Board 139: Factors Affecting Enrollment, Retention, and Attrition of STEM Undergraduates at a Minority Serving Institution

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Abstract

Higher education institutions experience a paramount problem of enrollment, retention, and attrition, which is particularly acute within the Science, Technology, Engineering, and Mathematics (STEM) fields. Based on the National Center for Education Statistics, 48 percent of bachelor's degree students who began STEM programs between 2003 and 2009 had left them by spring 2009, 28 percent switched to a non-STEM major, and 20 percent left the program and exited the educational institution without earning a degree. That said, nearly half of STEM students change majors to a non-STEM program, perform deficiently compared to their peers in other programs, or leave the educational institution before completing their degree and/or not earning academic credentials. Students' attrition occurs most frequently in the first and second year of their academic programs; in fact, more than 60 percent of dropouts occur in these years. These rates are especially troubling for undergraduate STEM students from historically marginalized communities. Several factors play a significant role in STEM undergraduate students' attrition, such as poor-quality teaching and advising, curriculum difficulty, lack of belonging, lack of interaction between students and faculty, financial difficulties, and lack of hands-on project activities. The goals of this paper are to (1) identify the main factors that hinder undergraduate STEM students' interest, success, and perseverance, particularly those from marginalized communities, which contribute to the change in their career path or them dropping out before earning their degree; and (2) identify the actions that can be taken by educational institutions to increase undergraduate STEM student's enrollment and retention while decreasing attrition. To achieve these objectives, this study: (1) identified the main factors contributing to these problems of utmost importance to academia from previous literature; (2) collected and analyzed enrollment and retention data from Florida International University (FIU), one of the largest minority serving institutions in the United States; and (3) identified strategies and best practices aimed at addressing these paramount difficulties within undergraduate education through literature review. The data collected regarding retention rates of STEM and Engineering and Computing students showed that approximately (a) 17 percent of students that started their programs between 2008 and 2014 were not retained after their first year, while 8 percent of students that started their programs on the following years were not retained after their first year; (b) 28 and 15 percent, respectively, after their second year; (c) 35 and 21 percent after their third year; (d) 40 and 22 percent after their fourth year; and (e) 41 and 22 percent after their fifth year. This research proposes several strategies and best practices including orientation programs, early academic advising, peer-to-peer mentoring and tutoring, math review sessions/courses, early warning systems to identify potential switch-outs or dropouts, equitable financial aid mechanisms, and creation of more hands-on project activities.

Keywords: Academic Success, Attrition, Construction Management, Engineering, Enrollment, Retention, STEM education

Background and Motivation

Low enrollment, poor academic performance, low retention, and high attrition of Science, Technology, Engineering, and Mathematics (STEM) students are concerns of utmost importance for higher education institutions [1]–[3]. According to the National Center for Education Statistics (NCES), 48 percent of STEM undergraduate students who started their programs between 2003 and 2009 had deserted their program by spring 2009. From that 48 percent, 20 percent dropped out and abandoned the educational institution without earning a degree and 28 percent switched to a non-STEM major [2], [4]. Particularly in engineering majors, 20 percent dropped out and 21 percent switched to a non-STEM major by 2009 [4]. Furthermore, graduation rates of engineering majors have hovered steadily around 50 percent for the past 60 years. This indicates that nearly half of the students do not complete their degrees and leave their educational institution before earning academic credentials [3], [5], [6]. Undergraduate STEM student dropout rates at higher education institutions, as well as transitions to non-STEM majors, mostly occur during the initial years of the academic program. In fact, more than 60 percent of dropouts occur between the first and second years [2]. These rates become more concerning when we examine undergraduate STEM students from historically marginalized communities, who tend to have even lower retention and higher attrition rates [7]. This group of students tend to receive negative feedback and, as a result, may be more likely to change their academic plans, which can widen the racial/ethnic gap in STEM. Negative feedback can exacerbate existing issues, such as stereotypes and biases, that may lead them to believe they do not belong in STEM fields [7]. Additionally, negative feedback can discourage these students from seeking support, mentoring, and guidance, which can further disadvantage them [7]. As a result, historically marginalized communities have lower retention and higher attrition rates [7].

With retention being a complex issue within undergraduate education, understanding the reasons of student's poor academic performance, low persistence, and low motivation is crucial to increasing enrollment, academic success, decreasing change of major or dropout, and increasing retention rates. The literature suggests that several factors impact students' success and engagement, and thus play a significant role in STEM undergraduate students' high attrition rate. These factors include (a) poor-quality teaching and advising, lack of competent faculty as well as unsuccessful teaching and training methods [1], [2], [8], [9]; (b) curriculum difficulty [8], [9]; (c) deficiencies in mathematics and analytical skills of freshman students who struggle to complete math courses, which are fundamental to success in STEM programs [3], [8]–[10]; (d) uninspiring introductory courses [9]; (e) lack of sense of belonging as well as an academic culture that is not always pleasant and welcoming, particularly to minority students [9], [11]; (f) lack of interaction between students and faculty, such interaction is important to students since it not only allows for the positive climate within the institution but also contributes to students' success [2], [8]; (g) financial difficulties, thus not being able to cover tuition and expenses; and (h) lack of hands-on project activities and the availability of infrastructure and labs [1], [9].

Several factors may contribute to the success of undergraduate STEM students from historically marginalized communities. It is crucial to explore the experiences and challenges that this population face as well as how to address them. There are three significant characteristics that contribute to STEM and engineering attrition according to the literature: (1) lack of student engagement with faculty as a result of a 'chilly climate;' (2) the agreement that students' aptitude

is not primarily responsible for their decision to change majors from engineering [1]; and (3) lack of sense of belonging as well as an academic culture that is not always pleasant and welcoming, particularly to those from historically marginalized communities [9], [11]. That said, this warrants further exploration of these factors in relation to this specific student population in order to gain a deeper understanding of how to best prepare these students for success in STEM and engineering fields.

This study investigated the main factors hindering the interest, success, and perseverance of undergraduate STEM students, particularly those from marginalized communities, at Florida International University (FIU), one of the largest minority serving institutions (MSI) in the United States (U.S.). Furthermore, this study analyzed the actions that can be taken by educational institutions to increase enrollment and retention, while decreasing attrition. To achieve these goals, this study (1) conducted a literature search to identify the contributing factors impacting enrollment, retention, and attrition rates; and (2) collected and analyzed enrollment and retention data from Accountability [12], an intranet site created by FIU's Office of Analysis and Information Management (AIM) that contains raw data from all students at the academic institution. Finally, based on the literature search and the analysis of the enrollment and retention data, the authors identified several strategies and best practices to address the problems of enrollment, retention, and attrition within undergraduate education. The findings of this study serve educational institutions and education stakeholders by paving the way to address enrollment, retention, and attrition concerns and contribute to the academic success of students, particularly those from historically marginalized communities. Furthermore, increasing undergraduate STEM retention significantly helps maintaining a robust STEM workforce in the U.S., thus alleviating the STEM professional shortage.

Methodology

This study was motivated by the paramount problem of enrollment, retention, and attrition in STEM undergraduate education with a focus on those from historically marginalized communities. The study is guided by two research questions: (1) what are the main contributing factors impeding STEM undergraduate students' interest, success, and persistence, particularly those from historically marginalized communities, which impact their low enrollment rates, career change, and dropout? And (2) what actions can be taken by academic institutions to increase enrollment and retention, and decrease attrition, particularly those from historically marginalized communities?

To address these two questions, this study (a) performed a literature search using Papers on Engineering Education Repository (PEER), which is the American Society for Engineering Education conference proceedings database, to identify the contributing factors impacting enrollment, retention and attrition rates; (b) collected and analyzed STEM and Engineering and Computing (EC) student enrollment and retention data obtained from Accountability [12], an intranet site created by an MSI's Office of AIM which contains raw data of all students at FIU; and (c) identified strategies and best practices that can be implemented at educational institutions to address the low retention and high attrition rates of STEM undergraduate students as well as contribute to their academic success based on the literature search and the analysis of the enrollment and retention data.

ASEE's PEER Database

The PEER database was selected since it is limited to engineering and conference proceedings which can serve as a starting point for the preliminary literature search. The authors used the following keywords for the search: (1) +"enrollment" +"retention" +"attrition" +"undergraduate" +"minorities"/"minority"; and (2) +"enrollment" +"retention" +"attrition" +"undergraduate" +"marginalized." To demarcate the phrase, the authors used quotation marks and a plus "+" symbol to require words. This study searched for publications made over the past 10 years. Results were downloaded as a CSV file to aid in the examination of the results. The results were then combined into one Excel sheet, duplicates were eliminated, and the initial title examination was performed. The titles of the documents identified were reviewed for eligibility based on two criteria: (1) postsecondary engineering contexts; (2) included any of the following keywords in the title: minority, minorities, marginalized, underrepresented, since the focus was on students from these groups. If the researchers were unsure whether to include a document based solely on the title, they inspected the abstract. In case the examination of the titles and abstracts was not sufficient, a scan of the complete text was performed.

AIM's Accountability Student Sample and Demographics

Student enrollment and retention data obtained from Accountability [12] contained raw data for all students at FIU. In this paper, First Time in College (FTIC) STEM and EC students were examined. Over the past five years, the MSI increased the number of enrolled STEM students. Within the institution, there are over 14 thousand undergraduate STEM students, out of which 43% identify as female and 57% identify as male. The majority of the students are non-international/domestic, with 6% identifying as international. There is a total of 18% enrolled first-generation students. Undergraduate students' racial/ethnic data is divided depending on international status, where only non-international/domestic demographic information is provided. As such, race/ethnicity at the institution is as follows: 69% Hispanic, 11% Black or African American, 8% White, and 4% Asians.

Similarly, over the past five years, the MSI increased the number of enrolled EC students. Within the institution, there are over 7 thousand undergraduate EC students, out of which 21% identify as female and 79% identify as male. The majority of the students are non-international/domestic, with 8% identifying as international. There is a total of 17% enrolled first-generation students. Undergraduate students' racial/ethnic data is divided depending on international status, where only non-international/domestic demographic information is provided. As such, race/ethnicity at the institution is as follows: 66% Hispanic, 11% Black or African American, 9% White, and 4% Asians.

Results

PEER Preliminary Literature Search

The PEER search identified a total of 621 papers based on the aforementioned keywords. There were 99 duplicate values found that were excluded. Upon screening the remaining 522 papers using the eligibility criteria, a total of 482 papers were excluded. This left 40 papers which illustrated the need for further research in the exploration of enrollment, retention, and attrition of STEM undergraduate students from historically marginalized communities. It is important to recognize the need for targeting this population as it is vital to sustaining a strong STEM workforce in the U.S. and addressing the STEM professional shortage.

Accountability Enrollment rates

The data collected regarding enrollment rates from FTIC STEM students showed that the number of students that enrolled in STEM programs (a) decreased from 804 students in 2008 to 778 students in 2009; (b) increased from 778 students in 2009 to 944 in 2010 and 1174 in 2011, having an increase of almost 51 percent in two years; (c) decreased almost 10 percent from 1174 students in 2011 to 1065 students in 2012; (d) increased almost 23 percent from 2012 to 2013, where 1306 enrolled in STEM programs; (e) decreased from 1306 students in 2013 to 1213 students in 2014 and 1177 students in 2015; (f) increased to 1246 students enrolled in 2016; and (g) decreased to 1234 students in 2017. This data is presented in Figure 1.

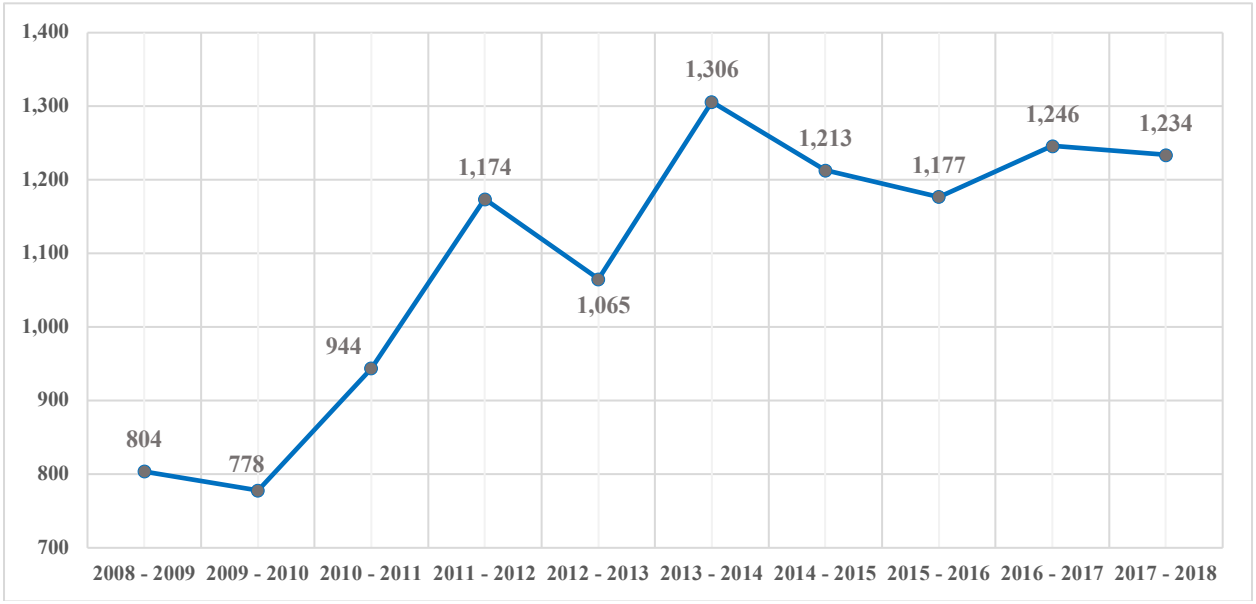

Figure 1: FTIC STEM Students Enrollment Rates

The data collected from Accountability [12] on enrollment rates of FTIC Engineering and Computing (EC) students showed that the number of students that enrolled (a) decreased from 361 students in 2008 to 328 students in 2009; (b) increased to 374 students in 2011 and to 470 students in 2011, thus having an increase of almost 43 percent in two years; (c) decreased from

470 students in 2011 to 458 students in 2012; (d) increased to 598 students in 2013, hence having an increase of almost 31 percent from 2012 to 2013; (e) decreased around 20 percent from 598 students in 2013 to 501 students in 2014; (f) decreased to 458 students in 2015; and remained almost constant in 2016 and 2017 where 457 students and 459 students enrolled, respectively. This data is presented in Figure 2.

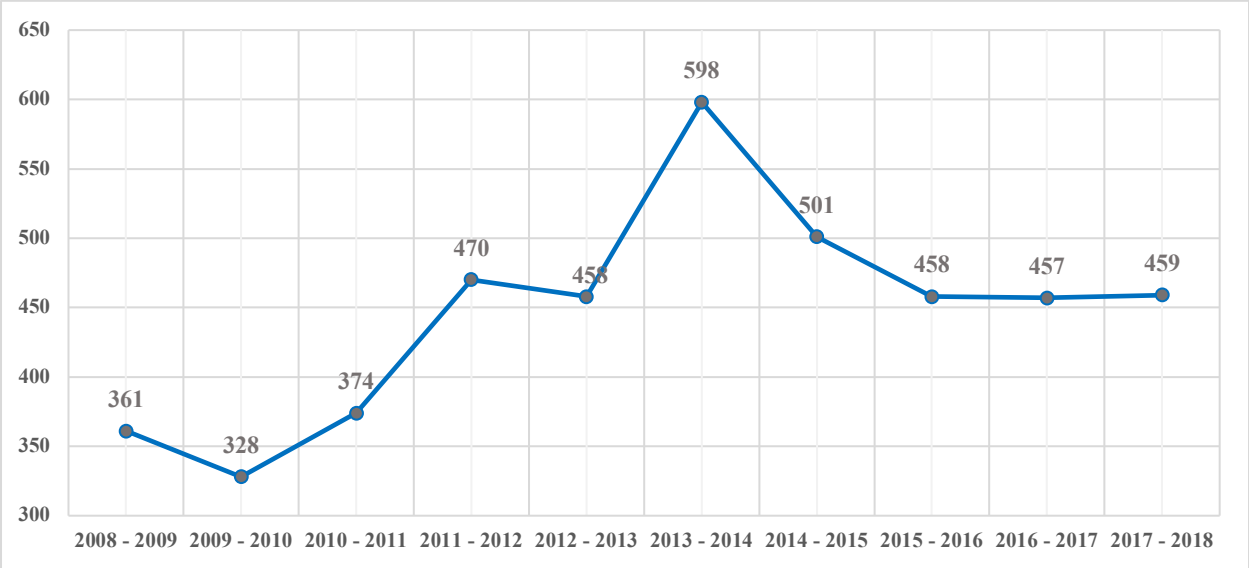

Figure 2: FTIC EC Students Enrollment Rates

Accountability Retention rates

The data collected from Accountability [12] on retention rates of FTIC STEM students showed that (a) between 14 and 19 percent of students that started their programs between 2008 and 2014 were not retained after their first year, while between 6 and 11 percent of students that started their programs on the following years were not retained after their first year; (b) between 24 and 30 percent of students that started their programs between 2008 and 2014 were not retained after their second year, while between 13 and 19 percent of students that started their programs on the following years were not retained after their second year; (c) between 29 and 37 percent of students that started their programs between 2008 and 2014 were not retained after their third year, while between 16 and 24 percent of students that started their programs on the following years were not retained after their third year; (d) between 32 and 40 percent of students that started their programs between 2008 and 2014 were not retained after their fourth year, while between 17 and 25 percent of students that started their programs on the following years were not retained after their fourth year; (e) between 33 and 41 percent of students that started their programs between 2008 and 2014 were not retained after their fifth year, while between 19 and 25 percent of students that started their programs on the following years were not retained after their fifth year; (f) between 33 and 42 percent of students that started their programs between 2008 and 2014 were not retained after their sixth year, while between 24 and 26 percent of students that started their programs on the following years were not retained after their sixth year; and (g) between 33 and 42 percent of students that started their programs between 2008 and

2014 were not retained after their seventh year, while 27 percent of students that started their programs on 2015 were not retained after their seventh year. This data is presented in Figure 3.

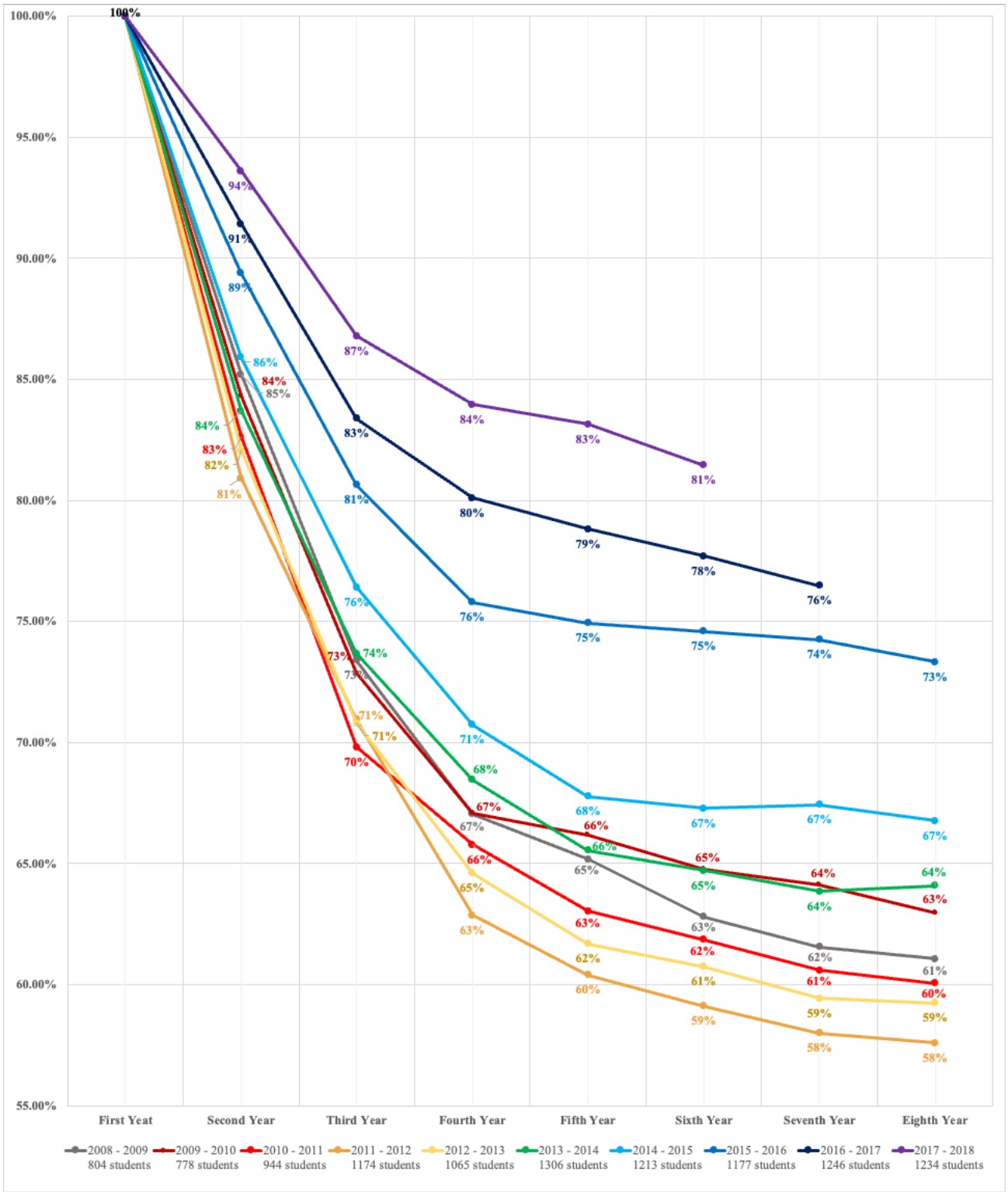

Figure 3: FTIC STEM Students Retention Rates

Furthermore, Figure 3 shows that STEM students' higher education attrition occurs most frequently in the first and second year. However, there is still a considerably high attrition rate in the third year. Despite that retention rates have been increasing throughout the years, still (a) 27 percent of students that started their programs in 2015 were not retained after their seventh year in the academic institution; (b) 24 percent of students that started their programs in 2016 were not retained after their sixth year; (c) and 19 percent of students that started their programs in 2017 were not retained after their fifth year. As a result, we see a large proportion of STEM students not retained, that either end up changing majors or dropping out without earning a degree.

As far as FTIC EC students, the data collected from Accountability [12] showed that (a) between 13 and 22 percent of students that started their programs between 2008 and 2014 were not retained after their first year, while between 3 and 8 percent of students that started their programs on the following years were not retained after their first year; (b) between 24 and 34 percent of students that started their programs between 2008 and 2014 were not retained after their second year, while between 12 and 15 percent of students that started their programs on the following years were not retained after their second year; (c) between 31 and 44 percent of students that started their programs between 2008 and 2014 were not retained after their third year, while between 14 and 21 percent of students that started their programs on the following years were not retained after their third year; (d) between 32 and 45 percent of students that started their programs between 2008 and 2014 were not retained after their fourth year, while between 16 and 22 percent of students that started their programs on the following years were not retained after their fourth year; (e) between 34 and 46 percent of students that started their programs between 2008 and 2014 were not retained after their fifth year, while between 17 and 22 percent of students that started their programs on the following years were not retained after their fifth year; (f) between 34 and 47 percent of students that started their programs between 2008 and 2014 were not retained after their sixth year, while between 19 and 22 percent of students that started their programs on the following years were not retained after their sixth year; and (g) between 35 and 48 percent of students that started their programs between 2008 and 2014 were not retained after their seventh year, while 23 percent of students that started their programs on 2015 were not retained after their seventh year. This data is presented in Figure 4.

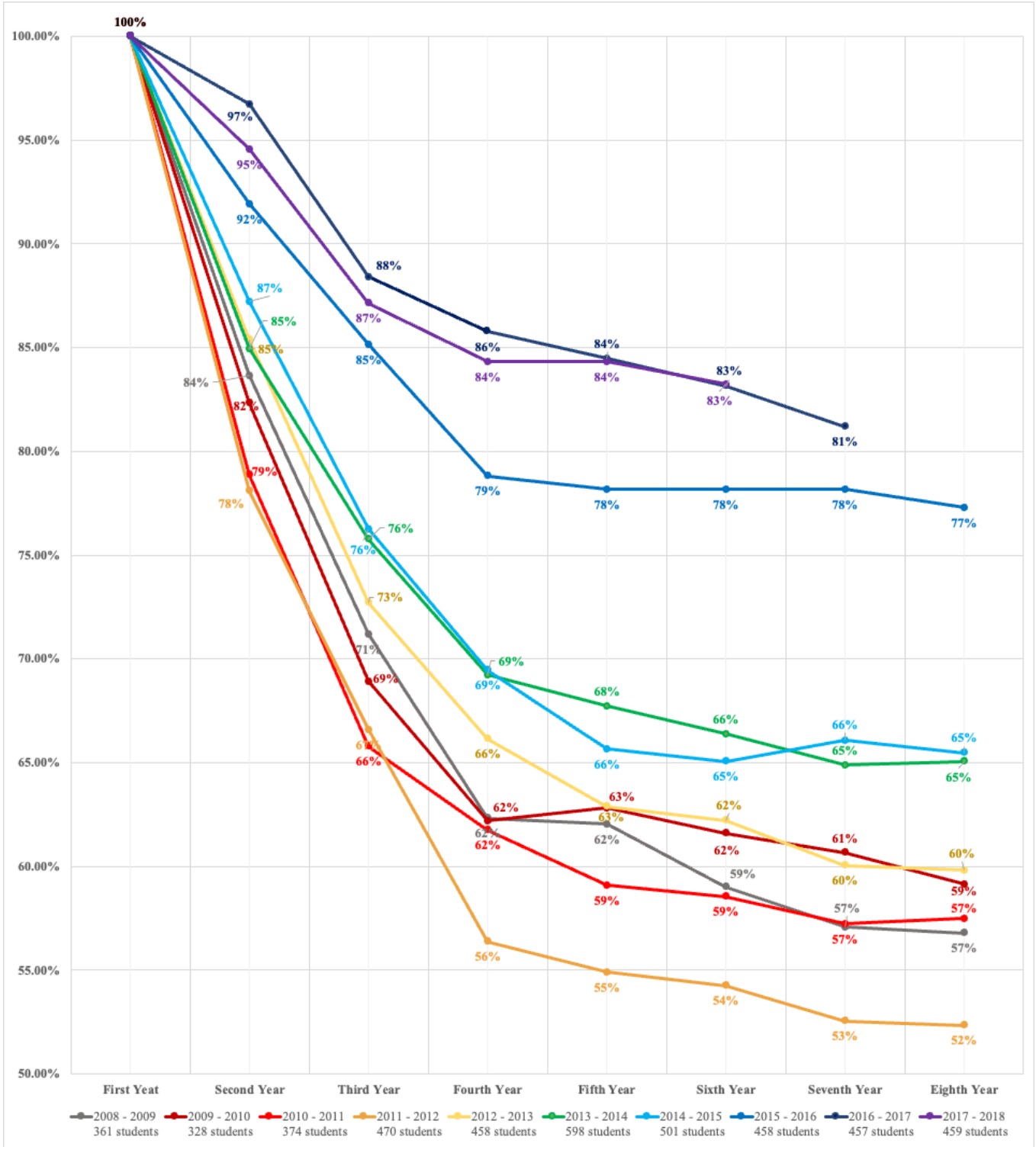

Figure 4: FTIC EC Students Retention Rates

Furthermore, Figure 4 shows that EC students' higher education attrition occurs most frequently in the first and second years. However, there is still a considerably high attrition rate in the third year. Even though EC students' retention rates have been increasing throughout the years, still

(a) 23 percent of students that started their programs in 2015 were not retained after their seventh year in the academic institution; (b) 19 percent of students that started their programs in 2016 were not retained after their sixth year; and (c) 17 percent of students that started their programs in 2017 were not retained after their fifth year. As a result, a large proportion of EC students are not retained and either change majors or drop out without earning a degree. Additionally, it can be observed that EC students' attrition rates are very similar to STEM students' attrition rates.

Discussion

The Accountability [12] data presented above illustrates the change in the enrollment and retention rates at FlU, one of the largest MSIs in the U.S. As it may be observed, enrollment and retention rates have improved. This highlights that there were university-wide institutional actions taken to address the increase in enrollment as well as a shift in practices to target the retention of students, particularly those from historically marginalized communities. According to reports from FIU's AIM website for retention and graduation studies [13], some of these actions and practices included:

1. **Changes in grading options** – The No Credit (NC) grading option replaced a D or F in any University Core Curriculum course with an NC grade. While NC grades may be considered a negative impact on retention and graduation, they are less detrimental to a student's success than Fs. Using the NC policy as an intervention helps bring about behavior change and thus increases the number of returning students.
2. **Implementation of an Early Alert system to identify at-risk students** – Professors sent out early warnings to inform students of their progress in a course. If students deviate from their course plans, they and their academic advisors are notified. This allows for proper interventions to prevent them from failing their classes.
3. **Shift into using technology and predictive models to track student related data** – FIU started to use an online, updated tool for checking retention and graduation rates by college, major, student type (FTIC or transfer), and admit year. The institution started using predictive models to identify factors that could potentially contribute to freshman students' dropout. The identifying factors include unweighted high school GPA, financial assistance, unmet need, ethnicity, major type, and housing.
4. **Creation of pathways for undergraduates** – Some of the pathways created included the Accelerated Bachelor's/Master's Pathways which provides an opportunity for highly qualified students to complete both their undergraduate degree and a corresponding master's degree in five years. Another pathway program that was created was the First Year Pathways: Supported Transition to Excellence Program (STEP) for Engineering and STEM. STEP is intended for students who are not calculus ready or have not finished college-level math courses satisfactorily. This program offers student success workshops and specialized advising.
5. **Student success initiatives** – FIU implemented several initiatives to support student's success, including the University's Graduation Success Initiative. This initiative aimed to (1) assist students in early identification of an appropriate major; (2) offer students with a clear route to graduation; (3) provide students with rapid support and feedback; (4) eliminate barriers to enhance support for students; and (5) reach out to students proactively.

6. **First-generation academic success initiatives** – Student Support Services is a federal TRIO program funded by the U.S. Department of Education. The Federal TRIO Programs are federal outreach and student assistance programs that are aimed at identifying and serving those from historically marginalized communities. FIU hosts the following TRIO programs: Post-baccalaureate Achievement, Educational Talent Search, Upward Bound, and Upward Bound Math-Science. These initiatives contributed to making FIU one of the top producers of bachelor's degrees for historically marginalized students, including first-generation students.
7. **Addressed obstacles to graduation** – Unavailability of courses as well as classes that overlap in their schedule has been an obstacle to graduation. This was especially troublesome for FTIC students who tend to choose face-to-face classes. As such, FIU identified and targeted critical courses needed for graduation. Furthermore, the institution created the vertical integration of undergraduate and graduate courses to help add more course offerings. Thus, contributing to students' graduation goals.
8. **Admission into Exploratory-Engineering** – Dropout at FIU was found to be associated with poor academic performance in early mathematics and English courses for the majority of EC students. As such, Exploratory Studies tracks were created to (1) help students choose their major; and/or (2) help students who did not meet the admission requirements for selective programs. For example, students who want to pursue engineering majors but are unable to enroll in MAC 2311 (Calculus I) could be assigned to the Exploratory Engineering major. This would allow them to declare a major in engineering or computer science (BS degree) only after meeting this prerequisite.
9. **Course modality** – FIU started to incorporate more online and hybrid course since (1) it was found that the average GPA for these courses was higher than the one for in-person courses; and (2) many students work part or full time and thus this modalities help them to achieving their graduation goals.
10. **Change in advising practices** – FIU determined that students with advising comments in their Advisor files were more likely to be enrolled than those without notes from their advisor. An increased engagement from the advisor significantly contributed to identify students who were struggling in their selected major. As a result, interventions and advice were given to students. This contributed to not only helping them achieving academic success, but also to find leveling courses and/or alternative degree pathways.

Limitations and Future Work

This paper used one specific database for the preliminary literature search which was limited to only conference proceedings. Some of the keywords and selected eligibility criteria may have excluded some papers that could potentially aid in answering the research questions. Future work will expand the literature search to other databases to include journal publications for a more thorough analysis of the literature. Furthermore, this paper only assessed FTIC students at one MSI. While this MSI might not be representative of all FTIC student populations, it is one of the largest MSIs in the U.S. and thus a representative of the historically marginalized population of STEM and engineering programs. The recommendations are preliminary, and future work will look at additional demographics to continue adapting these recommendations to the needs of other students' populations. This way, they can not only help a greater population of students across educational institutions but also significantly benefit several institutions that struggle with

enrollment, retention, and attrition. Future work will also explore transfer students' retention and attrition.

Furthermore, on-time graduation and degree completion of undergraduate students are critical tertiary educational challenges, as the time to complete a bachelor's degree in the U.S. has increased considerably over the past two decades [14]. In fact, more than 50 percent of bachelor's students fail to complete their degrees on time [15], [16]. Future work will study students' on-time graduation and degree completion, as well as the factors contributing to these paramount problems in the academic community.

Conclusions and Recommendations

Several academic as well as non-academic factors hinder minority students' interest, persistence, and success. These factors include poor-quality teaching and advising, a challenging curriculum, deficiencies in mathematics, uninspiring courses, lack of sense of belonging, a lack of interaction between students and faculty, financial difficulties, a lack of hands-on projects as well as the availability of infrastructure and laboratory facilities [1]–[3], [8]–[11]. All of these factors greatly contribute to major change and dropout rates. Based on the preliminary literature search and considerations of all the aforementioned factors, as well as the analysis of the enrollment and retention data, this paper identified several strategies and best practices that might assist academic institutions in increasing enrollment and retention, decreasing attrition, and thus contributing to students' academic success and progression, particularly students from historically marginalized communities. These strategies and best practices include:

1. **Orientation programs and/or courses** – Providing students with orientation programs and/or courses can positively influence students' attitudes [17], [18] and contribute to their academic success by (a) teaching them study habits and skills; (b) helping them manage their time better by teaching time management skills; (c) helping them set achievable expectations for their coursework; (d) helping them adjust to campus life; and (d) developing new connections and supportive relationships [3], [18]. Since academic performance and success is a paramount factor affecting retention, orientation can be successful at decreasing dropout and career change of STEM programs [17].
2. **Early academic advising** – Interaction between students and faculty not only allows for a positive academic climate, but also contributes to students' performance and success [2], [8], [19]. Early academic advising can contribute to students' interest and success through (a) establishing a roadmap that considers course requirements as well as optimal combination of courses to enhance academic performance and achievement [20], [21]; (b) alleviating fears and concerns regarding performance and career goals; and (c) helping students integrate life, educational, and career goals. Enhancing students' performance and success positively impacts retention, since there is a positive relation between academic performance and low dropout rates of STEM programs [3], [22].
3. **Math review sessions and/or leveling courses** – Mathematical, analytical, and problem-solving skills are pivotal to success in STEM programs. However, many freshmen lack these skills and struggle to complete math courses [3], [8]–[10]. Around 45 percent of incoming freshmen have considerable problems with Mathematics. In fact, one of the most contributing factors to STEM attrition is the lack of mathematical and analytical skills [3]. Leveling

courses and/or math review sessions can help students acquire these vital skills, advance their knowledge, and positively contribute to their academic performance and success [23]–[26].

4. **Early warning systems to identify potential switch-outs or dropouts** – Most dropouts in STEM programs, as well as switching to non-STEM majors occurs in the initial years of the academic program. In fact, more than 60 percent of dropouts occur in the first and second years [2]. Thus, efforts to decrease attrition and improve students' success should focus on these initial years. Additionally, retention is positively related to first term GPA and a considerable number of students who dropout or change majors are placed on first term probation [6]. Thus, identifying medium and high-risk students, who are most likely to change majors or dropout, and helping them improve their performance by providing them with leveling courses, tutoring, and/or workshops is key to decreasing attrition. Early warning systems, such as SAT scores, school rank, lack of adequate study habits, poor initial preparation in math, lack of problem-solving skills, are paramount to identify these students [6].
5. **Equitable financial aid mechanisms and budgeting workshops** – Financial difficulties and lack of financial health, which translates to students not being able to cover their tuition and expenses, are main contributors to dropouts [1], [9], [27]–[29]. There are several financial resources in academic institutions including financial aid, scholarships, loans, grants, funding from companies, and federal work-study. However, many students are not aware of all these resources. Furthermore, not many students have proper knowledge in budgeting or overall financial management practices that would help them better manage their finances [30], thus further aggravating their financial difficulties. Financial wellness and budgeting workshops can help students discover all the available equitable financial aid mechanisms as well as teach them sustainable management practices. This will contribute positively to their financial health and academic success by reducing their chances of dropping out.
6. **Peer tutoring and/or mentoring programs** – Curriculum difficulty is a key contributor to STEM students' career change and dropout [8], [9]. Peer tutoring and/or mentoring programs, where advanced or higher-grade level students help lower-grade level students with their courses and assignments, can contribute to students' performance and success by (a) helping them understand their courses better [20], [21], [23], [26], [27], [31], [32]; (b) advising them in choosing their courses in an optimal combination to enhance academic performance [20], [21]; (c) teaching them how to improve their study habits as well as other valuable academic skills; (d) building a support system where mentors positively encourage and inspire mentees [33]–[36]; and (e) developing connections and friendships, which further contributes not only to students' academic success, but also enhances their sense of belonging, overall well-being, and helps create a better academic environment for them.
7. **Creation of more hands-on project activities** – Students' enrollment in academic institutions is greatly influenced by the availability of infrastructure and laboratory facilities. Additionally, hands-on project activities and lab-work are critical to maintaining students' interest in STEM programs. Thus, academic institutions should prioritize hands-on project activities to improve enrollment and retention rates, as well as to enhance students' interest, persistence, and success [1], [37].
8. **Extra-curricular activities and/or student organizations** – Lack of sense of belonging as well as an academic culture or environment that is not always pleasant and welcoming, particularly to minority students are factors that impact students' success and greatly contribute to students' attrition [9], [11]. Extra-curricular activities, such as workshops,

keynote speeches, field trips, as well as student organizations, not only encourage social integration and help in developing a network of friends and a support system but also can help increase the students' interest in their professional careers [38].

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