job to pay (at least in part) for school, their ability to do well in STEM majors is inhibited. Students who must work to afford college are typically from lower socioeconomic status (SES) groups, and it has been suggested that support in the form of scholarships helps overcome the financial challenges that compel students to work. Many colleges have also created programs that foster community for students in STEM majors to enhance success. In this paper, we discuss literature showing that students from low SES groups graduate overall at lower rates than students from wealthier backgrounds. We then examine data from constituent schools of the University System of Maryland to see the effect of scholarships on graduation rates. Specifically, we test the hypothesis that scholarship support improves graduation rates. With data from one of these institutions, we test the second hypothesis: that graduation rates improve still further when scholarships are offered in combination with a supportive community. Our results show that financial support combined with a supportive community works better than financial support alone.**

I. Introduction

Social mobility provided by education is a fact of many modern societies. In the United States, multiple studies show that attaining a bachelors degree leads to desirable economic and social outcomes. For example, the College Board recently published a study, *Education Pays 2023* [1], showing that people with a bachelor's degree earn about $29,000 more per year at age 25 than those with a high school diploma alone. A New York Federal Reserve study [2] from earlier this year shows that the median income for bachelor's degree holders is $60,000, compared to $35,000 for those with a High school diploma alone. A recent report from Association of Public and Land Grant Universities (APLU) [3] indicates that over a lifetime, the earning difference is about $1.2 million.

Questions have increasingly arisen regarding the value of a four-year degree. Not everyone needs to go to college; certainly, there are many examples of people doing well in life without a college degree. However, the data make it fairly clear that the long-term socioeconomic benefits provided by a college education are significant. Data also show that degrees in areas where the workforce is growing lead to the best economic outcomes. Majors in Engineering broadly, and especially in and related to Computing, tend to command some of the highest starting salaries and long term earning potential.

Clearly, a college education is of great benefit, especially to those from low SES groups. Yet, these groups tend to have the lowest graduation rates. In fact, a person that goes to college, incurs debt, and does not graduate, experiences worse outcomes than those who did not attend college at all. In a recent survey by the University Professional and Continuing Education Association [4], financial challenge was the most-cited reasons for dropping out of college (42% of all non-completers). As majors like Engineering and Computing are very demanding, they require a significant investment of time outside of classroom hours in studying, projects, and homework. This means that those who need to support themselves by working jobs, especially off-campus jobs, often do not have adequate time to devote to their studies and are more likely to drop or fail out of school.

In this paper, we explore two propositions empirically. First, that providing scholarships to students, especially students from low SES groups in STEM majors, helps them graduate. As a proxy for socioeconomic status, we use the FAFSA Expected Family Contribution (EFC) computation. We show that scholarships very clearly help, raising graduation rates significantly. Second, we explore whether a supportive community increases graduation rates. Many universities have now created communities that provide support and scaffolding to students. Such communities provide some combination of dedicated advising, living learning communities, students taking classes together, external mentors etc. Often, these communities are associated with scholarships as well, meaning that most (if not all) students who participate in the community receive some form of scholarship. The rationale is that students from low SES backgrounds are often the first generation in college, and often come from groups that are historically underrepresented in STEM programs. It is these students who tend to benefit most from additional community support. For example, the Meyerhoff Scholars Program at the University of Maryland Baltimore County (UMBC) is a national model for increasing the number of students from historically underrepresented groups in STEM disciplines. Similarly UMBC's

Cyber Scholars Program is intended to diversify the pipeline of future leaders in cybersecurity and computing. Using data, we explore whether students complete college at a higher rate because of the financial support received, and whether the community support provided further helps. We show that both factors are important and that their combination raises graduation rates more than financial support alone.

II. Related Work

Anecdotally, most faculty in STEM majors, especially Computing and Engineering disciplines, believe that students who need to spend a significant amount of time in outside work to pay for college find it hard to complete their degrees, and often switch majors or drop out. There is significant literature to substantiate this, as discussed below. Providing scholarships has been seen as a solution, but prior studies that deal with this topic have found mixed effects. Dynarski[5] studied scholarship programs in Arkansas and Georgia and showed a 3% increase in graduation rates. Our results are significantly better, as shown in section IV. Angrist *et al.* show[6] that providing a financial incentive for good grades does not significantly impact student success. However, this is not the same as providing a scholarship.

Bjorklund-Young[7] provides a good overview of the literature on the SES completion gap, that is, the gap between the number of students from low SES backgrounds who finish college vs. the number of those from high SES backgrounds. It builds on the data from National Center for Education Statistics (NCES)[8] showing that only 14% of students from poorer families graduate from college, while 60% from wealthier families do. The NCES data indicate that this is not due only to the level of academic preparation coming into college; it is also because college is expensive, and not getting the right help makes it harder to complete. The paper shows that when students from low-income families get financial help and good advice on how to apply to college, they do better. It points out that giving these students more support can make a big difference in helping them graduate.

A book published by Mark Kantrowitz in 2021, summarized in a Forbes article[9], claims that students from low SES backgrounds (Adjusted Gross Income of less than $50,000) are two-thirds of all college non-completers. It describes the various reasons contributing to the lower graduation rates among these students, with a particular emphasis on the challenges posed by balancing work and education. It points out that students who are forced to work full-time jobs while attending college are half as likely to graduate as those who work fewer than 12 hours a week. The article describes other factors such as starting at a community college, being economically independent from their families, and living off-campus that also contribute to lower graduation rates, and many of these factors are strongly correlated with a low SES background.

Caro *et al.* [10] studied the effect of family SES on education and labor force outcomes in a longitudanal U.S. study. They argue that academic achievement disparities related to SES begin early in life and continue into adulthood. They discuss the mechanisms through which a family SES influences children's education outcomes. The study highlights the persistent effect of SES on labor force outcomes, where high family SES correlates with higher earnings and occupational status. The research suggests that addressing education inequalities and providing more comprehensive support to students from low SES backgrounds could help mitigate these long-standing disparities.

III. Data and Methods

Recall that our aim is to see if there is empirical support for the proposition that students, especially those in STEM majors like Engineering and Computing, benefit from scholarships in terms of higher graduation rates. We also wish to see if creating supportive communities helps in addition to the scholarship money. We used anonymized data from the University System of Maryland (USM) for the cohort entering in Academic Year 2014, both first-time and transfer students. This cohort has approximately 30,000 students spread across disciplines. USM institutions are extremely diverse – they include two R1 universities, an R2 university, Urban, suburban and rural universities, three Historically Black Institutions, and a Minority Serving Institution. They range from universities that enroll under 1500 students to one that enrolls more than 40,000.

For each student, we have information about the major they pursued and the degree they obtained as Higher Education General Information Survey codes. We also have data about finances – the students EFC from FAFSA, and the financial support, either need based or merit based, given to the students. In our analysis, adhering to USM categories, we identify high need students as those whose EFC from their FAFSA is $6,656 or less. This amount corresponds to eligibility for a Pell Grant. Medium-need students were defined as those whose EFC was less than twice this number. Others were identified as low need.

We analyzed this data for the entire cohort, for a subset for STEM students only, and a subset of Engineering and Computing students only. For each student, we note whether they graduated. We did not look at time to graduation, although our data covered the time period up to 2022, eight years after they entered. We also do not, in this study, look at the amount of financial support provided. We simply note whether support was provided at any time during a student's course of study.

In addition, we have data from a similar time period from two constituent institutions of the USM. The University of Maryland, Baltimore County (UMBC) is a medium-sized (about 14,000 students) R1 in a suburban setting with primarily residential students. It has thriving *scholars programs* that combine financial assistance with a supportive community environment. This data had entering cohorts from 2014 to 2016. We used this data to test our second proposition, namely that financial and community support together raise graduation rates higher than financial support alone. Meanwhile, the University of Maryland Global Campus (UMGC) *"was*

founded in 1947 to make respected, state university education accessible to working adults and servicemembers." It has no residential facilities, and offers classes online and onsite at remote locations, especially to members of the US Armed Forces. Its dataset, like USM, was limited to the entering cohort in 2014.

The data were originally available as Excel spreadsheets. The analysis was done using programs written in Python that used built in or library functions in Python for common things like finding correlations or doing χ^2 tests. The excel data was loaded into Panda tables, which were then transformed using standard Panda methods such as *selection* and *groupby* to get various subsets such as those relating to majors, graduation status, and financial aid status.

A. Potential Limitations

Our data set is extremely large, and has data from 12 different institutions of varying characteristics. This lends support to our results. We recognize however, that this is data from a single cohort entering in 2014. It is theoretically possible, though not likely, that this particular cohort is in some way not representative of USM students as a whole. We also note that the data from UMBC, while much smaller, does span entering cohorts over three years, and shows similar trends. Further, this data is limited to Maryland public institutions. It is possible that the strong effect of financial support we see on graduation rates for low-income students does not apply to students in private universities, or students outside Maryland. However, this too is unlikely, as financial aid for students from low SES backgrounds is an even bigger issue at private universities given their significantly higher tuition rates.

IV. Results

We start with a very general analysis from the USM data. It shows that regardless of major, and regardless of need level, scholarship support helps (Table I). The change however is largest for high need students, their graduation rates rise from about 25% to nearly the mean graduation rate across all USM institutions. We tested the statistical validity of this association of financial support with graduation rates using the χ^2 test, and found that the p value was 2.82×10^{-29} for high-need students, which shows that the provision of financial support strongly affects graduation rates.

Financial Need	Supported	Graduation Rate
High	No	25%
High	Yes	59%
Medium	No	45%
Medium	Yes	77%
Low	No	62%
Low	Yes	79%

TABLE I
USM Graduation rates.

When broken down by gender (table II) and by ethnicity (table III), we see the same effects, except for groups like Native Hawaiians and Native Americans for which the numbers in the data st were very small. We note that underrepresented groups see a very significant increase. For example, high-need Black or African American students graduate at a rate of 14% when not supported, compared with 52% when supported. High-need Hispanic students' graduation rate increases from 28% to 64%. For White students, the corresponding figures are 41% and 64%. We note that, as has been reported elsewhere, women tend to graduate at higher rates than men across all need levels, but that at each need level, regardless of gender, financial support raises graduation rates significantly.

Financial Need	Supported	Gender	Graduation Rate
High	No	Female	27%
		Male	22%
	Yes	Female	60%
		Male	58%
Medium	No	Female	46%
		Male	43%
	Yes	Female	79%
		Male	74%
Low	No	Female	67%
		Male	57%
	Yes	Female	81%
		Male	76%

TABLE II
USM Graduation rates based on gender.

Financial Need	Supported	Ethnicity	Graduation Rate
High	No	Asian	24%
		White	41%
		Black	14%
		Nat. Hawaiian	0%
		Hispanic	28%
		American Indian	0%
	Yes	Asian	76%
		White	64%
		Black	52%
		Nat. Hawaiian	47%
		Hispanic	64%
		American Indian	41%
Medium	No	Asian	59%
		White	49%
		Black	34%
		Nat. Hawaiian	50%
		Hispanic	49%
		American Indian	0%
	Yes	Asian	83%
		White	80%
		Black	70%
		Nat. Hawaiian	100%
		Hispanic	74%
		American Indian	67%
Low	No	Asian	66%
		White	68%
		Black	48%
		Nat. Hawaiian	0%
		Hispanic	62%
		American Indian	67%
	Yes	Asian	86%
		White	80%
		Black	71%
		Nat. Hawaiian	50%
		Hispanic	78%
		American Indian	88%

TABLE III
USM graduation rates based on ethnicity.

We also looked at USM graduation data for STEM majors only, and for Engineering and Computing majors only. This

data is summarized in tables IV, V, and VI, and shows that for high-need STEM students, the graduation rate changes from 22% to 60% for those from low SES. This is higher than the change across all majors. For Computing and Engineering, these rates rise from 27% to 52%, and from 0% to 69% respectively. For Engineering, our data did not contain any student who was not financially supported yet still graduated. χ^2 test results continue to lead to very small p values for the effect of scholarship on graduation. The *largest* p value we found was for high-need Engineering students, and even that was 0.051. All other p values were significantly smaller.

Financial Need	Supported at any level, any year	Graduation Rate
High	No	22%
High	Yes	60%
Medium	No	44%
Medium	Yes	78%
Low	No	57%
Low	Yes	81%

TABLE IV
USM GRADUATION RATES FOR STEM STUDENTS.

Financial Need	Supported at any level, any year	Graduation Rate
High	No	27%
High	Yes	52%
Medium	No	32%
Medium	Yes	69%
Low	No	53%
Low	Yes	68%

TABLE V
USM GRADUATION RATES FOR COMPUTER SCIENCE STUDENTS.

Financial Need	Supported at any level, any year	Graduation Rate
High	No	0%
High	Yes	69%
Medium	No	67%
Medium	Yes	78%
Low	No	67%
Low	Yes	87%

TABLE VI
USM GRADUATION RATES FOR ENGINEERING STUDENTS.

We then analyzed the STEM and Engineering/Computing graduation data for the USM, disaggregated by ethnicity and gender. We see that the effect of scholarships is slightly more important for STEM students. High need women in STEM graduate at a rate of 62% when support is provided, compared to 60% with support for high need women overall. For Black or African American high need students provided support, the overall graduation rate is 52%, but for STEM students it is 53%. Graduation rates are similarly higher for high-need Asian American STEM students provided support. We do notice a slight decline for Hispanic students. These data are shown in tables VII and VIII, and can be compared with the corresponding overall data shown earlier in tables II and III.

UMBC and UMGC data also show lift in graduation rates for STEM majors. For financially supported high-need students at UMBC, graduation rates changed from 38% to 71%. When broken down by gender and ethnicity, these changes were seen across all demographics. Like the USM data overall, the change in graduation rates was higher for historically underrepresented groups when provided financial support.

Financial Need	Supported	Gender	Graduation Rate
High	No	Female	24%
		Male	22%
	Yes	Female	62%
		Male	59%
Medium	No	Female	55%
		Male	38%
	Yes	Female	84%
		Male	74%
Low	No	Female	67%
		Male	52%
	Yes	Female	85%
		Male	79%

TABLE VII
USM STEM GRADUATION BY GENDER.

Financial Need	Supported	Ethnicity	Graduation Rate
High	No	Asian	20%
		White	47%
		Black	9%
		Nat. Hawaiian	0%
		Hispanic	25%
		American Indian	0%
	Yes	Asian	79%
		White	60%
		Black	53%
		Nat. Hawaiian	50%
		Hispanic	61%
		American Indian	50%
Medium	No	Asian	73%
		White	43%
		Black	36%
		Nat. Hawaiian	0%
		Hispanic	27%
		American Indian	0%
	Yes	Asian	86%
		White	82%
		Black	67%
		Nat. Hawaiian	0%
		Hispanic	61%
		American Indian	100%
Low	No	Asian	65%
		White	63%
		Black	40%
		Nat. Hawaiian	0%
		Hispanic	53%
		American Indian	0%
	Yes	Asian	87%
		White	82%
		Black	76%
		Nat. Hawaiian	0%
		Hispanic	82%
		American Indian	100%

TABLE VIII
USM STEM GRADUATION RATES BY ETHNICITY.

For the UMBC data, we also separated out first time students (table IX) from transfers (X). Once again, we see that the effect of financial support is consistently positive in both these groups across need categories. For transfer students, who often are from low SES backgrounds, the increase in graduation rates is higher than for first time students.

For UMBC students, we also knew whether they were participating in a scholar community such as the Meyerhoff or

Financial Need	Supported at any level, any year	Graduation Rate
High	No	38%
High	Yes	71%
Medium	No	63%
Medium	Yes	79%
Low	No	67%
Low	Yes	85%

TABLE IX
UMBC GRADUATION RATES FOR THE FIRST TIME STUDENTS.

Financial Need	Supported at any level, any year	Graduation Rate
High	No	38%
High	Yes	68%
Medium	No	51%
Medium	Yes	81%
Low	No	63%
Low	Yes	89%

TABLE X
UMBC GRADUATION RATES FOR THE TRANSFER STUDENTS.

Cyber Scholars programs. We examined the graduation rates for students without support, with financial support, and those with financial support in tandem with a supportive community. It is clearly evident from table XI that both factors help. For high need students, the graduation rates rise from 38% without financial support to 70% with support, and to 87% when that financial support is provided as part of a supportive community. Similar increases are seen for other need groups.

Financial Need	Supported at any level, any year	Graduation Rate
High	No	38%
High	Yes, financial aid	70%
High	Yes, financial aid+community	87%
Medium	No	63%
Medium	Yes, financial aid	76%
Medium	Yes, financial aid+community	100%
Low	No	67%
Low	Yes, financial aid	83%
Low	Yes, financial aid+community	92%

TABLE XI
UMBC GRADUATION RATES(FINANCIAL AID ALONE AND COMBINED WITH COMMUNITY).

Major	Graduation Rate
Mechanical Engineering	77%
Chemical Engineering	81%
Computer Science	75%
Information Systems	75%
Computer Engineering	73%
Business Technology Administration	64%

TABLE XII
GRADUATION RATES FOR VARIOUS ENGINEERING AND TECHNOLOGY DISCIPLINES.

V. CONCLUSION

This paper presents an empirical analysis of data from a large state university system, and some of its constituent institutions. It is well understood in literature that financial constraints, especially prevalent among students from low SES backgrounds, considerably hinder their academic performance and graduation timelines. Such students often belong to groups that are historically underrepresented in Computing and Engineering majors in the US. We show that graduation rates for students from low SES backgrounds increase when they are provided scholarships and a supportive community. Previous work has found some limited improvement in graduation rates when scholarships are provided, our work shows a much stronger effect. Furthermore, the combination of financial assistance with community support programs proved even more effective than financial aid alone. This suggests that holistic support strategies that address both financial and social integration aspects are crucial in enhancing student success in STEM disciplines. We recommend that legislators and policymakers consider both scholarships and structured community support programs as essential components of strategies to boost graduation rates of students from low SES backgrounds. In ongoing work, we are extending our analysis using machine learning to see if we can identify what level of support works best for increasing graduation, and whether there is diminishing returns beyond a certain level of support.

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