

## **Measuring the Impact of Budding Support Programs for Women Undergraduates in Computing Degrees**

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Ilknur Aydin is an Associate Professor of Computer Systems at Farmingdale State College in New York. She received her Ph.D. in Computer Science from University of Delaware in DE, USA and received her BS degree in Computer Engineering from Marmara University in Istanbul, Turkey. She also worked as a software engineer in Turkey on projects about implementation of a GPS (Global Positioning System) based vehicle tracking system.

Dr. Aydin's research is in the general area of wireless and mobile networks with a focus on transport layer issues including multihoming, SCTP, multipath transfers, congestion control, and network coding. Dr. Aydin has mentored undergraduates and high school students on research projects that involve the use of Arduino boxes and Raspberry Pi's in the context of Internet of Things.

Dr. Aydin has been a vivid supporter of women in computing and increasing diversity in computing. She has been the co-faculty advisor for Women in Computing club at Farmingdale, and contributed Grace Hopper Celebration as a technical committee member and reviewer. and published and presented in peer reviewed venues about women in computing and broadening the participation over a decade.

### **Dr. Mary V. Villani, State University of New York, College of Technology at Farmingdale**

Mary V. Villani is an Associate Professor at Farmingdale State College (FSC). She holds a doctoral degree from Pace University, the Ivan G. Seidenberg School of Computer Science, and Information Systems. Her dissertation topic was Keystroke Biometric Identification Studies on Long-Text input. Publications in this area include peer-reviewed journal articles, external conference papers and a co-authored book chapter in Behavioral Biometrics for Human Identification: Intelligent Applications. Dr. Villani has been actively seeking funding and has been awarded funding both internally and externally to address the gender disparity in the Computing Programs at FSC and is Co-Faculty Advisor to the Supporting Women in Computing Club. Dr. Villani has presented and published in peer reviewed journals regarding initiatives and outcomes addressing the gender disparity in computing disciplines including co-moderated a Birds of a Feather Session at the virtual NY Celebration of Women in Computing at the Spring 2021 Conference entitled: Learning and Sharing from the Decade long Journey of Success and Failures on Women in Computing Initiatives. Professor Villani presented a paper entitled, Solving the Gender Disparity Puzzle in Computing Disciplines at a Commuter State College at ISECON virtual conference in October 2021 and co-moderated a Birds of a Feather session at SIGSCE 2022 virtually entitled: Mentoring a Women in Computing Club: The Good, The Bad and The Ugly. Dr. Villani presented a paper at ASEE 2022 in Minneapolis, MN entitled: Designed A (Re)Orientation Program for Women Computing Students at a Commuter College and Measuring its Effectiveness. Fall 2023 a paper entitled: An Early Measure of Women-Focused Initiatives in Gender-Imbalanced Computing programs were presented at CCSC Eastern Conference. Dr. Villani has been a Grace Hopper Scholarship reviewer, Dr. Villani was awarded the Chancellor's Award for Teaching Excellence in 2013. Prior to joining FSC, Dr. Villani had a fifteen-year Computer Consulting Career in the Risk Management and Insurance industry. Throughout her career, she wrote articles and papers on the topic of Risk Management Information Systems and delivered several invited presentations at Risk Management Conferences as she was a recognized expert in the discipline.

### **Dr. Lisa Cullington, National University**

Lisa Cullington, Ph.D. is an educational researcher with expertise in curriculum development, learning outcomes and educational assessment best practices. She focuses on building and evaluating academic programs that promote inclusive excellence for all learners. Currently, Dr. Cullington serves as the Director of Learning Outcomes for National University. Previously, she was the Founding Co-Director of the Honors Program at SUNY Farmingdale and Associate Director of the Research Aligned Mentorship (RAM) Program where she designed, implemented, and evaluated academic programs to engage students

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## Abstract

Gender disparity in computing degree enrollment, a well-documented global and national issue, persists at both the undergraduate and graduate levels. Consistent with these trends, enrollment in computing majors at Farmingdale State College (FSC) has doubled over the past decade while the percentage of women in these majors has remained steady at 8-15%. The short-term goal of this study was to explore the implementation of institutional initiatives to improve the experience of women in undergraduate computing degree programs. The long-term goal is to increase retention and recruitment to balance the gender disparity in enrollment. For this project, FSC designed and implemented multiple co-curricular support programs (initiatives). Despite scarce local opportunities for funding due to the global COVID19 pandemic, local funding was secured for these initiatives. This paper presents the three works in progress initiatives started at FSC to address gender imbalance, including 1) maintaining the women in computing student club, 2) hosting a summer orientation program, 3) attending women-centric conference and field trips. Findings suggest positive implications for women in the computing degree programs of FSC in terms of their experience as they complete their degree program at FSC, their connection and sense of belonging to the field, and academic self-concept.

## 1. Introduction and Background

Gender disparity in computing degrees is a well-known and historic issue both globally and nationally. Similarly, the gender disparity in enrollment of the undergraduate computing degrees at Farmingdale State College (FSC) has been a long-lasting issue since offering its first computing degree program over twenty years ago. While the enrollment in the undergraduate computing majors has been doubled and reached above 600 students at its peak, the percentage of women students remained steady at 8-15% over the past decade.

In earlier work [1,2] the authors studied and analyzed the ups and downs of the limited, inconsistent, and scattered efforts taken by a handful of faculty members and a few student leaders over the last decade to address the gender disparity at the computing degrees of FSC. This analysis provided critical insights from the past and new understandings as to why the efforts did not last and were not effective. As a result, the authors developed a vision including bringing the gender ratio to 50/50 following Anita Borg's vision [3]. To implement this vision, the authors identified a myriad of support programs (initiatives) from the relevant literature. In selecting which initiatives to be implemented from the extensive list, several contextual factors were also considered:

- limited funding (scarcity of local funding and limited access to competitive national funding),
- negative impacts of the global COVID19 pandemic on state budget allocations,
- inability to hire faculty members and/or staff to support the initiatives,
- limited existing faculty members availability to support initiatives due to intense teaching, research, and service requirements,
- lack of student leaders (82% of students are employed part- or full-time and majority of students live off campus), and
- implementation timeline of the initiatives.

These challenges are common among undergraduate public institutions like Farmingdale State College (FSC). After careful analysis of the context factors, the authors decided to short list and start implementing the following three support programs (initiatives) for Women in Computing (WiC) from spring 2020.

- 1) Maintaining an active Women in Computing student club
- 2) Hosting a summer orientation program for women computing students
- 3) Attending women-centric conference and field trips

Authors acknowledge that there is no silver bullet to solve the gender disparity issue and lack of diversity in computing degree programs of academic institutions. Instead, the issue must be approached and addressed from different angles in a long-term process. For example, schools that were part of the BRAID: Building, Recruiting, and Inclusion for Diversity initiative [4] were committed to implement a combination of four efforts (modifying introductory Computer Science courses to better serve the underrepresented students, leading outreach programs for high school teachers/students, building community among underrepresented students, and developing joint majors to attract to underrepresented students) to increase participation in computing programs from minority groups and women. As a result, some of the BRAID schools showed success at increasing their CS women enrollment to 30-47% but this took them almost a decade [4]. Harvey Mudd College implemented another three strategies to increase their women enrollment in CS major (modifying the introductory computer science course, providing summer research opportunities, and increasing student attendance at the Grace Hopper Conference) and as a result successfully increased their CS women enrollment to 40% in a seven-year span [5].

This research study provides a new context in which researchers can investigate how to increase enrollment in computing degree programs for women. The aforementioned institutions have more human and monetary resources to pour into their WiC support programs. FSC college is a public state institution with limited funds for initiatives outlined in this study. In addition, the student demographics differ where commuter schools such as FSC have substantial number of non-traditional students with limited time to spend on/off campus activities due to employment needs, while in previous schools, the student population, especially those who reside on campus, are better positioned to participate in the extracurricular and enrichment programs. Hence, this research contributes a critical perspective to the literature: how a limited set of WiC support programs that can be implemented with small local to nonexistent funding but with dedicated faculty members can improve the experience of women students in computing degree programs even in and through a global pandemic.

The short-term purpose of this research work is to improve the experience of the women computing undergraduates as they complete their degrees while the broader goal is to increase retention and recruitment to balance the gender disparity in enrollment. This paper reports the measure of impact of the WiC initiatives quantified from the end of semester surveys given to the women computing undergraduate students. The paper includes two-semester survey results and the analysis and its comparison to the one-semester survey results which show positive response to the budding initiatives on the women computing student experience. The following research questions are investigated.

- 1) What is the impact of each WiC initiative on improving women student experience?
- 2) What is the collective impact of the three WiC initiatives on women students' academic, social, and extracurricular experience?
- 3) How does the impact of the WiC initiatives compare and change from one semester to the next?

The rest of this paper is organized as follows. Section 2 discusses related work. Section 3 describes the research methodology including authors demographic, student participants demographic, and the support program components (initiatives). Section 4 presents an analysis of the two-semester survey results in spring 2022 and its comparison to one-semester survey results in fall 2021. Section 5 discusses the limitations of the presented results. Section 6 concludes the paper including the future research agenda.

## 2. Related Work

Equity issues in education have long become a focus of educational researchers at the K-12 and higher education levels. While some progress has been made, earned undergraduate degrees for women in the STEM fields, particularly in subjects, such as Math and Computer Science, lags [6]. To investigate this phenomenon, a theoretical framework informed by a review of the relevant literature was developed. This framework connects the following.

- **Sense of belonging:** Students who have a positive sense of belonging are more likely to persist and be engaged throughout their experience.
- **Academic self-concept:** Engagement in co-curricular and extra-curricular activities, such as academic conferences, may positively impact students' sense of their capabilities within the academic discipline.

### 2.1. Sense of Belonging

A sense of belonging has been central to understanding students' connection to their institutions and, as a result, their success in navigating and graduating from these institutions [7].

Researchers define sense of belonging as a "generalized sense of membership that stems from students' perceptions of their involvement in a variety of settings and the support they experience from those around them" [7]. Furthermore, the researchers' model of student retention posits that student involvement with peers and faculty members in extra or co-curricular activities provides students with a greater sense of belonging and the ability to successfully navigate higher education. As such, engagement is linked to an increased sense of belonging [7].

Engagement in both the academic and social experiences that college has to offer provides multiple points at which students can cultivate their sense of belonging to the college

community. Researchers put forward a student involvement theory that posits that to increase student success and persistence, students need to be involved in academic and social experiences at their institution [8]. Connection with the academic and social spaces of the college experience proves to be integral. Researchers found that students self-reported the benefits of being involved as it generated connections with faculty, helped them to feel part of the college community and developed relationships with others outside of the classroom [9]. Researchers provide an overview of how a lack of friends in a student's degree program increases the chances of that student changing their major. Additionally, faculty support significantly impacts a student's likelihood of persisting in a major. Through academic and social experiences, students form a network of connections that can positively influence their persistence in college and within their major [10].

Engaging in a variety of opportunities that span the academic and social communities within an institution has demonstrated to be essential in developing a strong sense of belonging for students. Results from a study show that student-advisor interaction, student-faculty interaction, extracurricular activities participation, and library utilization were positively associated with first-to-second fall retention. While student-advisor interaction was found to be the strongest predictor for first-to-second year retention, it suggests that institutions should not rely on one involvement practice [11]. Instead, institutions should design a comprehensive program that includes multiple involvement practices to increase retention, persistence, and student success.

## 2.2. Academic Self-Concept

Academic self-concept has become a recent addition to the literature regarding student persistence and success in higher education. Academic self-concept has been defined as students' perception of their own ability in an academic field and elevated levels of academic self-concept positively influence academic outcomes for students [12]. It is useful in defining the non-cognitive factors that make up student success for underrepresented students in the STEM fields [13-15]. Investigating academic self-concept can provide a conceptual tool to understand students' perceptions of their academic identity, their perceptions of their capabilities within the academic discipline and how they overcome academic challenges.

Complementing undergraduate enrollment numbers, women have been shown to demonstrate a higher academic self-concept in biology and medicine as opposed to engineering and math [14]. According to the National Science Foundation, men earned approximately 75% of the engineering, mathematical and computer science bachelor's degree in 2020 [6]. Men also demonstrate higher levels of academic self-concept [16]. Given the reported lower levels of academic self-concept and the lower representation of women in undergraduate computing degrees, further research is needed to determine the efficacy of interventions designed to increase academic self-concept for women in computing degrees.

## 2.3. Women in Computing

Within the literature of diversity and equity in higher education, Women in STEM, more specifically Women in Computing, have become an important focus. Previous research has primarily focused on psychological attitudes and motivation theories have shaped the academic and career choices of women [17]. These theories identify how preparedness to take on STEM major and contextual factors while a university student impact sense of belonging, particularly within their academic discipline, for women.

## 2.4. Gaps in the Literature

Although significant research has been completed to investigate sense of belonging and academic self-concept, limited research exists that connects these two concepts. Furthermore, while there has been research conducted on sense of belonging and academic self-concept in general and within the STEM disciplines, there is a lack of understanding how these concepts interact for women, particularly women in computing degrees. Furthermore, the literature suggests that a coordinated and comprehensive program that provides multiple opportunities for students to engage is required to increase retention, persistence, and student success. As such, this study adds to the growing body of literature that investigates the ways in which institutions can support women to persist and excel in the computing field through a comprehensive program offering multiple moments of interaction.

## 3. Methodology

This section describes the research methodology including target group and student participant demographic, authors/researchers' demographic, and the support program components (initiatives).

### 3.1. Target Group

The target group of this research study are all undergraduates self-identified as women and enrolled in the computing degree programs of FSC according to the college records. Two computing degree programs included in this study are the Computer Programming Information Science (CPIS) and Computer Science (CS) degree programs. While CPIS degree is well established over twenty years and has 452 students with only 13% women, the CS degree has started in fall 2021 and has 122 students enrolled with only 18% women, as of spring 2022. Participation in the WiC activities is voluntary and optional for all the students in the target group.

### 3.2. Researchers Demographic

The research study and WiC initiatives were conducted by the two women faculty members who are both tenured. One of the faculty members (M. Villani) is a senior department member who has been teaching for the past 20 years. She has taught the senior capstone project course for over ten years and has prior 15 years of executive level industry and consulting experience. The other faculty member (I. Aydin) is in her mid-career, teaching CS1 and CS2 courses as well as upper-level technical electives at the department for the past 12 years. While both faculty members are white and were first generation college students, the latter one shares the similar immigrant and ethnic background with some of the target group and student participants. Therefore, though there are only two faculty members running the WiC initiatives, their backgrounds cover a diverse set of student population that allows students to feel connected. In addition, owing to the small classroom sizes (about 23 students per course) at FSC, the faculty members are familiar to the students and know most by name. The third author (L. Cullington) identifies as a woman educational researcher with personal experience as a first-generation college student; a shared experience with some of the study participants. This study is not focused specifically on first-generation college students, the author's contribution incorporates a focus on advocating for underrepresented students in academic spaces. As an educational researcher, the third author provided insight understanding academic self-concept and sense of belonging. The social positions of the authors informed authors' (researchers') perception and

interaction within higher education as well as enabled the researchers to identify themes and patterns among the data to identify the usefulness of the sense of belonging and academic self-concept literature to the research study.

### 3.3. Support Program Components

The details of the three WiC support programs (initiatives) started at the computing degree programs of FSC since spring 2020 are provided below for further context and background.

- 1) **Maintaining the Supporting Women in Computing (SWiC) club:** The student club was first started in 2014 but was through periods of being inactive due to several reasons including lack of student leaders and other challenges at the FSC setting [18]. The club reinstated during the pandemic in fall 2020 with efforts of dedicated faculty advisors and student leaders. Since then, the club has maintained an active calendar of virtual, hybrid and in-person events for the members to become an instrument in creating bonding opportunities for students and help the faculty advisors run some of the WiC initiatives. SWiC is even approved to become an official ACM-W student chapter in spring 2022 while ACM Tech club (the other active student club of the computing department at FSC) had already been a student chapter last year.
- 2) **Hosting a summer (Re)orientation program for women computing students:** The inaugural (re)Orientation program was designed as a one-day program for new incoming and returning students and was piloted in Summer 2021. It included connection opportunities (such as icebreakers, team building activities) to foster camaraderie among the participating incoming and returning CPIS and CS majors [19]. The second orientation program was organized and held in summer 2022.
- 3) **Organizing field trips to women-centric conference and events:** Two field trips were planned and carried out by the authors during the spring semester to this day. Both the trips were to the same regional ACM-W Celebration conference (<https://women.acm.org/category/celebrations>) due to its close-proximity and affordability. Spring 2021 trip was a virtual with 8 women undergraduates attended. Spring 2022 conference and trip was in-person with participation of 34 computing students where 70% were women.

Thus far, the three initiatives have been funded through a few small campus funding opportunities such as discretionary funding from departmental budgets overseen by the department chair, the school-wide budget overseen by the dean, and college-wide budget overseen by the provost. Funding at each level was instrumental in developing widespread institutional support for the initiatives. However, these funding opportunities came from discretionary funds that were not explicitly dedicated to these programs and future support is not guaranteed. Additionally, applying and obtaining local funding and implementing and maintaining these initiatives required significant commitments from faculty members regarding their time. Funding for course releases or sabbatical leaves were not possible to support these initiatives. As a result, faculty commitment was above and beyond their teaching, research, and service loads.

### 3.4. Surveys

The impact of these WiC initiatives was measured quantitatively with an end of semester survey distributed to the target group near the end of the semester with an e-mail. The online survey was



created in Qualtrics software where the participation was voluntary and data collection was anonymous. The informed consent information provided to the target group stated that survey participants must be at least 18 years of age to complete the survey. Note that this research study was first approved by the college Institutional Research Board (IRB) in spring 2021 to last for the next five years.

The end of semester surveys has been conducted twice so far, first in fall 2021 and then in spring 2022. The details of the analysis of the fall 2021 survey results were described and published in authors earlier work [20]. This paper presents the data analysis of the spring 2022 survey results and its comparison to the fall 2021 survey results in the next section.

#### **4. Results and Data Analysis**

End of spring 2022 survey was distributed via email to all 79 women students enrolled in CPIS and CS degree programs at the end of the semester on May 14 and then reminder email on May 22, and May 29 during and right after the final exams period. 23 students (28%) participated in taking the spring 2022 survey. Note that 3-4 of the respondents did/could not fully complete the survey until the end. This may be a technical issue, or a student may have decided to stop responding to the rest of the survey questions. Therefore, the readers are to be aware that the results presented below may have a difference in the total response count per survey question. The previous end semester survey in fall 2021 had a similar response rate (n=19/69 or 27%).

- The **composure of the end of spring 2022 survey participants** is as follows. Out of 23 respondents, 14 are from CPIS and 9 are from the new CS major. While 5 of the survey participants are first year students, 8 are sophomores, 3 are juniors and 7 are seniors. The number of survey respondents by year is consistent with the distribution in terms of participation in the degree programs. Out of 23 respondents, 3 have graduated high school over five years ago, indicating a status of non-traditional/adult students. More than half of the survey participants (n = 13/23) are transfer students from another college which is consistent with the overall FSC and CPIS/CS student demographic.
- The **demographic data of the end of spring 2022 survey participants** is as follows. In the results, 22 students identified as woman when given the following options Woman, Man, Agender, Cisgender, Intersex, Non-binary, Transgender, Prefer to Self-Describe. Participants could select only one of the options in the current survey; however, future versions of the survey will provide a multi-select option. Note that, the target group of this research study are CPIS/CS majors who self-identified as women. This group included cisgender and transgender woman-identifying students. Participants' identification of their sexual orientation was not a focus of this study; however, the study was inclusive to consider diverse ways one can identify as a woman. The respondents are from a diverse race/ethnicity background such that 7 are Hispanic, Latino, or of Spanish origin, 9 are Asian, 4 are Black or African American and only 2 are white. FSC's reporting convention was used in providing these race/ethnicity options. Note that FSC is considered a "minority majority" school and the survey participant demographic is consistent with the FSC demographic. There is one veteran. Note that the previous fall 2021 survey did not collect such demographic data to

compare to the spring 2022 survey, but the authors will continue collecting this data from spring '22 to track and highlight the diversity of the student population at FSC.

The purpose of the end of semester surveys is to learn, understand and measure the experience the women students in the program and their response to the three WiC initiatives in improving their experience. The specific metrics measured include the following.

- **Satisfaction/experience:** participants are asked to rate their academic, social, extracurricular experience.
- **Connection/sense of belonging:** participants are asked about their connection with peers, faculty, and computing field.
- **Academic self-concept:** is defined above in the related work section. This metric is used to measure the success of WiC initiatives to understand how the initiatives impact the self-believe of women students.

The following subsections present the data analysis of the spring 2022 survey with respect to the three WiC initiatives (maintaining an active Women in Computing club, summer orientation program for women computing students, and attending women-centric field trips), measured metrics, and comparison to the prior fall 2021 semester survey responses.

#### 4.1. Measuring Academic/Social/Extracurricular Experience of Women students

In the spring 2022 survey, when participants are asked about rating their experience at CPIS/CS major level vs. at the college level, their self-reported perceptions of their experience were similar at the departmental and the college level. Table 1 shows that women respondents rated their academic experience higher than their social experience. The extracurricular experience is rated lowest among the three. Improving the extracurricular and social experience is what the researchers aim for with the WiC initiatives. Results from fall 2021 survey show a similar experience rating trends compared to the spring 2022 results which hints that the WiC initiatives has not impacted women student experience much in one semester. This issue needs further

**Table 1. Spring 2022 Ratings for experience of women computing students (n=20)**

Experience	Excellent		Good		Acceptable		Poor	
Academic experience	30.00%	6	45.00%	9	25.00%	5	0.00%	0
Social experience	25.00%	5	50.00%	10	20.00%	4	5.00%	1
Extracurricular experience	15.00%	3	30.00%	6	35.00%	7	20.00%	4

investigation and will be tracked in the upcoming end of semester surveys.

#### 4.2. Measuring Impact of SWiC Activities

In the spring 2022 survey, only a small number of the respondents were registered members of the SWiC and ACM Tech student clubs in the college club management system that would allow students to get regular updates and emails from the club leaderships (n=7/22 vs. 2/22). In addition, half of the respondents (n=9/18) attended none of the meetings and events organized by SWiC in fall 2021 and spring 2022. This data supports the fact that FSC is a commuter college where student involvement in extracurricular activities is low compared to the residential

colleges. This is despite the rise in attendance at meetings because hybrid option is offered if students are not on campus on a meeting day.

However, as seen in Table 2, most of the respondents who are involved with SWiC reported improvement (“Strongly Agreed” or “Agreed”) in their sense of **connection and bonding** with their classmates and peers (n=5/8), and with people in the computing field (n=5/8 as well as them believe in having better future support in classes at FSC. Note that, in Table 2, Not Applicable (N/A) column is taken as n=10/18 respondents reporting as not being involved with SWiC activities.

In addition, as seen in Table 3, for all those women who are involved with SWiC, their **academic self-concept** has improved as they reported feeling more confident to succeed in their future computing classes (n=8/8 Strongly Agreed or Agreed) and complete their computing degree (n=7/8). Note that, in Table 3, N/A column is taken as 10-11 respondents reporting as not being involved with SWiC activities.

The authors realized that the previous fall 2021 survey did not have direct questions to measure the impact of SWiC activities to utilize in comparing with the spring 2022 survey results. The before questions have been added and the authors will continue measuring and tracking the impact of SWiC activities in upcoming end of semester surveys.

#### 4.3. Measuring Impact of Summer Orientation for Women Computing Students

In the spring 2022 survey, a suitable number of the respondents (n=7/20, 35%) stated that they had attended the summer 2021 orientation for women computing students. Note that they were a total of 33 women students attended the summer 2021 (re)orientation program and only 7 (21%) of those students felt compelled to respond the spring 2022 survey two-semesters later. Comparing the spring 2022 survey response rate with fall 2021 survey for the summer orientation attendance, slightly higher number of fall 2021 respondents (n=8/19, 42%) had attended the summer 2021 orientation. The lower response rate in spring 2022 (n=7/33, 21%)

**Table 2. Impact of involvement with SWiC during fall'21 and/or spring'22 on connection/belonging metric (n=18)**

	Strongly Agree		Agree		Neutral		Strongly disagree		Disagree		N/A	
I feel I bonded with classmates and peers at FSC	16.67%	3	11.11%	2	16.67%	3	0.00%	0	0.00%	0	55.56%	10
I feel I have a better peer support in my classes at FSC	11.11%	2	16.67%	3	16.67%	3	0.00%	0	0.00%	0	55.56%	10
I feel I expanded my network with people beyond FSC	11.11%	2	5.56%	1	22.22%	4	0.00%	0	5.56%	1	55.56%	10
I feel more connected with people in my field	11.11%	2	16.67%	3	16.67%	3	0.00%	0	0.00%	0	55.56%	10

**Table 3. Impact of involvement with SWiC during fall'21 and/or spring'22 on academic self-concept metric (n=18)**

	Strongly Agree		Agree		Neutral		Strongly disagree		Disagree		N/A	
I feel more confident to succeed in my computing classes	11.11%	2	33.33%	6	0.00%	0	0.00%	0	0%	0	55.56%	10
I feel more motivated to complete my computing degree	5.56%	1	33.33%	6	0.00%	0	0.00%	0	0%	0	61.11%	11

may also be due to some of the summer 2021 orientation attendees' graduation in the previous fall 2021 semester.

Spring 2022 survey measured the two-semester impact of the summer 2021 orientation on attendees while fall 2021 survey had measured the impact of one-semester or more immediate impact of the summer 2021 orientation. Spring 2022 survey results in Table 4 show that the summer 2021 orientation has impacted the **two-semester experience** of most attendees positively as they reported to be satisfied to “see familiar faces in their classes” and “meeting the faculty” earlier in summer 2021.

Note that the high percent of N/A in Table 4 is also interpreted as not attending the summer 2021 orientation. In fall 2021 survey, the summer orientation impact was measured differently (using a multiple select options rather than Likert scale as in spring 2022 survey), but still when compared with spring 2022 survey results, two semester positive impact of the summer orientation is slightly higher on the attendees as they may have met more classmates and faculty in two semesters than one semester. In addition, attending the orientation resulted in half of those attendees (n=4/7 Strongly Agreed or Agreed) getting involved with student clubs and hence

**Table 4. Impact of Summer’21 Orientation on Women Students’ spring 2022 experience (n=20)**

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
It was nice to see some familiar faces in my classes	20.00% 4	15.00% 3	10.00% 2	5.00% 1	0% 0	50.00% 10
It was helpful to had met faculty	15.00% 3	20.00% 4	15.00% 3	0.00% 0	0% 0	50.00% 10
I felt more confident attending classes	10.00% 2	10.00% 2	25.00% 5	5.00% 1	0% 0	50.00% 10
I got involved with SWiC (Supporting Women in Computing) club	15.00% 3	5.00% 1	10.00% 2	20.00% 4	0% 0	50.00% 10
I got involved with ACM Computer Tech Club	5.00% 1	15.00% 3	5.00% 1	25.00% 5	0% 0	50.00% 10

being engaged in campus life after two semesters (Table 4). The other measured success metric of the summer orientation was student **academic self-concept** where in spring 2022 survey half of the orientation attendees (n=4/7 Strongly Agreed or Agreed) stated feeling more confident with attending classes.

#### 4.4. Measuring Impact of Field Trips

End of spring 2022 semester survey included questions to understand and measure the impact attending the in-person NYCWiC’22 conference in April (that is spring’22 trip) on the rest of the participants’ Spring 2022 semester that ended in mid-May. This is a very immediate response to measure but was still considered valuable to measure. Even though a small number of spring 2022 survey respondents stated that they attended the NYCWiC’22 conference (n=4/19), those who attended overwhelmingly reported that “their Spring 2022 semester was positively impacted” and they learned about women in industry, researchers in other schools, and career opportunities. This is consistent with the previous fall 2021 end of semester results where all 3 of the 19 survey participants, who attended the virtual NYCWiC’21 trip in spring’21, responded positive impact of the virtual trip. The preliminary reports are consistent with student involvement theories. These theories posit that the student involvement with the academic and social offerings of an institution, and closer connections with peers, faculty, and staff, lead to positive impacts on retention, persistence, and academic outcomes.

In spring 2022 survey, the spring’22 field trip attendees reported improvement in their sense of **connection and bonding** with their classmates and peers, and with people in the computing field as well as them believing in having better future support in classes at FSC– See Table 5. Note that, in Table 5, Not Applicable (N/A) column is taken as n=11/19 respondents reporting as not attending the trip; hence 7/19 attended the trip. This is a contradiction to the direct question of

**Table 5. Impact of attending spring'22 field trip on attendees' rest of spring'22 considering the connection/belonging metric (n=19)**

	Strongly Agree		Agree		Neutral		Strongly disagree		Disagree		N/A	
I feel I bonded with classmates and peers at FSC	5.26%	1	21.05%	4	10.53%	2	5.26%	1	0.00%	0	57.89%	11
I feel I have a better peer support in my classes at FSC	5.26%	1	10.53%	2	21.05%	4	0.00%	0	0.00%	0	63.16%	12
I feel I expanded my network with people FSC	10.53%	2	0.00%	0	21.05%	4	0.00%	0	5.26%	1	63.16%	12
I feel more connected with people in my field	10.53%	2	5.26%	1	21.05%	4	0.00%	0	0.00%	0	63.16%	12

**Table 6. Impact of attending spring'22 field trip on attendees' rest of spring'22 considering self-concept metric (n=19)**

	Strongly Agree		Agree		Neutral		Strongly disagree		Disagree		N/A	
I feel more confident to succeed in my computing classes	5.26%	1	10.53%	2	21.05%	4	0%	0	0%	0	63.16%	12
I feel more motivated to complete my computing degree more than prior to attending the conference	10.53%	2	10.53%	2	15.79%	3	0%	0	0%	0	63.16%	12

“Did you attend the NYCWiC’22 trip?” which only 4/19 responded as “Yes”. It is possible that students got confused or incorrectly selected options to continue the survey.

In Table 6, a small number of women who attended spring’22 trip does not report much change/effect on their **academic self-concept** either. This is expected as the time difference between the trip and the rest of semester was only few weeks of the semester. However, most of the respondents said they are interested in attending next year’s spring field trip (only n=5/19 said No while the 14/17 said Yes/Maybe).

## 5. Discussion on the Limitations of the Results

First, the end-of-semester survey results from the three WiC support programs (initiatives) implemented are from two semesters, fall 2021 and spring 2022. The authors are aware that this is a short time span to show the true effectiveness of the initiatives in improving the women student experience while completing their degree programs; however, the results and their analysis are still vital and valid in terms indicating the initial response to the initiatives, and how to hone the initiatives moving forward. For this paper, data were collected using the survey

instruments. Through analysis, patterns and themes emerged that the researchers positioned within the theoretical concepts of sense of belonging and academic self-concept. Given the small number of women in the computing programs and the number of those students who participated in the initiatives, the number of potential respondents was low. Future work includes adding qualitative analysis to the research considering the small number of participants in the study. Additionally, this study did not look to identify the impact of each initiative individually, and thereby can be a limitation. However, this study investigated the initiatives in aggregate. The results of this study support [12]'s assertion for the need of multi-pronged institutional approaches to address the challenges of gender disparity in enrollment of undergraduate computing degree programs.

Second, the surveys participants are from two majors (CPIS and CS). There was one participant feedback for the free form question in spring 2022 survey about inviting more computing related majors in the WiC initiatives: "*Involve more majors in reorientation, such as computer security, engineering etc.*". Authors plan to expand the WiC initiatives to the computer security majors of FSC. There are security students who have been active SWiC members and leaders and as a part of their program requirements, take courses with the CPIS and CS majors.

Third, the fall 2021 and spring 2022 end of semester surveys are given only to women-identifying computing students that are the target group of the research study; however, expanding the survey participants to male students, faculty, and staff could help understand the entire ecosystem better and hence is considered to include in the future surveys and IRB. Any future inclusion of faculty, staff, and males would be to understand their interaction with woman-identifying students (target group) and how that might impact woman-identifying students' academic self-concept and sense of belonging.

Lastly, this study focused on self-identified women and did not disaggregate by race, ethnicity, or gender identity. While gender identity was asked as demographic question on the end of semester survey, the full spectrum of gender identities was not the focus of this study. This study explicitly focused on woman-identifying students, with this group being inclusive of transwoman. The number of students who identified as non-binary was low. Future work could build on this study by identifying gender as a theoretical construct and investigate the ways in which sense of belonging and academic self-concept interact with gender identity, ethnicity, and race.

## **6. Conclusions and Future Work**

This paper presents the three women in computing (WiC) initiatives started in 2020 at Farmingdale State College (FSC) to address the gender imbalance in its computing degree programs. The effectiveness of the Women in Computing (WiC) initiatives is measured with end of semester surveys given to the participating women students. This paper presents the spring 2022 survey (two-semester results) and its comparison to the fall 2021 survey (one-semester results) to understand the impact of the initiatives. The data analysis shows positive response to the budding initiatives and positive impacts on measured metrics (women student experience, connection/sense of belonging in the field, and academic self-concept). Students who were involved in more initiatives felt a stronger sense of connection and sense of belonging to the program. An overwhelming majority of the respondents felt that participation in these interventions increased their academic self-concept and confidence to complete their studies. These initiatives were localized to this institution and created a sense of belonging in this learning community. There might be national support programs and opportunities for students,

but the relevant literature advocates for programs to develop strong ties among their students at the local level. By fostering these connections, institutions can increase a student's sense of belonging within their immediate context.

The impact of the initiatives on the women students' academic performance such as aggregated GPA, graduation rate and retention rate are another measure to analyze. Future research will focus on whether women's academic performance increases in response to the WiC initiatives. Past academic performance data by gender from the last decade would be collected and reported in aggregate in comparison to aggregate and anonymous data collected into the year 3 (short term) and year 5 (longer term) of the implemented WiC initiatives. This analysis of the academic performance accompanying analysis of the women student experience would then be an additional contribution of this research work to the relevant literature.

The purpose of this research is to understand what enhances the experience for women in the computing programs of FSC that fosters enrollment, retention, and persistence that will help the department and college to implement policies and practices that have this positive impact. There is a shortage of women in computing in industry worldwide, improving the retention and completion rates at FSC have a broader impact on the gender numbers in local and national industry.

This study is an exploratory work in progress, and the results will be used to inform future analysis of these interventions, including incorporating psychometrically evaluated scales applied to other contexts. Appropriate IRB modifications will be made for future work. The research work underway is approved by the college IRB of FSC for five years. The plan is to extend the IRB beyond five years for longitudinal study while adding new initiatives to the existing ones, pending additional faculty and money support to jump start, and run such new initiatives.

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