Analyzing the Impact of Multi-Faceted Women in Computing Support Programs on Women Computing Students

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Abstract

Farmingdale State College (FSC) has taken a multi-faceted approach to tackle the issue of the low number of women students enrolled in its computing degree programs. FSC has only 8-16% women enrolled in its computing degree programs over the past decade despite doubling enrollment in these programs during the same time. Recognizing the gender disparity in computing is well-documented as a global and national issue, the three women in computing initiatives (support programs) instigated at FSC from 2020 are as follows: 1) maintaining a women in computing student club, 2) hosting summer orientation programs for women computing students, and 3) attending women in computing conferences. This study utilizes end of semester surveys as a quantitative tool and aims to understand the combined impact of these women in computing (WiC) initiatives on three areas: i) women students' experience as they complete their computing degree, ii) women students' sense of belonging, and iii) women students' academic self-concept. An analysis of the Year 2 (fall'22, spring'23) survey results and their comparison to the previously published Year 1 (fall'21, spring'22) survey results show positive impacts on the women students on the aforementioned areas over a two-year period.

1. Introduction and Background

Farmingdale State College (FSC) has served local commuter students as part of the large State University of New York system for more than hundred years in Long Island. Operating as a regional, public institution, FSC currently enrolls a high number of students from underrepresented racial and ethnic backgrounds (57%), students eligible for financial aid (62%) and students employed on- or off-campus (82%). Despite the increase in enrollment among women in higher education national, FSC's student enrollment is only 42% women across all its programs.

Gender disparity in computing degrees is a well-documented global and national issue. FSC similarly experiences a persistent gender disparity in its undergraduate computing degrees where women have represented 8-16% of its enrollment for over a decade. Despite the computing programs more than doubling their total enrollment from 2010 to 2023 (from 293 students to 765 students), the gender disparity remains sharp. This disparity is present in both the Computer Programming and Information Systems (CPIS) degree program, that has existed for over 20 years, and the Computer Science degree program, that started in fall 2021.

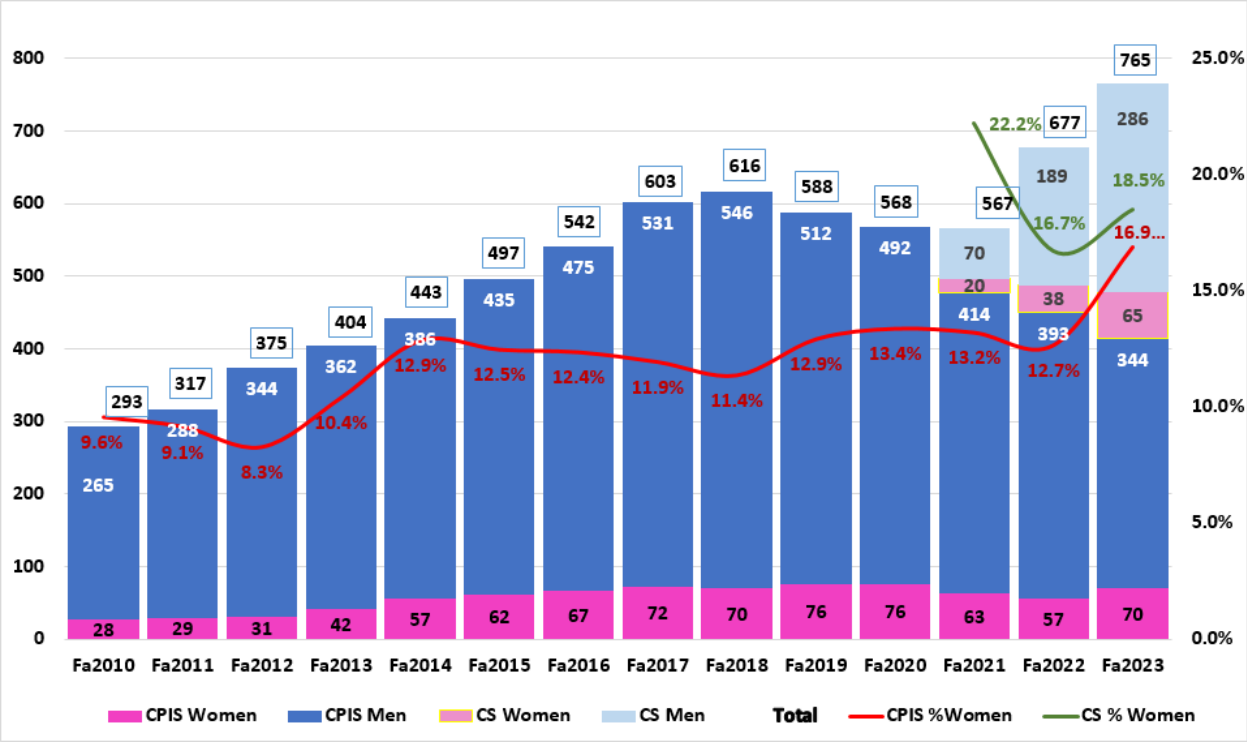

Figure 1. Computing degrees enrollment during the past decade since fall 2010

In their earlier work, authors analyzed the issue at FSC during the past decade and the efforts to address the issue. These efforts were inconsistent and temporary in nature due to various on-campus factors (such as limited funding, lack of faculty time, difficulty of hiring new faculty) and external factors (such as COVID19 pandemic, campuswide and statewide budget freezes) [15-16]. Subsequently, in 2019, the authors developed a vision to balance enrollment based on gender in the computer degree programs inspired by the "50/50 by 2025" vision of Anita Borg [1]. Based on a review of successful initiatives in supporting women in undergraduate computing degrees, the authors selected three support programs (initiatives) to implement. The main selection criterion was the financial resources required to implement the initiatives. The time of selection was during the early months of the COVID19 global pandemic. The three initiatives included: 1) maintaining a women in computing student club, 2) hosting summer orientation programs for women computing students, and 3) attending women in computing conferences (field trips). The implementation timeline and highlights for WiC initiatives is provided in Table 1 while the details about each WiC initiative are as follows.

1) *Maintaining the Supporting Women in Computing (SWiC) student club:* SWiC was first launched in 2014. From 2014-2020, the club was inconsistently active as an option to students at FSC. It was officially re-instantiated in the fall 2020 semester during the COVID19 global pandemic. Finding student leaders with the time and commitment to participate in leadership training, complete administrative club paperwork each semester, and plan, organize, and host club activities at FSC has been a challenge [19]. As stated earlier, FSC serves primarily commuter students with considerable outside of school commitments (e.g. part- or full-time employment and familial responsibilities). However, the recent faculty advisors (authors)

have recruited students and maintained consistent online-communication and periodic meetings yearlong which has yielded some student leaders to own the club "business" across semesters. This resulted in a vibrant club that organizes hybrid events (with both in person and online presence) on campus.

2) *Summer orientation program for women computing students:* Student orientations provide students with opportunities to familiarize themselves with their peers and computing faculty and develop a community among participants. Student orientation sessions were provided to women computing students in the August 2021 (inaugural), 2022, and 2023 (not included in this paper) as one-day events to engage women in a small community prior to the start of the academic year. These events offered opportunities for women computing students to engage in game-based teamwork, explore technical skills needed for their future courses, and attend panel discussions of role model women in the computing field including computing programs alumni [20-21].
3) *Field trips to women-centric conferences:* Each spring the ACM-W Regional Celebration of Women conference is hosted in the state. Due to its proximity and affordable registration cost that included overnight accommodations, FSC was able to provide this opportunity to its women computing students in three spring semesters (2021-virtual, 2022 and 2023) [22]. In total, 10 women attended virtually, 59 women attended in person, and 10 men attended the conference since spring'21. The recent spring'24 trip to Harvard WeCode event (1 faculty and 10 women students) is not included in this paper.

The combined impact of the initiatives is measured and quantified using End of Semester (EoS) surveys conducted starting from fall'21. In this paper, authors present an analysis of the Year 2 (fall'22, spring'23) EoS survey results and their comparison to previously published Year 1 results (fall'21, spring'22) [17, 18].

Table 1 Timeline of WiC initiatives and End of Semester Surveys (EoS) since spring'20 along with self-references to publications

EoS surveys						**F21 EoS surveys [17]**	**Sp22 EoS surveys [18]**		**F22 EoS surveys**	**Sp23 EoS surveys**
Initiatives	**Sp20**	**Su20**	**F20**	**Sp21**	**Su21**	**F21**	**Sp22**	**Su22**	**F22**	**Sp23**
#1 SWiC student club		Reinstated	Active	Active	Active	Active	Gained ACM-W student chapter status [19]	Active	Active	Active
#2 Summer Orientation for women					Inaugural-1st attended by 22 women [20]			2nd annual attended by 32 women [21]		
#3 Field trips to women-centric trips	Cancelled trip to regional NYCWiC'20, for 30 women & 2 faculty due to COVID19 outbreak			10 women & 2 faculty attended at virtual NYCWiC'21			25 women & 10 men & 2 faculty attended at regional NYCWiC'22 [22]			34 women & 2 faculty attended at regional NYCWiC'23

Using strategies like the WiC initiatives presented in this paper, several schools, and programs (e.g. the BRAIDs program, Harvey Mudd College) have accomplished increase in enrollment of women computing students [2, 3]. However, FSC is a commuter undergraduate state college serving a high number of non-traditional students that work on- or off-campus. FSC's student population has significant other than school commitments and hence has limited time for extracurricular activities. Therefore, this research contributes a critical perspective to literature. While the long-term goal of this research in implementing the three WiC initiatives at FSC is to increase women enrollment, in the short term, the research aims to improve the experience of women students as they complete their studies. This paper analyzes the impact of these women in computing initiatives on three areas: (i) women students' experience as they complete their computing degree, (ii) women students' sense of belonging (SoB), and (iii) women students' academic self-concept (ASC).

In the rest of the paper, Section 2 discusses related work on SoB and ASC, Section 3 describes the research methodology, Section 4 presents the EoS results from Year 2 compared to Year 1, and Section 5 concludes the paper with discussion and future work.

2. Related Work

Earned undergraduate degrees for women in Math, Computer Science, and Engineering lags other STEM majors such as Biology [7]. Overall, there is a persistent gender gap in STEM enrollment at universities across the nation. Educational researchers have long established the impact of cultivating a sense of belonging (SoB) and an academic self-concept (ASC) on students' retention and academic performance.

Student navigation through and graduation from an institution is influenced by their connection to that institution [8]. Engagement in extra and co-curricular activities cultivates a strong sense of belonging and navigational skills in the higher education context. Students who reported a strong sense of community with their college tend to have higher retention and graduation rates [8]. Engagement in both academic and social experiences at college provides students with several opportunities to strengthen their perception of belonging and subsequently increase academic success and persistence [9]. Through involvement in academic and social experiences, students develop a social network, that includes both faculty and peers. These social networks are paramount to persistence in college and within a major [10, 11]. One study showed that a combination of student-advisor interaction, student-faculty interaction, participation in extracurricular activities, and utilizing the library correlated with a higher first to second year retention rate (fall to fall) among students [12]. While each method is helpful, institutions would be well served in designing academic support opportunities that include the variety of stakeholders in their students' social networks at college.

In addition to feeling connected to the college community, educational researchers have demonstrated the efficacy of a positive academic self-concept. Students perceive their academic abilities through self-reflection and comparison to others. This perception, their academic self-concept, has been found to positively associate with academic performance [13]. Furthermore, academic self-concept sheds light on the non-cognitive components of success, particularly for underrepresented students in the STEM disciplines [4]. Academic self-concept may provide

insight into students' perception of their academic abilities and how they persist through academic challenges.

Researchers have documented a gap between women enrolled in biology and medicine as opposed to engineering and math in terms of self-reported measures of academic self-concept [14]. In comparison to men, women earned only 25% of the bachelor's degrees in engineering, mathematics, and computer science in 2020 [7]. Overall, women also self-report lower levels of academic self-concept in these disciplines [14]. The intersection of low enrollment and graduation rates of women in undergraduate computing degrees and lower self-reported levels of academic self-concept, this study aims to identify methods to increase enrollment and academic self-concept for women in computing degrees.

3. Research Methodology

This research is approved by the college's IRB board and targets the undergraduate computing students in CPIS and CS majors of FSC that self-identify as women (cisgender or trans) according to the college records. Participation of the target group in the three WiC support programs (initiatives) is voluntary and optional.

The WiC initiatives have been planned and implemented by two tenured women faculty members with combined experience of 35 years in academia and FSC. One of them has taught the senior project class for the computing majors for over a decade while the other one has taught the programming I-II-III and core courses in the CPIS and CS majors. The faculty members' teaching load is 4+4 (spring and fall) with about 25 students per section. While both faculties are white, one shares a similar ethnic background with some of the students in the target group. Hence, together the two faculty members cover a wide range of courses in the computing majors and have moderate direct access and familiarity with the students at various stages of their computing studies.

The combined effects of the initiatives are measured with End of Semester (EoS) surveys conducted at the end of fall and spring semesters since fall'21. The EoS survey is a Qualtrics survey administered via emails sent periodically from the last week of classes to just after final exams period. Survey responses are collected anonymously, and students are voluntarily asked to participate. No other incentive is provided to the students to participate. The recruited student pool and response rates for Year 1 and 2 are depicted in Table 2. The "participated" and response rate is calculated as the number of students that answer the consent and age >18 years old question as "Yes" and then answer at least one follow up survey question. Some of the surveys are not fully completed, as students may have a technical issue in submission or decide to stop taking the rest of the survey.

Table 2. EoS Survey response rates for Year 1 and Year 2

EoS Survey	Emailed total	Participated	Response Rate
fall'21	69	19	28%
spring'22	79	23	29%
fall'22	100	38	38%
spring'23	93	36	39%

4. Results and Data Analysis

The initial EoS survey results from fall'21 [17] and spring'22 [18] were earlier shared with the research communities. This paper presents an analysis of the Year 2 (fall22, spring'23) survey results and compare them with Year 1 results whenever possible. Note that, the EoS survey questions were piloted in fall'21 and since then modified slightly in the following semester.

EoS survey participant Demographics: When it comes to the demographic characteristics of the survey participants in Year 2 (see Table 3), they show similar characteristics to the Year 1 survey participants. When survey participants were given the following option for the gender question *Woman, Man, Agender, Cisgender, Intersex, Non-binary, Transgender, Prefer to Self-Describe*, the majority (89% in fall'22 and 91% in spring'23 EoS survey) self-identified as woman, while a few self-identified as transgender (1 of 37 in fall'22 and 2 of 33 in spring'23 EoS survey), cis gender (2 of 37 in fall'22), and non-binary (1 of 33 in spring'23 EoS survey). Most of the survey participants (92% in fall'22 survey and 80% in spring'23 survey) were from ethnic or racial minorities, which is well above the college statistics (~57%). About half of the survey respondents are transfers students (40% in fall'22 survey and 53% in spring'23 survey) like the college statistics, who spend limited time (2-4 semesters) at FSC to benefit from the aforementioned WiC support programs. A good amount of the participants was from the new CS major that started only in fall'21 (50% in fall'22 survey and 32% in spring'23 survey) and rest are from the CPIS major (see Figure 1 above for CPIS vs. CS major enrollment statistics). Finally, women that are both members of the SWiC club in the majors as well as non-members of SWiC (62% in fall'22 survey and 45% in spring'23 survey) have participated in the surveys.

Table 3. EoS survey participant Demographics for Year 2

	Fall'22	Spring'23
Self-identified Woman	89%	91%
Ethnic/Racial minority	92%	80%
Transfer student	40%	53%
CSC major	50%	32%
Non-SWiC member	62%	45%

4.1. Impact on Women Student Experience

Table 4 presents the self-reported responses of women computing students' experience over three semesters as they complete their computing degree. The table shows a comparison of the responses of the women who participated in at least one WiC support program versus no participation. The table shows that survey respondents rated their social and extracurricular experience lower when they were not involved with any of the WiC initiatives. This trend is clearer to see in Year 2 (fall'22, spring'23). Authors hypothesize that the increase in positive ratings of social experience can be attributed to more opportunities to attend one or more WiC initiatives in Year 2. For example, in spring'23, 76% of the survey respondents who were involved with one or more WiC initiatives (n=17), rated their social experience highly (Excellent or Good) while only 50% of the survey respondents who were not involved with any WiC initiatives (n=8) rated their social experience highly (Excellent or Good). Note that the fall'21 EoS results are not included in Table 4 as the experience questions were not directly asked to the survey participants for that pilot study.

Table 4 *Ratings of Women Computing Student Experience over three semesters.*

	Involved with one or more WiC initiatives				*Not* involved with any WiC initiative			
EoS	N	Responded Excellent or Good *Academic experience*	Responded Excellent or Good *Social experience*	Responded Excellent or Good *Extracurricular experience*	N	Responded Excellent or Good *Academic experience*	Responded Excellent or Good *Social experience*	Responded Excellent or Good *Extracurricular experience*
Sp22	13	77%	46%	36%	7	86%	57%	0%
F22	19	84%	74%	79%	12	83%	42%	33%
Sp23	17	88%	76%	71%	8	100%	50%	50%

4.2. Impact of SWiC Activities

Tables 5 and 6 show the impact on women students' ASC and SoB, respectively that were actively involved with SWiC events and activities. The sample size in these tables is the number of women who self-rated themselves as being involved in SWiC activities actively (attended 4+ SWiC meetings) or somewhat (attended 1-3 SWiC meetings) at the time of completing the EoS survey. For example, in Table 5, n=12 of the spring'23 EoS survey respondents have attended 1 to 4+ SWiC activities and 75% of those n=12 women Strongly Agreed or Agreed with the statement "I feel more confident to academically succeed in my computing classes" because of being involved in SWiC activities. Though the sample size is small, the percentage values Table 6 across three semesters (between 60%-89%) shows that SWiC positively helped some of the women increase their self-reported ASC.

Similarly, being involved with SWiC improved the SoB of some women over semesters. For example, fall'22 survey participants who were involved with SWiC (n=12) Strongly Agreed or Agree to being bonded to classmates at FSC (75%), having better peer support (75%), expanding their network beyond FSC (58%), and feeling more connected to the people in the field (75%).

A free form (written response) question was also asked to the survey participants: *"Can you tell about the impact of your involvement in SWiC events and meetings on your academic performance and social experience at FSC.*" Responses from Year 2 EoS surveys provided further insights about the positive influence of the SWiC on women students such as "*SWIC has overall been a great experience for me, from getting to know some of my professors, to seeing many familiar students when going through the halls. It's very welcoming and helps me socialize with others in my department who I may work with in the future. It also makes it easier to approach others in my department when asking for help"* and *"Attending only under a handful of meetings so far, I have still been able to take in the options available through this club such as the field trip ordeal and other opportunities and the availability of the group. Knowing I have the support to turn to even if I am not actively using it is a great comfort".* The responses also provided insights about the challenges women has been facing on campus and in the major, such as "*It was nice just having social events in the first place. FSC is kind of an isolated place for students, so having a speaker come and giving everyone pizza is nice just for facilitating a social space"* and *"I find SWIC as a good resource if needed. I wish I had more time to be more*

actively involved.". Finally, some of the responses included proposals to improve SWIC, such as *"I am able to see more familiar faces around, but I wish the club was more social oriented."* and *"I need to attend these events and meetings but have a difficult time getting in contact with the groups and finding the information on the website. I have emailed a member but did not get a response"*.

Table 5 Impact of SWiC Involvement on Academic Self-Concept

Impact of SWiC Involvement on Academic Self-Concept of women	**EoS surveys in chronologically increasing order***		
Strongly Agree or Agree	**sp22** (n=9, where 3 attended 4+ meetings, 6 attended 1-3 meetings)	**f22** (n=12, where 5 attended 4+ meetings, 7 attended 1-3 meetings)	**sp23** (n=15, where 5 attended 4+ meetings, 10 attended 1-3 meetings)
I feel more confident to academically succeed in my computing classes	88.89%	75.00%	60.00%
I feel more motivated to complete my computing degree more than prior to attending the conference	77.78%	83.33%	66.67%

**No SWiC related questions were asked in f21 pilot EoS survey*

Table 6 Impact of SWiC Involvement on Sense of Belonging

Impact of SWiC on Sense of Belonging of women	**EoS surveys in chronologically increasing order***		
Strongly Agree or Agree	**sp22** (n=9, where 3 attended 4+ meetings, 6 attended 1-3 meetings)	**f22** (n=12, where 5 attended 4+ meetings, 7 attended 1-3 meetings)	**sp23** (n=15, where 5 attended 4+ meetings, 10 attended 1-3 meetings)
I feel I bonded with classmates and peers at FSC	55.56%	75.00%	66.67%
I feel I have a better peer support in my classes at FSC	55.56%	75.00%	73.33%
I feel I expanded my network with people beyond FSC	33.33%	58.33%	60.00%
I feel more connected with people in my field	55.56%	75.00%	73.33%

**No SWiC related questions were asked in f21 pilot EoS survey*

4.3. Impact of Summer Orientation for Women

Tables 7, 8, and 9 show the effect of attending a summer orientation on women computing students' ASC, SoB, and their experience during their degree completion, respectively. The sample size in these tables is the number of women that attended at least one orientation program (in Summer'21 or Summer'22) at the time of completing the EoS survey.

Table 7 show that ASC of some of the women (64% according to the fall'22 EoS survey and 86% according to the spring'23 EoS survey) is improved after attending orientation as they Strongly Agreed or Agreed to the "I felt academically more confident attending classes" after the participating in an orientation program.

Table 8 show that the SoB of some of the women (64%according to the fall'22 EoS survey and 64% according to the spring'23 EoS survey) is improved after attending an orientation as they Strongly Agreed or Agreed to the "I felt less intimidated attending classes as a result of seeing familiar faces from Summer Orientation".

As a result of attending a summer orientation some women (71% according to the fall'22 survey and 64% according to the spring'23 survey) Strongly Agreed or Agreed that they became "involved with SWiC (Supporting Women in Computing) club" (see Table 9). This suggests that orientation attendance could increase students' social and extracurricular experiences at FSC.

Table 7 Impact of Summer Orientation Participation on Academic Self-Concept

Impact of summer orientation participation on academic self-concept of attendees	**EoS surveys in chronologically increasing order**			
Strongly Agree or Agree	**f21** (n=9)*	**sp22** (n=7)	**f22** (n=14, where 4 of 14 attended both summer'21 and '22 orientations)	**sp23** (n=14, where 4 of 14 attended both summer'21 and '22 orientations)
I felt academically more confident attending classes	44.44%	57.14%	64.29%	85.71%

Table 8 Impact of Summer Orientations Participation on Academic Self-Concept

Impact of summer orientation participation on Academic Self-Concept of attendees	**EoS surveys in chronologically increasing order**			
Strongly Agree or Agree	**f21** (n=9)*	**sp22** (n=7)	**f22** (n=14, where 4 of 14 attended both summer'21 and '22 orientations)	**sp23** (n=14, where 4 of 14 attended both summer'21 and '22 orientations)
I felt less intimidated attending classes as a result of seeing familiar (student/faculty) faces from Summer Orientation	44.44%	100.00%	64.29%	64.29%

**In f21 this question was asked as a part of a multi-select check box (Yes or No) rather than rating as Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree, Not applicable*

Table 9 Impact of Summer Orientation Participation on Students' Social and Extracurricular Experience

Impact of summer orientation participation on social and extracurricular experiences	**EoS surveys in chronologically increasing order**			
Strongly Agree or Agree	**f21** (n=9)*	**sp22** (n=7)	**f22** (n=14, where 4 of 14 attended both summer'21 and '22 orientations)	**sp23** (n=14, where 4 of 14 attended both summer'21 and '22 orientations)
As a result of attending a summer orientation "I got involved with SWiC (Supporting Women in Computing) club"	55.56%	57.14%	71.43%	64.29%

**In f21 this question was asked as a part of a multi-select check box (Yes or No) rather than rating as Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree, Not applicable*

A free form (written response) question was also asked to the survey participants*: "Can you tell about the impact of attending one or both of the Summer (Re)Orientation program(s) on your*

academic performance and social experience at FSC since then." Responses from Year 2 EoS surveys provided further insights about positive impact of summer orientation program on the attending women such as "*I made more friends, connections, and help for studying and homework"*, "*I made more friends, connections, and help for studying and homework."*, "*Attending the re-orientation meetings has helped me learn how to come out of my comfort zone and to speak up confidently"*, and "*I felt less alone being a minority in the computer science program"*

Responses also provided insights about the challenges faced by women such as "*By attending the Summer Orientation program of 2022, I felt more comfortable knowing that there are many women attending computer science related fields. But I still found that a majority of the actual courses were male students. I wish that the orientation had honestly reflected the gender ratio in the major more. But It is also understandable that computer sciences and similar majors are not a popular choice among the female population. I really liked the idea and attending the summer orientation event for women computing students. I believe that there should be more opportunities especially career wise for female students who are not sure how to go about diving into the computer/IT world. It is not easy in general, and I think that it is even more difficult for women to have those opportunities"*.

4.4. Impact of Field Trips

Tables 10 and 11 show the impact of attending a field trip on women computing students' ASC and SoB, respectively. The sample size in these tables show the number of women attended at least one in person field trip (in spring'22 or spring'23) at the time of completing the EoS survey.

Table 10 show that ASC of some of the women is improved because of attending a women in computing conference. For example, 100% of the trip participants in the fall'22 EoS survey and 69% of the trip participants in spring'23 EoS survey Strongly Agreed or Agreed to the statement "I feel more confident to academically succeed in my computing classes" after attending one or more field trips.

Similarly, attending a women centric field trip improved the SoB of some women over semesters as they self-reported (see Table 10). For example, spring'23 survey participants that attended a field trip (n=12) Strongly Agreed or Agree to being bonded to classmates at FSC (77%), having better peer support (92%), expanding their network beyond FSC (85%), and feeling more connected to the future (85%).

The free form (written response) question asking general feedback presented from Year 2 EoS surveys below give further insights about the positive impact of the women centric field trips on women students such as "*... Lastly NYCSWIC is a great way of networking outside the college and is inspiring to hear journeys of other women in tech. (from 2023 NYCSWIC I gained around 40 LinkedIn connections)."* and *"It would be nice to be offered another event other than the 1 April conference. It can be another conference or something else. Just another opportunity to network outside."*

Table 10 Impact of Field Trips on Academic Self-Concept of trip-attending women

Impact of Field Trips on Academic Self-Concept of trip-attending women	**EoS surveys in chronologically increasing order**			
Strongly Agree or Agree	**f21** (n=4)*	**sp22** (n=4)	**f22** (n=6)	**sp23** (n=13 where 3 of 13 attended *both* spring'22 and spring'23 trips)
I feel more confident to academically succeed in my computing classes	N/A	50.00%	100.00%	69.23%
I feel more motivated to complete my computing degree more than prior to attending the conference	N/A	75.00%	83.33%	92.31%
I feel empowered from the knowledge gained from the industry leaders, women, researchers	N/A	N/A	50.00%	84.62%

**N/A means these questions did not exist in this EoS survey. But 100% (4 of n=4) of the fall'21 EoS survey participants responded "Yes" to "attending Spring 2021 Virtual NYCWiC impacted my fall 2021 semester positively" question.*

Table 11 Impact of Field Trips on Sense of Belonging on trip-attending women

Impact of Field Trips on Academic Self-Concept of trip-attending women	**EoS surveys in chronologically increasing order**			
Strongly Agree or Agree	**f21** (n=4)*	**sp22** (n=4)	**f22** (n=6)	**sp23** (n=13 where 3 of 13 attended both spring'22 and spring'23 trips)
I feel I bonded with classmates and peers at FSC	N/A	75.00%	100.00%	76.92%
I feel I have a better peer support in my classes at FSC	N/A	75.00%	83.33%	92.31%
I feel I expanded my network with people beyond FSC	N/A	50.00%	66.67%	84.62%
I feel more connected with people in my field	N/A	75.00%	50.00%	61.54%
"Yes" to attending the same or another conference	75.00%	100.00%	100.00%	84.62%

**N/A means these questions did not exist in this EoS survey.*

5. Conclusions, Discussion, and Future Work

This research has been in progress since 2019 to understand the persistent gender disparity in enrollment and experience of women computing students at FSC. Three support programs (initiatives) namely 1) maintaining a supporting women in computing student club 2) organizing summer orientation programs for women computing students and 3) field trips to women in computing conferences have been implemented. The effectiveness of the initiatives is measured by utilizing End of Semester surveys (EoS) to gauge the impact of the initiatives in three areas: i) women students experience as they complete their major, ii) women students' SoB, and iii) women students' ASC. The data analysis shows that from Year 1 to Year 2, women student experience in social and extracurricular areas have improved as more students participated in more of the support programs and the support programs matured. The data suggests that the

sense of belonging and academic self-concept of the support program participants has been positively impacted.

The duration of the presented EoS quantified results in this paper has grown over a longer period (4-semesters) which provides more data as a basis for evaluation and conclusions, however, authors acknowledge the small sample size (the survey participants) for making significant conclusions about the impacts on women from the surveys alone. It is not only the low response rate, but also the number of women in the computing degree programs is low to start with. In addition, students are asked to voluntarily take the EoS surveys while no incentive or reward was offered. The future plan is to include interviews to add depth to the data gathered from the EoS survey participants to better understand the impact of the initiatives on the individual students. In addition, the IRB will be extended to make a longitudinal study moving into Year 3 to 5 to better see the trends on the impact of the support programs on women students. Finally, the academic performance of the women "participating in the support programs" versus "*not* participating" will be tracked and compared with the men in the computing degree programs to demonstrate the impact of the initiatives of women students' academic performance in addition to their perception of ASC.

References

[1] Borg, A. 50/50 by 2020 [Video]. YouTube https://www.youtube.com/watch?v=3nImg8vPUe4

[2] https://anitab.org/braid, Sources: BRAID Beacon school chairs, publicly reported data, and report on Beacon school rate of change by Kaitlin Splett, UCLA.

[3] M. Klawe, "Increasing female participation in computing: The Harvey Mudd College story". Computer, 2013, 46(3), 56–58. https://doi.org/10.1109/MC.2013.4

[4] M. Bong, E. M. Skaalvik, "Academic Self-Concept and Self-Efficacy: How Different Are They Really?", Educational Psychology Review, 2003, 15(1), 1–40, 2003. https://doi.org/10.1023/A:1021302408382

[5] A. Haktanir, J.C. Watson, H. Ermis-Demirtas, M.A. Karaman, P.D. Freeman, A. Kumaran, A. Streeter, "Resilience, Academic Self-Concept, and College Adjustment Among First-Year Students", Journal of College Student Retention: Research, Theory & Practice 2021;23(1):161-178. doi:10.1177/1521025118810666

[6] A. Sullivan, "Academic self-concept, gender and single-sex schooling", British Educational Research Journal, 35(2), 259–288, 2009. https://doi.org/10.1080/01411920802042960

[7] Diversity and STEM: Women, Minorities, and Persons with Disabilities 2023, National Center for Science and Engineering Statistics (NCSES) Directorate for Social, Behavior, and Economic Sciences, National Science Foundation. https://ncses.nsf.gov/pubs/nsf23315

[8] V. Tinto, "Completing College: Rethinking Institutional Action," University of Chicago Press" 2012.

[9] A. W. Astin, "Student involvement: A developmental theory for higher education," Journal of College Student Development, 1999, 40(5), 518–529

[10] S. Hopkins, J.L. Workman, W. Truby, "The Out-of-Classroom Engagement Experiences of First-Generation College Students that Impact Persistence", Georgia Journal of College Student Affairs, 2021, 37(1) p 36-58.

[11] J.A. Crowe, "Creating a departmental climate that increases a student's sense of belonging, perceived faculty support, and satisfaction with the major," in Innovative Higher Education, 2020, 46(1), 95–109.

[12] M. Xiao, K.D. Bradley, J. Lee, "Exploring the Relationship between Student Involvement and First-to-second Year Retention at Four-year Postsecondary Institutions", Mid Western Educational Researcher, 2020, 33(3).

[13] L. Jacob, A. Lachner, K. Scheiter, "Do school students' academic self-concept and prior knowledge constrain the effectiveness of generating technology-mediated explanations?" Computers and Education, 2022, 182, 104469–. https://doi.org/10.1016/j.compedu.2022.104469

[14] A. Rittmayer, M. Beier, Overview: Self-Efficacy in STEM, 2008.

[15] Mary Villani and Ilknur Aydin, "Learning from the Journey: A Decade of Supporting Women in Computing at a Commuter State College", in 2021 IEEE Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT), Philadelphia, PA, USA, 2021, pp. 1-2, doi: 10.1109/RESPECT51740.2021.9620593

[16] Mary Villani and Ilknur Aydin, "Solving the Gender Disparity Puzzle in Computing Disciplines at a Commuter State College", in Information Systems Education Conference (ISECON), https://www.isecon.org, 2021.

[17] Villani M, Aydin I and Cullington L., "An Early Measure of Women-Focused Initiatives in Gender-Imbalanced Computing Programs", Journal of Computing Sciences in Colleges. 38:3. (86-97). Online publication date: 1-Nov-2022. doi/10.5555/3580523.3580532

[18] Ilknur Aydin, Mary Villani and Lisa Cullington, "Measuring the Impact of Budding Support Programs for Women Undergraduates in Computing Degrees", in American Society for Engineering Education (ASEE) Annual Conference and Exposition, 2023.

[19] Mary Villani and Ilknur Aydin, "Mentoring a Women in Computing Student Club: The Good, The Bad, and The Ugly", In Proceedings of the 53rd ACM Technical Symposium on Computer Science Education V. 2 (SIGCSE 2022). Association for Computing Machinery, New York, NY, USA, 2022, pp. 1191. https://doi.org/10.1145/3478432.3499186

[20] Ilknur Aydin, Mary Villani and Lisa Cullington, "Designing a (Re)Orientation program for Women Computing Students at a Commuter College and Measuring Its Effectiveness", in American Society for Engineering Education (ASEE) Annual Conference & Exposition, 2022.

[21] Villani M, Aydin I and Cullington L., "Analyzing the Impact of Summer Orientation Programs for Women Computing Undergraduates", Journal of Computing Sciences in Colleges. 39:3. (182-194). Online publication date: 1-Oct-2023. doi/10.5555/3636988.3637016

[22] Mary Villani, Ilknur Aydin and Lisa Cullington, "Analyzing the Impact of Attending a Women in Computing Conference on Undergraduate Computing Students" in American Society of Engineering Education (ASEE) Annual conference and Exposition, 2023.