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Promoting Persistence: Female STEM Professors and Graduation Rates of Female STEM Students

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PROMOTING PERSISTENCE: FEMALE STEM PROFESSORS AND GRADUATION RATES OF FEMALE STEM STUDENTS

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CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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Promoting Persistence: Female STEM Professors and
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has been approved by the Examining Committee for the thesis requirement for the

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Abstract

In higher education there have been notably more men than women pursuing areas of study in STEM (science, technology, engineering, and mathematics). This quantitative mixed method study investigated pre-existing data including faculty male to female ratios and female graduation rates within the STEM fields. This study also surveyed current male and female students studying STEM in their final undergraduate year at a Midwest, faith-based, liberal arts college, with the intention of analyzing the impact of the role of female professors on the retention and graduation rates of female students studying in the STEM fields. The discussion unpacks the responses of these students and their goals for post-graduation. Both male and female students were surveyed in order to compare the responses to have a better scope. This research is impactful for faculty and institutions to obtain a better understanding of how to support women in their undergraduate study as they pursue careers in the STEM fields.

Acknowledgements

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Chapter 1

Introduction

Science, technology, engineering, and mathematics (STEM) fields are regarded as critical to the national economy (Chen & Soldner, 2013, p. 1). Despite the need for people to work in STEM fields, students pursuing STEM undergraduate degrees are in the minority. In 2016, only 7% of women who earned a college degree classified it as STEM, while 15% of men who graduated college earned STEM degrees (Stockwell, 2017). Among those who graduated with a STEM bachelor's degree, 37% were female, and 63% were male. Despite efforts to increase the number of women in STEM, "shortages of women in the [STEM] fields are common in today's job environment" (Bailey, 2016, p. 1). Many factors contribute to that shortage in the workforce, but one of those factors is retention of women in STEM majors in undergraduate study.

Statement of the Problem

Bailey (2016) cites "research which shows that 50% or more of the students entering college with STEM career aspirations either switch to a non-STEM field or leave postsecondary education altogether" (p. 6). Students transferring out of STEM majors to non-STEM majors needs to be addressed if colleges and universities want to continue to graduate competent female mathematicians, scientists, and engineers. The solution to this problem does not only lie in female students declaring as STEM majors when they enter college but also in retaining those same students through graduation. For that reason, the retention of female STEM students was the focus of this study.

Female STEM Professors

In a 2016 report, the American Council on Education "indicated that gender inequality remains a problem in higher education. Although women have earned over 50% of doctoral degrees since 2006, they continue to be underrepresented in tenured faculty positions and overrepresented in non-tenured, instructional faculty positions" (Taylor et al., 2017, p. 392). For example, in 2016, women earned less than half of mathematics and statistics bachelor's degrees and less than 30% of mathematics and statistics doctoral degrees. This is not a large improvement from 1997, when 24% of mathematics and statistics doctoral degrees were achieved by women. In fact, the percentage of women who received these types of degrees dropped from 46% in 1997 to 42% in 2016 (National Science Foundation, 2019). This study is being conducted to ascertain if more female representation at the faculty level in colleges and universities impacts female students' retention in their field of study.

Female Student Retention

This study will focus on female student persistence or success rate specifically in the STEM fields and majors. Female student success is determined by retention and graduation rates in STEM undergraduate majors. Retention in STEM fields in this study is defined as students who declare as STEM majors in their first or second year in undergraduate studies and remain in that field until graduation. Despite earning almost half of the total awarded mathematics bachelor's degrees, "women [are] accounting for less than 25% of the total STEM workforce… all of these appear to have been exacerbated by the lack of female role models" (White & Massiha, 2016, p. 2). There is a

need for female examples in STEM fields and STEM professors—not only mathematics, but in all STEM fields.

The skills students need to be successful in STEM fields, including the ability to confront open-ended problem scenarios, think creatively, and produce novel designs, have all been lauded as necessary skills for today's 21st learners (Bartholomew & Strimel, 2018). A student's ability to work throughout school to attain their bachelor's degree demonstrates their perseverance. A contributing factor in studying success during college is confidence in one's own ability. "Belief in one's ability to achieve in STEM was a predictor of STEM majors in college and STEM concentrations in graduate school… as women had lower self-efficacy" (Heilbronner, 2009, p. 1). This could be a factor in the retention rate, since without professor and faculty representation, female students do not have role models or mentors to look to during their studies. The lack of female professors and advisors could be influencing female students' desires to continue through undergraduate STEM degrees to graduation.

Purpose of the Study

The purpose of this study was to quantify the significance of female professors in STEM fields for undergraduate students, as well as female professors' impact on the retention of female STEM undergraduate students. This study sought to determine if a correlation exists between the retention of female STEM undergraduate students and the percentage of female faculty members. This research utilized quantitative descriptive analysis. Research has shown that "among female students in the upper quartile of the ability distribution, it is clear that assignment to a female professor improves academic performance and increases the likelihood of graduating with a STEM degree" (Mansour

et al., 2020, p. 13). Understanding contributing factors in female STEM student retention could be beneficial to colleges and universities that are working to increase STEM student retention.

Conclusion

The retention and graduation rates of female STEM students are on average lower than the retention and graduation rates of male STEM students. Therefore, the following research question guided this study: Does the percentage of female STEM professors have an impact on graduation rates of female STEM undergraduate students? There are many studies that focus on women in STEM, but few, if any, that examine the link between female professors and the retention of female students to graduation at the undergraduate level. The closest study that examined the interaction of female faculty and students provided "credible evidence that freshman-year interactions with female math and science professors can profoundly affect career trajectories" (Mansour et al., 2020, p. 2). However, that specific study only looked at freshman students and does not look at graduation rates or their later accomplishments. Therefore, this type of mixed method study is important to better understand factors that aid in female students' success in STEM undergraduate degrees. The following chapter will examine research regarding females in STEM fields within higher education.

Chapter 2

Literature Review

The literature review in this chapter will examine the different constructs of this study. The constructs include the definition of STEM, female STEM professor, and female STEM students and their retention in undergraduate studies. Each of these components contributed to answering the research question: Does the percentage of female STEM professors have an impact on graduation rates of female STEM undergraduate students?

Science, Technology, Engineering, and Mathematics

Science, technology, engineering, and mathematics graduates are critical for our society to continue to run. Historically, men have played a larger role than females in these fields. Over the last few decades, the role women play in STEM careers and in higher education has been a source of discussion. These discussions are about how many women are pursuing mathematics and science bachelor's or further degrees and how to retain those that are in STEM fields.

In one study, 90% of participants "identified a lack of awareness of educational and career opportunities in STEM as a barrier to pursuit of STEM careers" (Swafford & Anderson, 2020, p. 70). In that same study, 75% of participants agreed that STEM educational toys are directed at boys and emphasized "a lack of female mentors/role models" (p. 70). Young girls and women are not made aware of possibilities or opportunities that could be available to them in the STEM field. Even at a young age,

girls do not see themselves as scientists or engineers because of the lack of representation in media. Even though 50% of STEM bachelor's degrees recipients are women, more than 70% of scientists and engineers are men (Mansour, 2020, p. 1). Less than 25% of the STEM workforce are women, which begs the question: Where are these women with STEM degrees going if not to work STEM careers post-graduation? The adversity these women face in navigating career path seems to stem from "lack of self-confidence as compared to their male peers, and potentially strong cultural influences. All of these appear to have been exacerbated by the lack of female role models" (White & Massiha, 2016, p. 2). If young girls see women as scientists, astronauts, or any other STEM field roles, then they can dream it for themselves.

Female STEM Professors

Looking to female role models starts young, but it also continues in education, specifically in colleges and universities. Male professors and faculty significantly outnumber female professors and faculty in STEM fields in higher education. "STEM women faculty were 40% more likely than men to leave the tenure track and assume an adjunct position" (Pascale, 2018, p. 248). In 2010, according to the National Science Foundation, "women constituted 22% of full professors, 37% of associate professors, and 44% of assistant professors." Women getting through the educational system and earning doctorate qualifications to be a professor is the first step. However, the number of women earning degrees in STEM declines as they move through the educational pipeline. "While women earn 50% of all bachelor's degrees in science and engineering, they earn only 45% of master's degrees and 40% of doctorates in these fields, compared to 57% of bachelor's degrees, 60% of master's degrees and 46% of doctorates in other fields"

(Pascale, 2018, p. 248). Compared to other fields of study, women in STEM fields are less likely to continue studying past undergraduate level. Something is contributing to that decline in percentage of female students moving from bachelor's to doctorates. Professors may play a large role in students' experiences at their individual college or university, which can lead to retention of students or students leaving the program or institution.

Female STEM Students

For the purpose of this study, retention of female students in STEM fields is defined as female students who declare as STEM majors in their first or second year in undergraduate studies and remain in that field until graduation. Overall, women make up 58% of college students, while men make up 42% of college students, though this is not the case in STEM degrees. Within the STEM fields, 36% are female, while 64% are male (Indicator 26: STEM Degrees, 2019). Starting in higher education, there are fewer female than male students. This leads to an overall lower percentage of females compared to males working in STEM careers post-graduation with a bachelor's degree. In 2015, "only 28% of employed scientists and engineers were women" (Mansour, 2020, p. 1).

The statistics of females in STEM majors in the United States are similar to those reported in Canada. In 2016, "women made up 34% of STEM bachelor's degree holders and 23% of science and technology workers among Canadians aged 25 to 64" (Wall, 2019, p. 1). The shortage of women in STEM is widely recognized as detrimental to women. Engineering, computer science, and technology careers are among the highest-paying and fastest-growing occupations. However, women who do pursue STEM degrees tend to be more likely to pursue science-oriented fields which are typically lower paid

positions (Stockwell, C., 2017). So, it is important for professors and faculty in higher education encourage young women to pursue the full range of STEM fields post-graduation.

Research shows that "belief in one's ability to achieve in STEM was a predictor of STEM majors in college and STEM concentrations in graduate school" (Heilbronner, 2009, p. 1). There are many contributing factors that impact women's self-confidence in STEM fields. Specifically, in higher education, faculty and student interaction in and out of the classroom impacts students' sense of support in their department. The institution's campus climate around female STEM students will also have an impact on whether students feel competent in their fields and can be a predictor of future success (Trautvetter, 2018, p. 102). A college student's confidence in their own ability to be successful in each field allows students to challenge themselves and reach for bigger goals. A professors' encouragement, or lack thereof, can highly impact a student's sense of belonging or belief they can succeed with not only their chosen major but also their chosen field post-graduation.

There has been an increased problem of STEM students, both male and female, switching majors during their time in college. "A total of 48% of bachelor's degree students and 69% of associate degree students who entered STEM fields between 2003 and 2009 had left these fields by spring 2009" (Chen & Soldner, 2013, p. iv). Within that percentage, roughly half of the students switching majors were moving out of STEM fields to non-STEM degree tracks. One of the more popular tracks to switch to from STEM degrees is business. Of those that left STEM fields by the spring of 2009, "22% of bachelor's degree students and 16% of associate's degree students who entered STEM

fields and later switched majors ended up pursuing business" (Chen & Soldner, 2013, p. 16). As administrators and faculty of higher education institutions, the question that should be asked is: Why are these students not remaining in their chosen STEM fields?

Connection Between Female Professors and Female Students

Female representation within higher education, specifically in science, technology, engineering, and mathematics, matters. Even outside of the world of STEM higher education female representation is important. Unfortunately, there has been a considerable lack of positive, powerful role models for young girls to look up to in STEM fields, both in the real world and in media. In the media's portrayal of STEM characters from 2002 to 2014, "female STEM characters were outnumbered by male STEM characters in speaking roles by 2 to 1" (Steinke & Tavarez, 2018, p. 1). This imbalance is only part of the problem. The overall lack of awareness and portrayal in media is only a fraction of lack of women representation in STEM.

A research study showed that the gender of academic advisors is seen to make an impact on female students enrolling in STEM undergraduate courses. Of the female first-year students, "only 5.3% of female students matched to a male science advisor enroll in a STEM degree. However, moving from a male to a female science advisor increases the likelihood to 10%" (Canaan & Mouganie, 2019, p. 13). If there is that large of an impact of enrolling females in STEM degrees, then the examination of the impact of female STEM professors should also very important. Through this kind of research, we can better understand how higher education can support and encourage female STEM undergraduate student. That support is critical for both undergraduate study and future success post-graduation. Additionally, continuing to look at graduation rates, "female

students matched to male science advisors are 4.2% likely to graduate with a STEM degree and this likelihood increases to 8.5% when matched to a female advisor" (Canaan & Mouganie, 2019, p. 13). A student is assigned to an advisor at the beginning of their undergraduate career. The right advisor placement for a student can make all the difference in their retention and overall educational experience.

By the start of the second year, "17% of women in STEM had either switched to BHASE [business, humanities, health, arts, social science, and education] or left undergraduate degree studies entirely. Between then and the start of third year, another 10% left" (Wall, 2019, p. 5). After those initial two years, females leaving the STEM fields was less common. The relationship between female professors and the retention of female STEM undergraduate students has not been extensively studied. A strong female role model can be influential for female undergraduate students. "The role models who had the strongest impact on girls' choices were more effective in projecting a positive image of science-related careers and in stimulating students' aspirations for them, while putting less emphasis on the underrepresentation of women in science" (Breda et al., 2020, p. 26). Female students do not need to hear that there are very few of them in the STEM field. Instead, they need to see that it is possible to succeed and be empowered by the example of successful women who have gone before them. Furthermore, the underrepresentation of women in traditionally male-dominated fields can "also constitute a self-fulfilling prophecy for subsequent generations, as girls have little opportunity to interact with women working in these fields and who could inspire them" (Breda et al., 2020, p. 1). Female students should be exposed to successful and admirable female scientists, engineers, and mathematicians during their time in college. These examples of

future careers for students can “extend female students’ possibility set, raise their aspirations, alleviate stereotype threat, and provide relevant information” (Breda et al., 2020, p. 1). Within higher education, providing positive role models and empowering students should be a priority. Specifically, within STEM fields, it is important to inspire women to pursue whatever career path they choose.

Conclusion

Higher education must adapt to the changing of needs of students to retain students within STEM fields. Each institution is unique, but the statistics of students leaving STEM fields are universal across the United States. From 2003 to 2009, only 28% of bachelor’s degree students chose a STEM field of study. Of those students, 48% of bachelor’s degree level students exited STEM fields by changing their major or leaving college without completing their degree (Chen & Soldner, 2013, p. 47).

This mixed methods study will use retention and graduation rate data to determine the impact of female STEM professors on the retention of female STEM undergraduate students. Research in this area will inform future colleges and universities on ways they can grow their STEM enrollments and retention. The following chapters discuss the methodology of the study and the results of the quantitative analysis of female retention rates in science, technology, engineering, and mathematics majors.

Chapter 3

Methodology

The following chapter will review the methodology for this study. The study employed a mixed methods analysis. The purpose of this study was to examine if there is a correlation between the presence of female STEM professors and the graduation rates of female STEM undergraduate students. The design, context and participants, procedure, data analysis, and benefits of the study will all be discussed in this chapter.

Research Design

The quantitative descriptive methodology used in this study examined trends to see retention rates from 12 cohorts of students that declared a STEM major by their second year and remained through graduation. The second part of the quantitative study analyzed current students' survey data results. The study utilized pre-existing data from the institution on retention as well as survey data from current female STEM students and female students who have switched to majors outside of STEM fields. Those results will be compared to male students from the same majors.

Context and Participants

This study was based at a small, liberal arts, faith-based college in the Midwest. Archival data for this quantitative study was collected from the university registrar. This study looked at students who have switched majors over the previous 20 years. Female STEM faculty employment data from the same years were also collected. The second collection of data is from 53 current senior students from the same institution. Surveys

were be completed by male and female STEM students who remained in the field. Male and female students were surveyed to compare responses for senior STEM majors.

Procedure

The institution's registrar was contacted and, with permission, pre-existing data from the previous 12 cohorts of students in the last 20 years was obtained and analyzed. The data are from female and male students who initially declared a STEM major in their second year at the institution and persisted until graduation. The other data set collected was female STEM professors' employment percentages over the same period. This quantitative descriptive portion of the research was analyzed to evaluate trends in the data.

The survey (see Appendix A) was administered online to students at the same institution with permission from the Institutional Review Board. Students were sent an email asking them to participate voluntarily. Female and male students who declared a STEM major and remained in that major to their final year were surveyed about the factors that contributed to their persistence thus far in their undergraduate careers. The results from the survey were analyzed to find trends and themes. The results of those descriptive quantitative method analyses can be found in the results in Chapter 4.

Data Analysis

The the pre-existing registrar retention data and the survey data were analyzed in order to find patterns of student retention from their first or second year. These compare male and female students who persisted within their STEM major and those who have transferred out of STEM once in the major.

Chapter 4

Results

The purpose of this study was to determine if female STEM faculty have an impact on the retention and graduation rates of female STEM students. This chapter delineates the results of three sources of data analyzed in this study: pre-existing data, quantitative survey responses, and qualitative survey responses. Descriptive statistics are presented for each section. The pre-existing faculty and student graduation data is from cohorts over the last 20 years. The survey sample includes 32 female participants and 21 male participants for a total of 53 completed surveys. Both male and female students were included in this study so that responses could be compared for clarity in results. The academic departments that were included in this research are listed in the chart below.

Table 1

Department Name and Acronym

Department Name	Dept. Acronym
Biology, Environmental Science, Public Health, Sustainable Development	BESP
Chemistry and Biochemistry	CHB
Computer Science and Engineering	CSE
Kinesiology	KIN
Mathematics	MAT
Physics and Engineering	PHY

Pre-Existing Quantitative Data Analysis

Faculty Data

The first section of pre-existing quantitative data is the full-time faculty count for both male and female professors within the STEM departments at this particular institution (see Appendix B). Figure 1 shows the male and female faculty over the years. In the 2020–2021 school year, there were 10 female and 34 male professors. Figure 2 contains male and female faculty counts by department.

Figure 1

Trend of Male and Female STEM Faculty 2004–2021

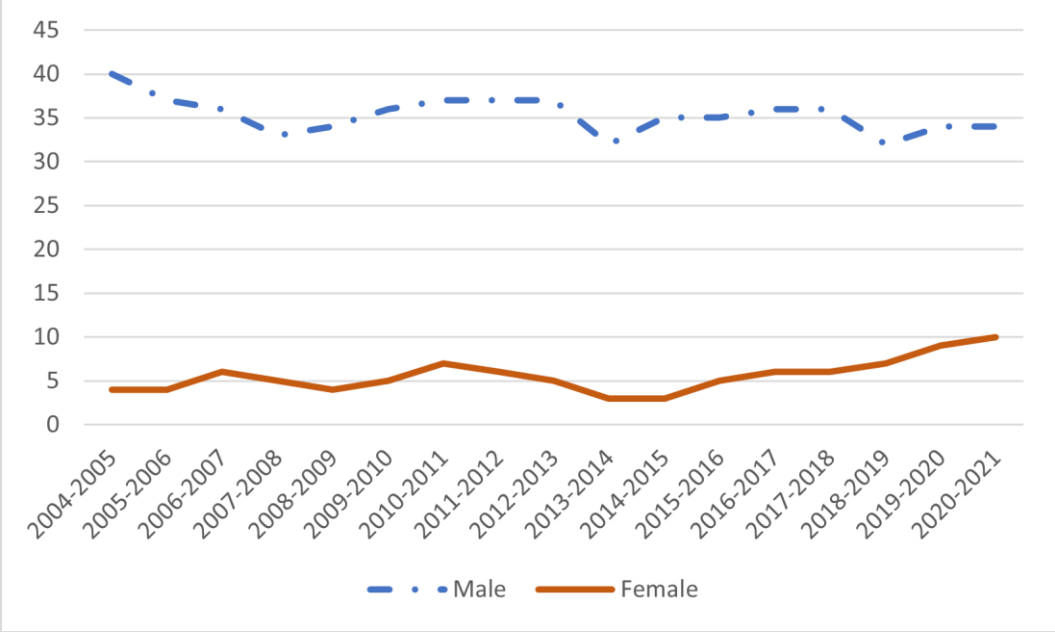
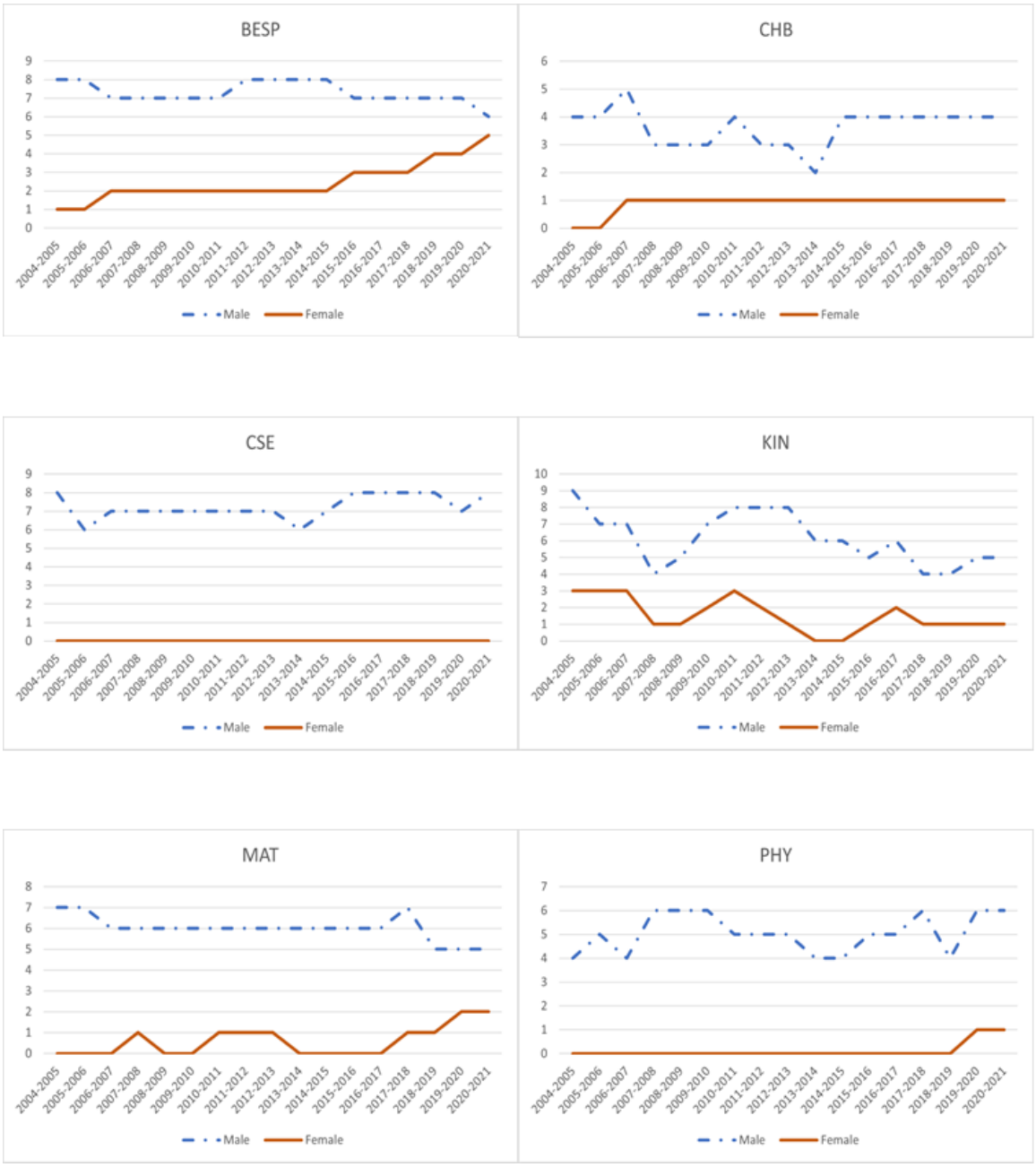


Figure 2

Trend of Male and Female STEM Faculty by Department



Student Persistence

The next pre-existing data analyzed ware anonymized student retention and graduation rates over all years broken down by department. Table 2 depicts the starting

cohort student count total, both for male students and female students. The table also shows the difference between the retention and graduation rate of male and female students by department.

Table 2

Graduation Rates for Male and Female STEM Students

	Total			Male			Female			
Dept.	Start	Grad	%	Start	Grad	%	Start	Grad	%	NET
BESP	449	343	76.4%	205	149	72.7%	244	194	79.5%	-6.8%
CHB	82	54	65.9%	39	30	76.9%	43	24	55.8%	21.1%
CSE	243	177	72.8%	218	165	75.7%	25	12	48.0%	27.7%
KIN	254	204	80.3%	82	68	82.9%	172	136	79.1%	3.9%
MAT	108	70	64.8%	54	32	59.3%	54	38	70.4%	-11.1%
PHY	94	72	76.6%	79	63	79.7%	15	9	60.0%	19.7%
Total*	1218	974	80.0%	668	534	79.9%	550	440	80.0%	-0.1%

*Difference in total graduates and total in department are due to double majors.

Note. NET is the difference between the male graduation rate and the female graduation rate.

Graduation Rates

Biology, Environmental Science, Public Health, Sustainable Development (BESP). The number of female faculty within BESP has steadily increased since 2005. The female graduation rate has been higher than the male graduation rate in nine of the 12 cohorts analyzed, with an overall average of 6.8% higher female graduation rate compared to male graduation rate.

Chemistry and Biochemistry (CHB). The CHB department has consistently had one female member since the 2006–2007 school year. The female graduation rate has

been higher than the male graduation rate four of the 12 cohorts analyzed. Overall, the male graduation rate is 21.1% higher than the female rate.

Computer Science and Engineering (CSE). In the 17 years of faculty data analyzed, CSE did not have a single female faculty member. Within the 12 cohorts analyzed, three of the cohorts had not a single female graduate. The only year that the female graduation rate was higher than the males was in 2009 when there was one female student that started in CSE and one female graduate. Across all years, the female graduation rate within CSE was 27.7% lower than the male graduation rate.

Kinesiology (KIN). In the 12 KIN cohorts, five had a higher graduation rate for female students, six had a higher graduation rate for male students, and one had equal graduation rates. Across all years, the female graduation rate within KIN was 3.9% lower than the male graduation rate.

Mathematics (MAT). The mathematics department has had between zero to two female professors over the 17 years analyzed. In MAT, of the 12 cohorts, seven cohorts had higher female graduation rates than male, and in two cohorts the male and female students had the exact same graduation rate. Across all years, the female graduation rate within the mathematics department was 11.1% higher than the male graduation rate.

Physics and Engineering (PHY). The PHY department did not have a single female faculty until the 2019–2020 school year. Of the 12 cohorts analyzed, five cohorts did not have a single female graduate, four cohorts the male graduation rate was higher than female, two cohorts where the female rates were higher than male, and one cohort with equal graduation percentage. Across all years, the female graduation rate within the physics department was 19.7% lower than the male graduation rate.

Table 2 shows that the overall graduation rate of 80% is almost identical to the graduation rates for male students (80.0%) and female students (79.9%). While BESP and MAT had higher graduation rates for female students than male students, CHB, CSE, KIN, and PHY had higher graduation rates for male students. The largest difference in graduation rate was in CSE, as male students' graduation rate was 27.7% percent higher than female CSE students.

Survey Quantitative Data Analysis

Turning our attention to the survey results collected, the first part of the survey was the quantitative data analysis section. The first topic covered in the survey was on the top reasons students remained in their major or department to their final year. The students were asked to choose two of the following reasons for their retention: your own ability, professor support, peer support, future career opportunity, parent encouragement/expectation, and interest in the subject. The following graph shows the male and female responses by percentage.

Table 3

Top Reasons for Retention

	Your Own Ability	Professor Support	Peer Support	Future Career	Parent Encouragement	Interest in Subject
Female	22%	41%	31%	56%	22%	59%
Male	33%	24%	14%	52%	5%	81%

The highest percentages for female students were Future Career Opportunity (56%) and Interest in the Subject (59%). The highest percentages for male students were Interest in the Subject (81%) and Future Career Opportunity (52%). The lowest for female students were Their Own Ability and Parent Encouragement/Expectation (both

22%). The lowest for male students were Peer Support (14%) and Parent Encouragement/Expectation (5%).

The next part of the survey asked students what their post-graduation plans were. They were given six options and instructed to pick the one that best fit their post-graduation plans. The options were graduate school within STEM, graduate school outside of STEM, job within STEM, job outside of STEM, teaching, or undecided. Table 3 shows the percentage for both male and female students.

Table 4

Post-Graduation Plans

Students	Grad School		Job		Teaching	Undecided
	STEM	Not STEM	STEM	Not STEM		
Female	63%	0%	25%	3%	3%	6%
Male	33%	5%	43%	5%	5%	10%

The proportion of female students planning on going to graduate school in a STEM field was nearly double the proportion of male students planning on going to graduate school in a STEM field. The majority of male students planned on going straight into a STEM field and hoped to get a job right out of undergraduate studies.

Survey Qualitative Data Analysis

Major

The second part of the survey (see Appendix A) had more open-ended questions. The main focus of these questions was on how the students felt about their major and their overall experience within their STEM department. The first question was, “Would you have chosen the same major if you had to do it all over again?” Of the 21 male

participants, 17 said they would choose the same major again. To the same question , 26 of the 32 female participants would have chosen the same major again. Three of the female students would have changed majors but remained in a STEM field and three would have changed but chosen a major outside of a STEM field. One male student and one female student said they would have chosen the same major, but if they had to do it again would have chosen a different institution.

Overall Experience

The next survey question was about student's overall experience within their major and department. The students were asked to give an open-ended answer about their overall experience within their STEM department. Twenty of the 21 male participants gave positive feedback about their experience. Twenty-one of the 32 female participants gave positive feedback about their overall experience.

Despite the majority of male and female students having a positive experience within their department, one female student really struggled during her time in her STEM major. She said,

> All the profs have been great in both departments. However, I have had lots of problems with the students' sexism. I've gotten some really sexist comments, like being told to go make a sandwich or grab them coffee during team projects in addition to being ignored whenever I try to add input. When I worked with non-[Institution] students over the summer, I noticed a complete difference in how they treated me. I would not recommend attending a Christian university in stem due to my experiences.

Changes Within the Department

The participants were asked, “What change, if any, would you like to see in your major department to feel more supported as a STEM student?” From the male participants no main theme came to the surface from their responses. The female participants, when answering the same open-ended question, had one major theme: ten female participants said they would like more female representation within faculty and guest speakers. One female student said,

> It would be great to have another female professor. I think there is a great range of age and diversity in the department, but once [Female Professor] retires (not that she will soon) there won’t be any female faculty members.

Biggest Challenge

Finally, the participants were asked, “What’s been the biggest challenge you’ve had to overcome to make it to this point?” The main theme in the male participant responses was of the challenge of course load and within that time management and the balance of schoolwork and life. By contrast, the major theme from the female participants was lack of confidence in their ability and doubts from others. One female participant said the biggest challenge was “doubts of other people. I don’t want to be a housewife, and that’s been really unacceptable to way too many people close to me. If I wasn’t so spiteful, I wouldn’t be here.”

Conclusion

This research study looked at pre-existing data on faculty and student retention over the years. Then the survey was employed to find a better understanding of how

current students feel about their experience in their specific STEM departments. The results presented in this chapter will be discussed in Chapter 5.

Chapter 5

Discussion

The purpose of this study was to examine if there is a correlation between female faculty representation and the retention and graduation rate of female students specifically within STEM undergraduate fields. The research question for this study was: Does the percentage of female STEM professors have an impact on graduation rates of female STEM undergraduate students? The study had 53 participants, 21 male and 32 female, all seniors studying STEM. Both male and female students were included in this study so that responses could be compared for clarity in results.

Male to Female Faculty Difference

All six of the STEM departments studied in this research have a significantly higher number of full-time male faculty compared to female faculty. The average number of female faculty from 2004 to 2021 is less than one faculty member per year in the CHB, CSE, MAT, and PHY departments. The only departments that had an average greater than one female faculty member per year were BESP and KIN. The former had an average of 2.5 female faculty and 7.3 male faculty per year, while KIN had an average of 1.5 female faculty and 6.1 male faculty per year. The average per year across all departments was 5.9 male faculty and 0.9 female faculty. That is roughly 13% female faculty compared to 87% male faculty, which, according to National Science Foundation (2010), is a much lower female faculty percentage than the national average. In 2010,

according to the National Science Foundation, “women constituted 22% of full professors, 37% of associate professors, and 44% of assistant professors.”

Male to Female Student Difference

Bachelor’s degree seekers in STEM fields are roughly 63% male and 37% female (Indicator 26: STEM Degrees, 2019). Based on the anonymized STEM graduation data obtained from the institution studied from 2004 to 2015, the graduating students in STEM fields were approximately 55% male and 45% female. The proportion of graduates who are female at the institution is much higher than the national average.

Challenges for Female Students

The participants, both male and female, had the same top two reasons for staying in their respective STEM departments through their final year: interest in the subject and future career opportunities. Even though both male and female students had the same reasons for retaining, the percentage of female students surveyed pursuing graduate school in STEM nearly doubled that of their male peers. Female students noted that their biggest challenge while pursuing their STEM degree was lack of confidence in their ability. One female student said,

> I keep wondering if guys brains are more tailored to STEM ideas or if there are just more guys in the field in general. But it seems like they enjoy the classes more than I do and that’s also caused a lot of doubt. At points I’ve felt like I’m trying to push a square peg through a round hole, but other women probably catch onto computer concepts faster than me.

Perhaps these female students feel the need get further education in the field to prove themselves or prove their ability to others or themselves. One female student noted,

> I think it's often assumed that many of the female stem students are pursuing less prestigious and rigorous graduate school or career plans. Every year I have to remind people what my plans are, and I've noticed it is assumed my male classmates are going into the harder fields.

Female students pursuing STEM fields can often feel as though they do not fit the mold of what a woman should.

Helping Female Students Succeed

A theme among the female students surveyed was a lack of confidence, which can impact students' STEM potential. "Belief in one's ability to achieve in STEM was a predictor of STEM majors in college and STEM concentrations in graduate school… as women had lower self-efficacy" (Heilbronner, 2009, p. 1). From the results of the survey conducted, it seems that the main reason for self-doubt was not from faculty, but from their male peers.

Representation

Roughly a third of the female participants indicated wanting to see more female representation in faculty hires and speakers coming to talk to their department. Representation has a major impact on how students perceive their ability to succeed. Representation also has an impact on self-confidence. Female students know they are in the minority, as one female student said something that would be helpful is "less emphasis on how few women there are—sometimes I feel like this singles us out and makes me self-conscious sometimes about whether or not I should be in the major."

For those female students that persevere through to their senior year, it can be empowering to look back on what they accomplished. One female participant noted that

"it was stressful sometimes, but very empowering other times. I doubted so much if I was in the right major but got a lot of my confidence from internship opportunities." Another female student said, "While the first two years were terribly difficult, having the skills, abilities, and career opportunities is certainly worth studying computer science."

Implications for Practice

A few implications for future practice within higher education include hiring more female faculty, having female speakers for events, bringing female alumni back to talk to students, and creating community among female students. First, the hiring of more female faculty will increase female representation within the STEM department. Intentionally recruiting and bringing more women into the STEM departments to teach will help close the gap that currently exists between male and female faculty numbers.

Second, due to the challenge of getting qualified female faculty, a great option would be to bring in women working in the STEM fields to come and speak to undergraduate students. These do not need to be conversations focused on women, but on the great work these women are doing in their respective careers. Additionally, it would be beneficial for female STEM alumni to come back and network with students hoping to work in the same field.

Finally, universities should create a community amongst female students. A club or organization specifically for female students studying STEM would build community and make them feel less isolated within their major. At the institution studied, there is a *Women of Chemistry* club that meets regularly for social events. Two of the students surveyed mentioned wanting a similar club in their own department.

To the male faculty that work in STEM departments in higher education: Be advocates for your female students. This includes advocating for hiring more female faculty and being aware of how the lack of female representation can impact female students. Professors and advisors should clearly communicate different opportunities their female STEM students can take, both in their graduate school options and their potential career paths.

Implications for Future Research

Items for future research include having a larger sample size, comparing graduation and retention rates to other similar institutions, conducting a case study with the implementation of a club for female students, and surveying students who have changed majors out of STEM during their time in undergraduate studies.

The first implication for future research would be to compare other institutions graduation rates in the STEM fields, giving a better scope of how an institution compares to others. Second, a club or community like *Women in Chemistry* should be implemented. Then, retention and satisfaction of female students can be compared from prior to starting the club to after the club is established. This would give an indication of the impact of such an organization. For the third implication, an effort should be made to survey female students as they transition from STEM to other fields. Exit interviews or surveys of female students that no longer want to pursue STEM careers would help the institution understand how to better support their female students. Academic advisors and the academic support center could assist in collecting that information.

Limitations

There were a few limitations to this study, including small sample size, low overall female faculty count, and institutional type. First, due to the size of the institution studied there was a small sample size of participants in the study. Second, the institution had very low female faculty count across all departments, so it was difficult to compare departments. The third limitation was the institution type, as the institution studied was a faith-based, liberal arts college in the Midwest. This type of institution has an impact on the type of female students that would attend the institution and pursue STEM fields and is not representative of all institutions.

Conclusion

The research question posed was: Does the percentage of female STEM professors have an impact on graduation rates of female STEM undergraduate students? Based on research at the institution studied, the answer is complicated. Female students want to see representation and find community through their STEM departments. This institution had low female faculty numbers, and it impacted the students. However, despite having low female to male faculty percentages, the institution had high female to male student graduation rates. This shows the lack of female professors did not directly impact female retention or graduation rates; however, the lack of female professors was felt profoundly by the female students. Forty-one percent of female students did indicate that professor support was a factor in retention, compared to 24% of the male students. Representation can impact the view of female students studying STEM on a larger scale. With an increase of female faculty and female speakers at STEM events, female students would feel more confident in their abilities and male students would see that female

students are just as capable, intelligent, and successful as men working in the STEM fields.

References

Bailey, B. L. (2016). *In their own words: Factors affecting the retention of female employees in STEM fields*. [Doctoral dissertation, University of Phoenix]. ProQuest LLC. D.M Dissertation.

Bartholomew, S. R., & Strimel, G. J. (2018). Factors influencing student success on open-ended design problems. *International Journal of Technology and Design Education*, *28*(3), 753–770.

Breda, T., Grenet, J., Monnet, M., & van Effenterre, C. (2020). Do female role models reduce the gender gap in science? Evidence from French high schools. https://doi.org/10.2139/ssrn.3584926

Canaan, S., & Mouganie, P. (2019). Female science advisors and the STEM gender gap. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3396119

Chen, X., & Soldner, M. (2013). STEM attrition: College students' paths into and out of STEM fields. *National Center for Education Statistics: Institute of Education Sciences*. https://nces.ed.gov/pubs2014/2014001rev.pdf

Heilbronner, N. N. (2009). Pathways in STEM: Factors affecting the retention and attrition of talented men and women from the STEM pipeline. [Doctoral dissertation University of Connecticut]. ProQuest LLC, Ph.D. Dissertation. https://opencommons.uconn.edu/dissertations/AAI3367359

Indicator 26: STEM Degrees. (2019). *National Center for Education Statistics*. Retrieved March 16, 2021, from https://nces.ed.gov/programs/raceindicators/indicator_reg.asp

Mansour, H., Rees, D., Rintala, B., & Wozny, N. (2020). The effects of professor gender on the post-graduation outcomes of female students. *National Bureau of Economic Research*. https://doi.org/10.3386/w26822

National Science Foundation. (2009). Characteristics of doctoral scientists and engineers in the United States: 2006 (NSF09-317). National Science Foundation.

National Science Foundation. (2010). SEH doctorate holders employed in academia, by type of position, sex, and degree field: 1973–2010.

National Science Foundation. (2019). *Women, minorities, and persons with disabilities in science and engineering: 2019*. Retrieved March 15, 2021, from https://ncses.nsf.gov/pubs/nsf19304/digest/field-of-degree-women#mathematics-and-statistics

Pascale, A. B. (2018). Supports and pushes: Insight into the problem of retention of STEM women faculty. *NASPA Journal About Women in Higher Education, 11*(3), 247–264.

Steinke, J., & Tavarez, P. M. P. (2018). Cultural representations of gender and STEM: Portrayals of female STEM characters in popular films 2002–2014. *International Journal of Gender, Science and Technology*, *9*(3), 244–277.

Stockwell, C. (2017). Women vs. men in STEM degrees: Do we have a problem? I*nside College Factual.* Retrieved March 16, 2021, from https://inside.collegefactual.com/stories/women-vs-men-in-stem-degrees

Swafford, M., & Anderson, R. (2020). Addressing the gender gap: Women's perceived barriers to pursuing STEM careers. *Journal of Research in Technical Careers, 4*(1), 61–74.

Taylor, L. L., Beck, M. I., Lahey, J. N., & Froyd, J. E. (2017). Reducing inequality in higher education: The link between faculty empowerment and climate and retention. *Innovative Higher Education, 42*(5–6), 391–405.

Trautvetter, L. C. (2018). Institutional practices and policies for recruiting and supporting undergraduate women in engineering across four-year institutions. *New Directions for Institutional Research*, *179*, 91–114.

Wall, K. (2019). Persistence and representation of women in STEM programs. *Statistics Canada*. http://www.statcan.gc.ca

White, J., & Massiha, G. H. (2016). The retention of women in science, technology, engineering, mathematics: A framework for persistence. *International Journal of Evaluation and Research in Education (IJERE).* https://files.eric.ed.gov/fulltext/EJ1094603.pdf

Appendix A

Survey Questions

1. In what department is your major?
    a. Biology, Environmental Science, Public Health, and Sustainable Development (BESP)
    b. Chemistry (CHB)
    c. Computer Science and Engineering (CSE)
    d. Kinesiology (KIN)
    e. Mathematics (MAT)
    f. Physics and Engineering (PHY)
2. Which professor (within your major department) has been most impactful in your success within your major? Please write name below.
3. Do you have a male or female Academic Advisor?
    a. Male
    b. Female
4. How important is peer support/community to your success in your major?

Not important 1 2 3 4 5 Very Important

5. Select your top 2 factors that contributed to your staying in your major through your senior year.
    a. Your own ability
    b. Professor support

c. Peer support

d. Future career opportunity

e. Parent encouragement / expectation

f. Interest in the subject you are studying

g. Other

6. How supported do you feel within your major?

Not supported at all 1 2 3 4 5 Very supported

7. Do you have a clear understanding of future jobs or career paths within your major field?

No idea what's next 1 2 3 4 5 Very clear understanding

8. Do you feel like you are valued in your major department?

Not valued at all 1 2 3 4 5 yes very valued

9. If you had to do college over again, would you choose the same major?

a. Yes

b. No

10. If yes, why? If no, which major would you choose and why?

11. Overall, how was your experience in your major?

12. Would you recommend your major to incoming students?

a. Yes

b. No

c. Maybe

13. What change, if any, would you like to see in your major department to feel more supported as a STEM student?

14. What's been the biggest challenge you've had to overcome to make it to this point?
15. What would you like to do post-graduation?
    a. Graduate school in STEM field
    b. Graduate school outside of STEM field
    c. Job in STEM field
    d. Job outside of STEM field
    e. Teaching a STEM subject
    f. Undecided
16. Any other comments on your experience in STEM in college.

Appendix B

Faculty Count Data by Year

Academic Year	2004-2005		2005-2006		2006-2007		2007-2008		2008-2009		2009-2010	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Biology, Environmental Science, Public Health, Sustainable Dev. - BESP	8	1	8	1	7	2	7	2	7	2	7	2
Chemistry and Biochemistry - CHB	4	0	4	0	5	1	3	1	3	1	3	1
Computer Science and Engineering - CSE	8	0	6	0	7	0	7	0	7	0	7	0
Interdepartmental - INT	0	0	0	0	0	0	0	0	0	0	0	0
Kinesiology - KIN	9	3	7	3	7	3	4	1	5	1	7	2
Mathematics - MAT	7	0	7	0	6	0	6	1	6	0	6	0
Physics and Engineering - PHY	4	0	5	0	4	0	6	0	6	0	6	0
Total	40	4	37	4	36	6	33	5	34	4	36	5

Academic Year	2010-2011		2011-2012		2012-2013		2013-2014		2014-2015		2015-2016	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Biology, Environmental Science, Public Health, Sustainable Dev. - BESP	7	2	8	2	8	2	8	2	8	2	7	3
Chemistry and Biochemistry - CHB	4	1	3	1	3	1	2	1	4	1	4	1
Computer Science and Engineering - CSE	7	0	7	0	7	0	6	0	7	0	8	0
Interdepartmental - INT	0	0	0	0	0	0	0	0	0	0	0	0
Kinesiology - KIN	8	3	8	2	8	1	6	0	6	0	5	1
Mathematics - MAT	6	1	6	1	6	1	6	0	6	0	6	0
Physics and Engineering - PHY	5	0	5	0	5	0	4	0	4	0	5	0
Total	37	7	37	6	37	5	32	3	35	3	35	5

Academic Year	2016-2017		2017-2018		2018-2019		2019-2020		2020-2021	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Biology, Environmental Science, Public Health, Sustainable Dev. - BESP	7	3	7	3	7	4	7	4	6	5
Chemistry and Biochemistry - CHB	4	1	4	1	4	1	4	1	4	1
Computer Science and Engineering - CSE	8	0	8	0	8	0	7	0	8	0
Interdepartmental - INT	0	0	0	0	0	0	0	0	0	0
Kinesiology - KIN	6	2	4	1	4	1	5	1	5	1
Mathematics - MAT	6	0	7	1	5	1	5	2	5	2
Physics and Engineering - PHY	5	0	6	0	4	0	6	1	6	1
Total	36	6	36	6	32	7	34	9	34	10