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Understanding the Gender Gap in Computer Science Undergraduate Academics

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Computer Science Honors Thesis
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1 Introduction

There is a gender gap in technical fields that has persisted through generations. In my research, I focus on the gender gap within computer science (CS) undergraduate academics. Diversity in technical fields starts with diversity in academics. Studies have shown that girls who are exposed to CS in or before high school are more likely to study CS in college. Other factors such as role models, life goals, and perception of CS also influence a girl's decision. I surveyed UMW students in different stages of their CS degrees, in addition to students who only participated in an introductory CS class.

Most students entering introductory computer science classes today use smartphones, laptops, and tablets in their everyday lives. The intuitive user interfaces and natural comfort with technology could be shielding young people from considering how their devices work. Many young people use their devices for social media which could be shifting the perception of CS. A common opinion is that after a student finishes high school, their decision to take a CS class becomes less malleable. There may be steps that universities can take to increase exposure and encourage first year students to try a CS class. Biases from parents, other family members and non-familial figures (teachers, club leaders, etc.) can be passed through generations and change a student's self-perception.

In my paper, I discuss factors that influence UMW students based on analysis of the data collected from an online survey of UMW undergraduates. I will be presenting my findings and attempt to describe the causes and possible solutions for the gender gap.

2 Background

The gender gap in CS fields permeates through the stages a of a computer scientist's life. The gender gap is more affected by the small quantity of girls choosing CS as a career path than women who leave CS jobs [1]. CS and engineering have the widest gender gap relative to all other STEM fields [2].

The first generation of women in computing between the 1960s and 1970s faced intentional and explicit discrimination. In these earliest years of CS, the work was primarily mathematical calculations. For women of privilege, education in math and science was seen as "necessary for motherhood" [3]. Women based their argument for access higher education on the fact that it would help them be better wives and mothers. [3]. There was an assumption that if a woman married, she would resign from her position [3]. Women were systematically ignored in the scientific community and "from 1911 onward, there were overt efforts to reduce the numbers of women in science" [3].

The second generation of women in CS, entering in the 1980s and 1990s, had advantages over the first. The first generation had *no* female faculty in academic science departments [3]. A study of 30 academic science departments from 1944, found that the qualitative improvements within the departments became more noticeable when 15% of the faculty members were female [4]. There was an inter-generational conflict of a woman's role in CS. Rather than being preoccupied with "getting on in a man's world, being a woman in a man's world was a preoccupation for the second generation" [3]. The number of women in the field and work life balance were concerns of the second generation [3]. There are several reports of first generation advisors having a sink or swim attitude towards their female advisees and being hesitant to participate in diversity initiatives because it made women "appear different and by implication weak" [3] [4].

The third generation of women entered into CS in the 2000s and 2010s. Groups had been founded to encourage and support women in the field and families became less of a barrier [3]. The establishment of the Grace Hopper conference and scholarship and research opportunities for women in CS are two examples of improvement. "For many women of the third generation, their departments made explicit efforts to improve the experience of women in their classrooms… [they were] far removed from the explicit sexism that the first generation experienced" [3].

I argue that women entering into CS degree programs and careers today are part of a fourth generation. Today, computers have become ubiquitous in everyday life which could be giving women a more organic comfort with computing [3]. It is important that young girls are exposed to CS early on in life; the four-year window between 11 and 15 is a unique chance to spark or maintain student's interests [5]. After that, and especially once she enters college, a girl's decision to study CS becomes less malleable [6] Gender stereotypes and social expectations become more and more powerful as girls get older [5].

I hypothesize that there are areas in which universities can help merge the gender gap. It is statistically proven that factors such as encouragement and early exposure to technology increase the chances that a female student will major in CS [6]. By the time she enters college, it is too late to change those experiences but there could be ways to supplement them. My research focuses on three factors: (1) self-perception and perception of CS, (2) sense of belonging, and (3) experiences in a student's first CS course.

2.1 Self-Perception & Perception of CS

A senior female scientist in Etzkowitz's study reported, "the [women] who did [science] were really tough cookies, now it's easier to get in. At one time it wasn't even acceptable to start. So if you started back then you were tough to begin with. I have quivering women coming through who are very smart asking can they compete with men… Of course they can. They just aren't taught to be competitive. They don't expect to win" [4].
In a recent Microsoft study, sixty percent of participants responded that they would be more inclined to pursue a STEM career if they knew that men and women were equally employed in those fields [5]. CS is not often perceived as "having diverse applications and a broad potential for positive societal impact" [6]. Wang's study found that "a high school girl's perception of computer science and its associated careers is the second most potent explainable factor influencing the pursuit of a computer science degree" [6]. It cites perception of CS as 27.5% of the explainable factors [6].

My research on self-perception and perception of CS focuses more on a student's view of computer scientists rather than the CS field. If students feel they are similar to the typical computer scientist, they are more likely to pursue a degree in CS.

2.2 Sense of Belonging

Similarity of self-perception and perception of CS could be an indicator of a student's sense of belonging. Girls who are less confident in technical subjects are less likely to pursue CS degrees [6]. Wang's study showed that high school girls are more likely to agree that they are "always in the top of 'honors' math classes" and that female CS majors were significantly more likely to agree with "I love math" [6]. For the purposes of my study, sense of belonging refers to a student's comfort in their CS classes.

2.3 Experiences in First CS Course

Encouragement and early exposure to CS are considered indicators of a girl's future interest in CS [6]. Wang found that social encouragement and academic exposure to CS were 28.1% and 22.4% of the explainable factors for high school girls, respectively [6]. Girls who take the AP computer science exam in high school are 46% more likely to pursue a CS degree. However, only 19% of students who take the exam are female [2] [6]. My analysis is based only on undergraduate students. By the time students reach college, the indicator of "early exposure" has either happened or not but is no longer applicable. Thus, I considered a student's experience in their first CS class at UMW an indicator of early exposure to CS in college.

2.4 Research Questions

(1) Do male and female students perceive a typical computer scientist differently?
(2) Does the similarity of a student's self-perception and his/her perception of CS influence the decision to major or not to major in CS?
(3) Do women feel that they do not belong in CS classes?
(4) To what extent is a student's experience in their first CS class indicative of the decision to major or not to major in CS?

3 Data Collection

The goal of this study is to find factors that attract or deter undergraduate students at UMW from majoring in CS; more specifically, to discover which factors are more significant for women.

The data from this research was gathered by means of a Qualtrics survey (see Appendix B). Students who had registered for CPSC 110 at UMW in the last four years were contacted by email and provided a link to the online survey. The email was sent to 878 students. I received 191 responses and 150 were used in analysis. Three participants asked that their data not be used in the study, and 35 participants did not indicate their gender and/or major. It is not possible to determine how representative this sample is of the entire selection pool. The selected pool was based on rosters from introductory level CPSC classes and the list of CPSC majors -- the rosters do not include gender.

3.1 Survey Design

The survey consists of seven main sections:

1. Introduction
2. Majors and minor information
3. Self-perception and perception of CS
4. Sense of belonging
5. First CS class experiences
6. Group work
7. Mentors
8. Gender & Enrollment
9. Conclusion

These sections were based on previous research showing statistical significance in similar categories for high school students [6] [7] [8]. The gender section was intentionally placed last to avoid influencing participants' answers.

3.1.1 Question Styles

The survey used 10 different style questions. Likert scale questions were used to show level of agreement with statements. Each Likert scale question gave 6 choices: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree. The responses were recorded as 1 to 6 respectively.

Semantic differential scales were used in the self-perception and perception of CS section. The scales ranged from 1 to 10 where a 1 represents the term all the way on the left and a 10 represents the term all the way on the right.

Dropdown lists contained semesters for participants to indicate what semester they took CPSC 110 or CPSC 220. Other dropdowns contain numbers. Yes/No questions were used to handle survey flow.

Gender questions had three options: male, female and other.

Participants were given a free response question that prompted for any additional experiences in CS.

Question type	**Quantity**
Likert Scale (strongly disagree – strongly agree)	7
Dropdown lists	4
Semantic Differential Scale (rate 1-10)	4
Multiple choice: yes/no	3
Multiple choice: Male/Female/Other	2
Select all that apply	2
Consent to use participant response	2
Number entry	1
Text entry	1
Total	26

Table 1 Question Types

3.2 Breakdown of Participation

The following describes the breakdown of participants based on gender, major, age, course enrollment and free response question.

	Male	*Female*	*Major totals*
Computer Science	57	18	75
Other	16	59	75
Gender totals	73	77	150 total participants

Table 2 Participation by Gender and Major

- 35% of participants took or are currently taking CPSC 220
- 88% of all UMW majors are represented in the survey
- Ages of participants:
    - Mean: 21 years old
    - Minimum: 17 years old
    - Maximum: 34 years old
- 21% of participants shared experiences in the free response question

4 Methods

4.1 Cleansing

The response data from the survey was downloaded from Qualtrics in CSV format. I created an SQLite database to store the values. The database has three tables:

(1) The *response table* stores data directly from the Qualtrics CSV. Each row represents a response and each column represents a question. All data is stored as an integer, except the free response questions (see 6 Supplementary Shared Experiences). Semantic differential scale responses appear in the table exactly as the participant selected. For example, Section 3 Q3_1 asks participants: "*In my opinion, a typical computer scientist is…"* and gives a scale from shy to outgoing. A response of 1 indicates completely shy and a response of 10 indicates completely outgoing. The value between 1 and 10 is stored in the Q3_1 column. Likert scale questions are stored with a value ranging from 1 to 6. A response of strongly disagree is stored as a 1 and a response of strongly agree is stored as a 6. The survey did not include a neutral value. Questions with yes/no and male/female responses are stored as 1 and 2 respectively. Other *select all that apply* questions are stored as integers where 1 is the first option, 2 is the second option, etc. Responses with multiple selections are stored in separate columns. For example, if a student majors in Computer Science (option 10) and Mathematics (option 26), the tables stores 10 and 26 in two separate columns.

(2) The *question table* has an id column representing the question number and a contents column containing the question text as a string. Each row in the question table represents a column in the response table.

(3) The *major table* contains an id column representing the integer value of the major and a name column with name of the major as a string. Majors are listed alphabetically from Accounting (1) to Women's and Gender Studies (38) and Undecided (39). The id column is the primary key of the major table and a foreign key of the response table.

4.2 Statistical Tests

Analysis of the data was done in R with Plotly for graphs. I used Kruskal Wallis tests to find significant p-values and Dunn's tests to determine significant pairs of categories. For all analysis I used a significance level of $\alpha = 0.05$. A p-value less than alpha indicates two or more of the categories are statistically different from each other.

4.2.1 Kruskal Wallis & Dunn's Tests

Kruskal Wallis tests are nonparametric and do not assume a continuous distribution. They are used to determine if the null hypothesis can be rejected. They are commonly used when testing ordinal or Likert scale data with more than two categories. A null hypothesis, H_0, assumes independence of variables; an alternative hypothesis, H_a, assumes dependence of variables.

Given a significant value of$p < \alpha$ from a Kruskal Wallis test, Dunn's tests determine which pairs of categories are significant. Dunn's tests produce adjusted p-values for each pair of categories. Then, compact letter displays (CLD) were used to assign letter values to each category; categories that do not share a letter are statistically different from each other.

4.2.2 Factors & Categories

This study focuses on four main categories and three main factors.
Categories:

1. Male CS - male students who study CS
2. Male other - male students with other majors
3. Female CS - female students who study CS
4. Female other - female students with other major

Factors:

1. Self-Perception & Perception of CS
2. Sense of belonging
3. Experience in first CS class

The data has six unique pairs of categories to compare:

1. Male CS & female CS
2. Male CS & female other
3. Male CS & male other
4. Female CS & female other
5. Female CS & male other
6. Female other & male other

5 Analysis & Results

The following sections describe the analysis and results for each of the factors.

5.1 Self-Perception & Perception of CS

I analyzed self-perception and perception of CS individually and collectively. The analysis and results in sections 5.1.1 through 5.1.3 are based on questions Q3 and Q4 from the survey (see appendix A). [1]

Participants rated themselves and a typical computer scientist on the following scales:

- Breadth of interests - "an expert with computers to a person with broad interests"
- Socialness - "antisocial to social butterfly"
- Outgoingness - "shy to outgoing"

Responses were recorded as a value between 1 and 10 – a one represents the term on the left and a 10 represents the term on the left.

5.1.1 Self Perception

The Kruskal Wallis tests for self-perception tested the following hypotheses:

$$H_0 = astudent'sselfratingisindependantofgenderandmajor$$
$$H_\alpha = astudent'sselfratingisdependantongenderandmajor$$

The test shows significant p-values for breadth of interests and socialness.

Breadth of interests	*Socialness*	*Outgoingness*
$1.42\boldsymbol{e} - 7$	$.044$	$\rho > \alpha$

Table 3 Self-Perception p-values

However, the Dunn's test showed that no groups were different for socialness.

[1] I omitted participant's ratings on the scale "a man to a woman" and "masculine to feminine" due to lack of clarity. The values were polarized with mostly 1s and 10s.

Dunn's test for breadth of interests produces the following CLD:

Category	*Letter*
Male CS	b
Female CS	a
Male other	a
Female other	a

Table 4 Breadth of Interests CLD

The following box plot shows the responses for each scale by category.

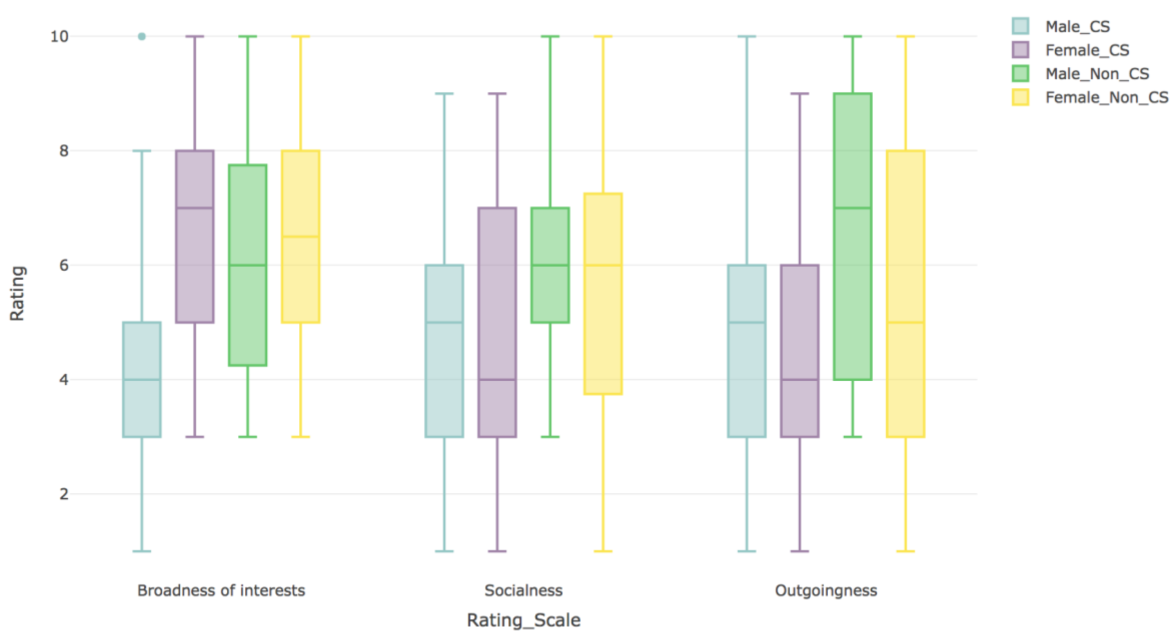

Figure 1 Self-Perception Box Plots

As shown in Figure 1, the median response for male CS students on the breadth of interests scale is 4, and 75% of all male CS students give a response of 5 or less. For all other categories the lowest response is a 3 and the highest is a 10. The CLD in Table 4, assigns male CS as *b* and all other categories as *a*. Thus, male CS majors rate themselves as having a significantly deeper expertise with computers as opposed to a wide breadth of interests relative to all other groups.

5.1.2 Perception of CS

The Kruskal Wallis tests for perception of CS tested the following hypotheses:

$$H_0 = a student's opinion of a typical computer scientist is independent of gender and major$$

$$H_\alpha = a student's opinion of a typical computer scientist is dependent on gender and major$$

The tests returned insignificant p-values on all scales with $\rho > \alpha$.

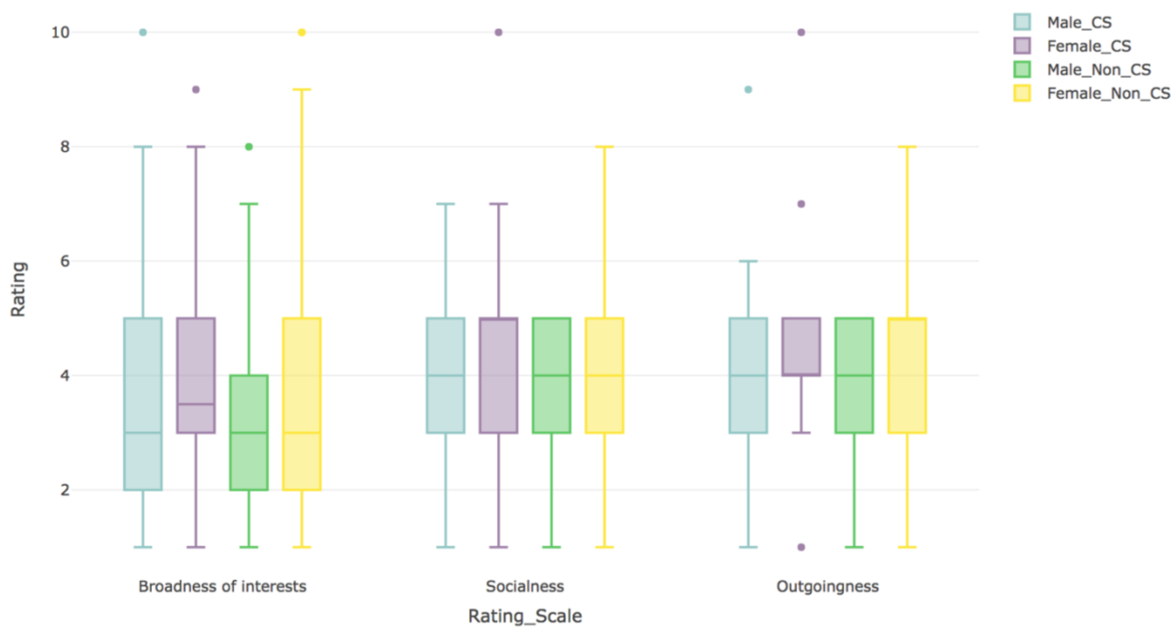

Figure 2 Perception of CS Box Plot

As shown in Figure 2, and confirmed with insignificant p-values, the median response and range of responses across all categories is similar. The similarity implies that the opinion or stereotype of a typical computer scientist does not vary based on a student's gender or major.

5.1.3 Difference in Perception by Scale

To compare differences in perception, rating of a typical computer scientist was subtracted from the self-rating.

$$diff = (selfrating) - (ratingofatypicalcomputerscientist)$$

For example, on the socialness scale, if a participant rates themself as a 7 and a typical computer scientist as a 3, they consider them self to be more outgoing and the difference of 4 is used. A difference of 0 signifies that the participant rated them self and a typical computer scientist the same.

The following table shows p-values for the four main categories and their respective difference between self and CS perception.

Breadth of interests	*Socialness*	*Outgoingness*
$2.32\boldsymbol{e} - 5$	$\rho > \alpha$	$\rho > \alpha$

Table 5 Difference in Perception p-values

The p-value for breadth of interest shows statistical significance with $\rho < \alpha$. The Dunn's test for that scale produces the following CLD:

Category	*Letter*
Male CS	b
Female CS	a
Male other	a
Female other	a

Table 6 Breadth of Interests CLD

The following box plot shows the difference in responses for each scale by category.

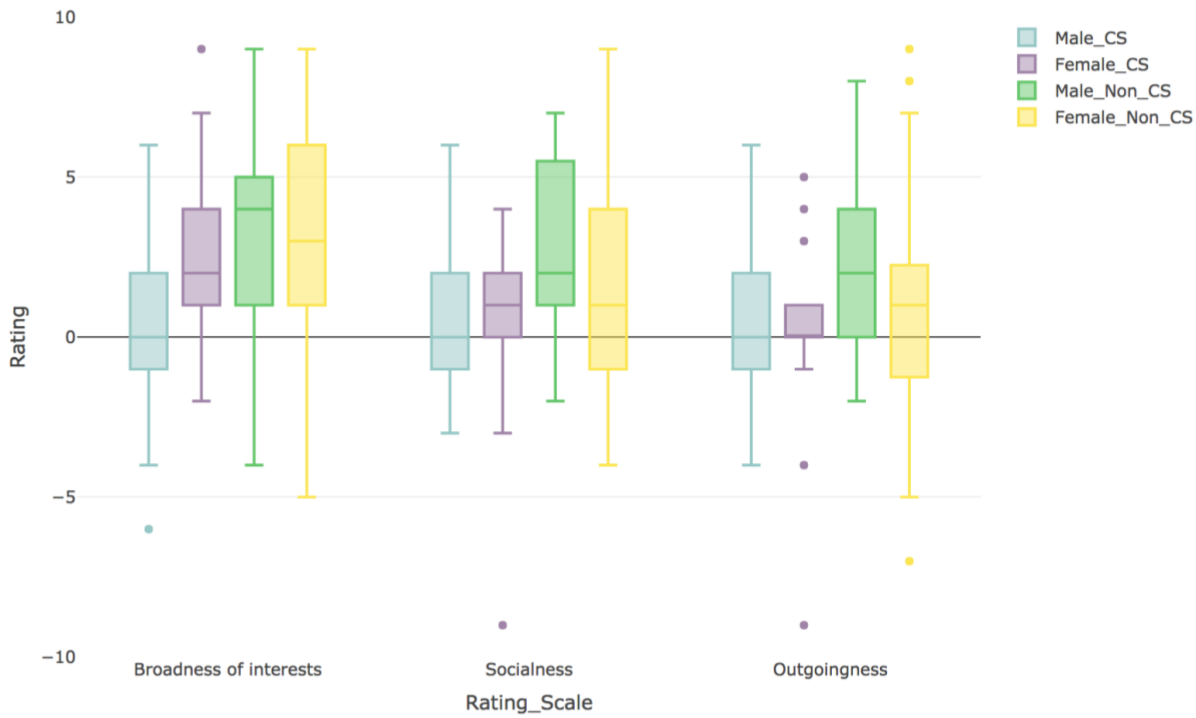

Figure 3 Difference in Perception by Scale Box Plot

As shown in Figure 3 the median difference for male CS majors is zero for all scales. However, as indicated by the p-values only the differences on the breadth of interests scale is significant. The CLD in Table 6, indicates that male CS majors rate their depth of expertise more similar to a typical computer scientist relative to all other groups.

5.1.4 Overall Difference

In addition to looking at the scales separately, I ran a Kruskal Wallis that included the differences for all scales.[2] The test returned a significant p-value.

All scales
$4.025\boldsymbol{e} - 5$

Table 7 Overall Difference p-value

The Dunn's test produces the following CLD:

Category	*Letter*
Male CS	b
Female CS	a b
Male other	c
Female other	a c

Table 8 Overall Difference CLD

[2] This method is combining samples because a participant's difference in response is used three times – once per scale. Thus, these results may show bias due to violating the assumption of independence.

The following box plot shows the overall difference in responses by category.

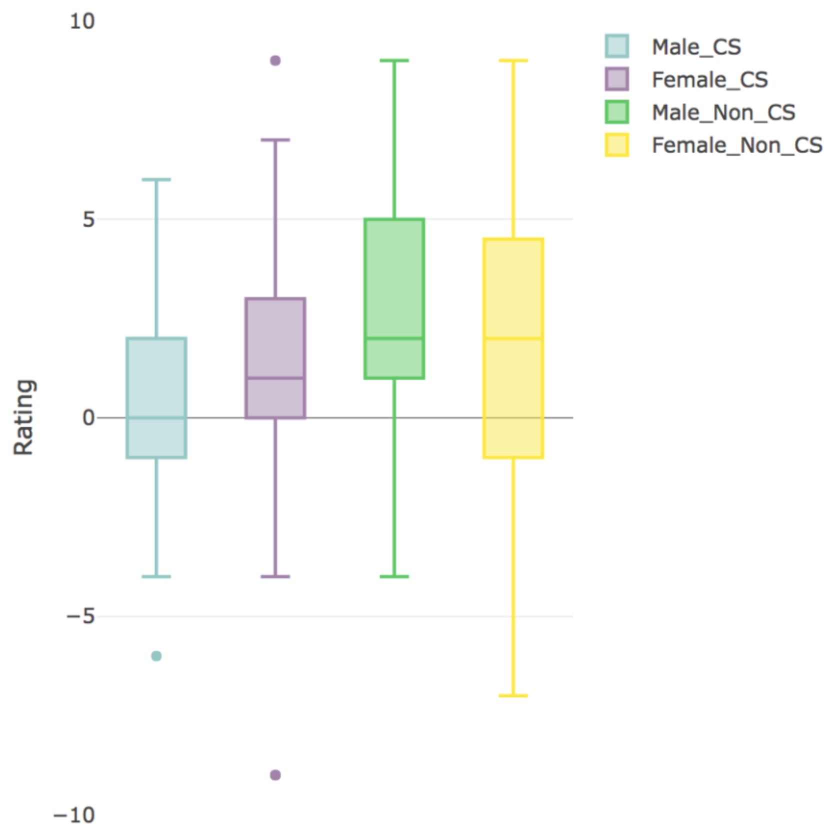

Figure 4 Overall Difference Box Plot

As shown in Figure 4 and Table 8, male CS majors consider themselves significantly more similar to a typical computer scientist relative to other majors of both genders. Female CS is significantly different than male other but not female other. Other majors of both genders are not significantly different from each other.

5.2 Sense of Belonging

Survey question Q8_1 asks participants to select their agreement to the statement "I feel like I belong in my CS classes."

The Kruskal Wallis tests for sense of belonging tested the following hypotheses:

$$H_0 = astudent'ssenseofbelonginginaCSclassisindependentofgenderandmajor$$
$$H_a = astudent'ssenseofbelonginginaCSclassisdependentongenderandmajor$$

The test returns a significant p-value which indicates the null hypothesis can be rejected.

Belonging
$1.47\boldsymbol{e} - 5$

Table 9 Sense of Belonging p-value

The Dunn's test produces the following CLD:

Category	*Letter*
Male CS	b
Female CS	a b
Male other	a
Female other	a

Table 10 Sense of Belonging CLD

The following box plot shows the agreement to the statement by category.

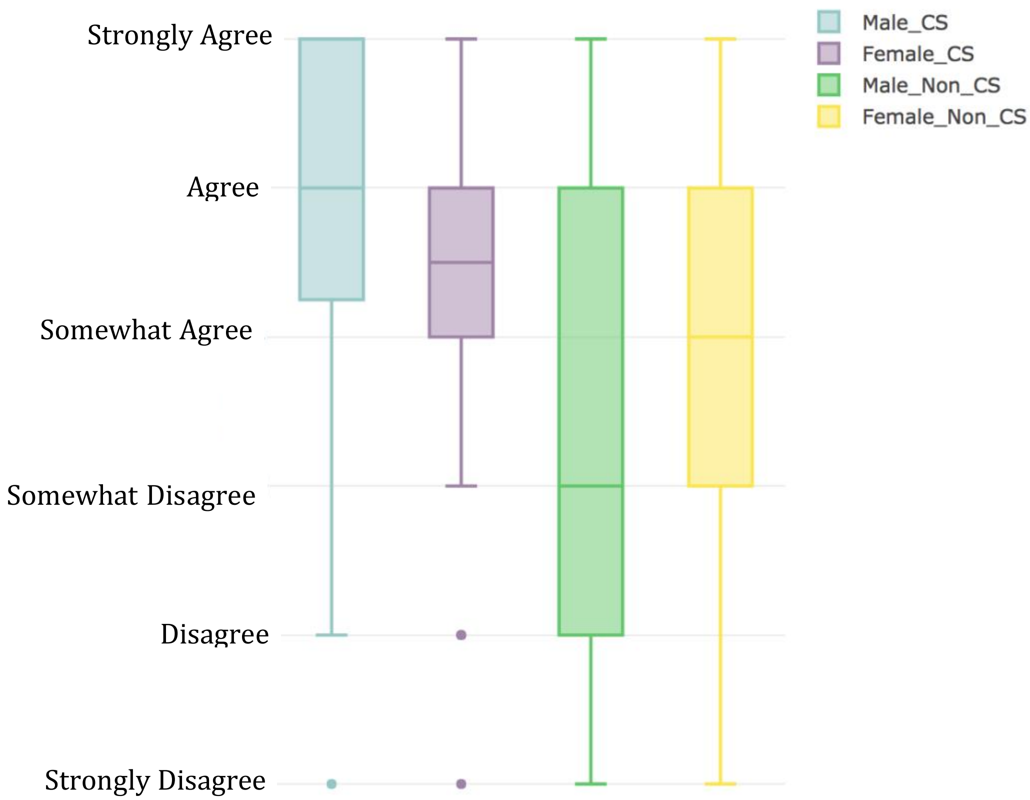

Figure 5 Sense of Belonging Box Plot

As shown in Figure 5 and Table 10, major is more indicative of sense of belonging than gender.

Male CS majors differ from other majors of both genders. However, female CS majors do not differ from any of the other categories. Approximately half of the male CS participants, *strongly agreed* with the statement.

The lowest agreement for Female CS participants, excluding outliers, was *somewhat disagree.* Male CS majors had a wider range of disagreement that included *somewhat disagree* and *disagree.*

Of students who do not study CS, 50% of males and 25% of females disagreed to some extent – *somewhat disagreed, disagreed,* or *strongly disagreed* – with the statement.

On average, male CS students feel a stronger sense of belonging in CS classes than their female CS peers.

5.3 First CS Class Experience

Survey question Q10_4 asks participants to select their agreement to the statement "I consider my first CS class to be an overall positive experience." The Kruskal Wallis tests for first CS class experience tested the following hypotheses:

$$H_0 = a student's experience in his or her first CS \\ class is independent of gender and major$$

$$H_a = a student's experience in her or her first CS \\ class is dependent on gender and major$$

The test returns a significant p-value which indicates the null hypothesis can be rejected.

First CS Class Experience
$2.14\boldsymbol{e} - 4$

Table 11 First CS Class Experience p-value

The Dunn's test produces the following CLD:

Category	*Letter*
Male CS	b
Female CS	a b
Male other	a
Female other	a

Table 12 First CS Class Experience CLD

The following box plot shows the agreement to the statement by category.

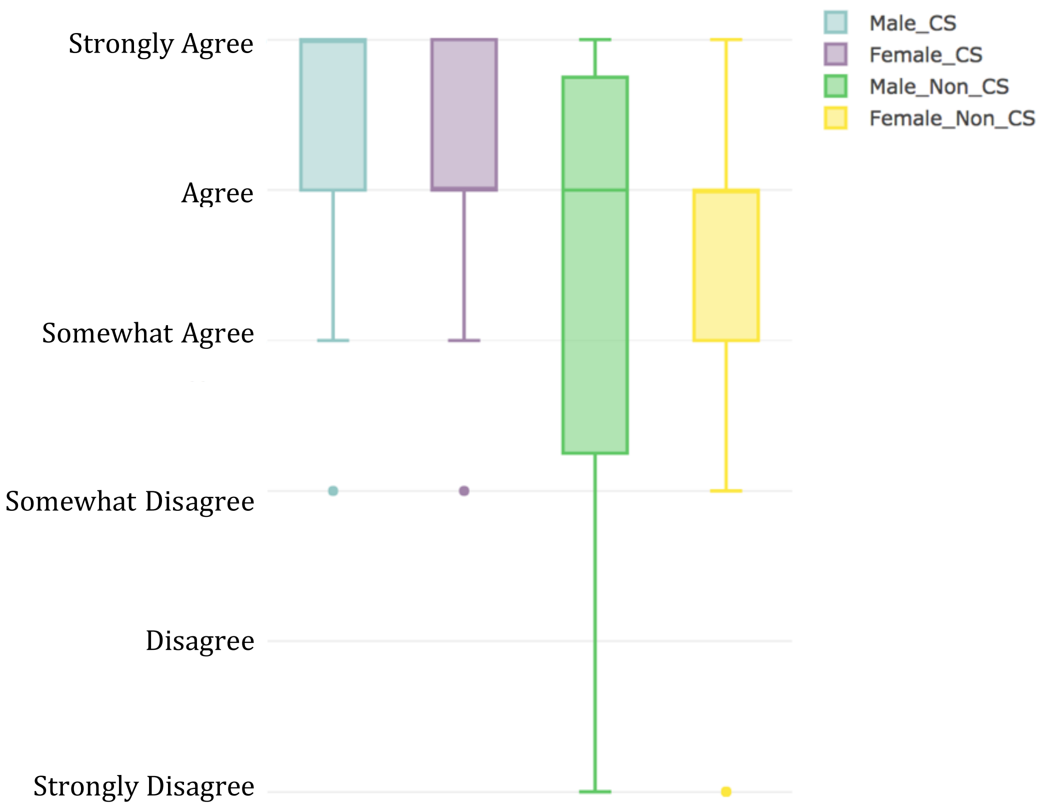

Figure 6 First CS Class Experience Box Plot

As shown in Figure 6 and Table 12, major is more indicative of first CS class experience than gender.

No female or male CS majors *strongly disagreed* or *disagreed* with the statement. More than half of male CS majors *strongly agreed* with the statement.

Of participants who do not study CS, male students have responses that range the entire scale, while female students, excluding outliers, range from *somewhat disagree* to *strongly agree.*

6 Supplementary Shared Experiences

Participants were asked to share any additional experiences regarding CS at UMW – 32 out of 150 participants responded. Selected responses[3] are categorized into five main categories:

1. Comment About Professors
2. Previous Knowledge of CS
3. Gender Gap
4. Neutral
5. Helpful or Rewarding

6.1 Comments About Professors

Of all 32 responses, 13 (approximately 40%) commented on their professor(s) – 8 positive comments, 5 negative comments.

A female psychology student commented that her professor, "is what made [her CS class] a more positive experience." Another female student, a communications and digital studies major (DGST), after expressing that her CPSC 220 class was not a positive experience said, "All that being said, I don't blame the professors. They were very willing and able to answer questions, and were very welcoming to me, the problem was much more social."

A male marketing major said, "The teacher is the reason I have no more interest in the class." Another female communication and DGST major responded, "The way my teacher teaches does not help me."

6.2 Previous Knowledge

Of all 32 responses, six (approximately 19%) mentioned previous experience in CS. Participants commonly expressed that professors assumed they had programming experience prior to their first CS class. A male math major wrote, "It looked like an alien language and I wasn't very good at it. My teacher expected us to be already very familiar with code." A female geography student commented, "Professors keep assuming I know things within computer science that I do not."

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[3] Categories were originally identified by Mikaela Goldrich and agreed upon with Dr. Jessica Zeitz, Dr. Stephen Davies, and Dr. Ron Zacharski

One participant, a female CS student, commented on experiences in CS before college: "I feel that the programming classes I took in high school helped me gain interest in CS and succeed in my first CS college courses."

6.3 Gender Gap

Of all 32 responses, four (approximately 13%) directly commented on the gender gap. A male CS student said, "There are also a lot of arrogant males within CS classes. The females seem to be undervalued by them due to their gender." Another male student who has not declared his major shared, "As a male, I haven't thought about the gender gap in the classroom." These two responses show opposite extremes in awareness of the gender gap.

A female CS major pointed out that she was the only female in her CS class and said, "I feel like I stick out." This comment described a phenomenon called imposter syndrome. Imposter syndrome is common in academically and professionally high-achieving women: it is the feeling of being a fraud or inadequate despite being equally qualified [9].

Another female student commented, "… [my experience in CPSC 220] made me nervous enough about my abilities as a coder that I didn't think I should pursue a CS major… The classroom environment and class make up needs to change. More women, more diversity, and allowing kids to skip to a class level that challenges them when they obviously already know how to code." This student is a communication and DGST major and expressed that she has had great success coding in her DGST classes.

6.4 Neutral Responses

Of all 32 responses, three females (approximately 9%) indicated that they either did not have time in their scheduled or preferred something else. One is a mathematics and international affairs major who said, "It was interesting, but I didn't love it enough to major in it, and my double major didn't let me take very many classes outside of my requirements." Another is a business administration major who commented, "I was thinking of making it my minor, but I didn't plan that with enough time left in my college career." Lastly, a psychology major commented, "I didn't continue pursuing computer science was because I wasn't doing as well as I was expecting and because I had more click with psychology and business (minor)." There were not any male students who expressed a neutral response similar to the three stated above.

6.5 Helpful & Rewarding

Of all 32 responses, three (approximately 9%) expressed that their CS experiences are helpful or rewarding to them. A female CS student commented, "The experience has been overall rough but rewarding."

A male accounting major responded, "Learned a lot and use the knowledge every day at my current job." A male math major expressed, "My internship over the summer requires basic knowledge of code in Java so I feel more confident than before I took any CS class." Interestingly, this is the same student who compared code to "an alien language." These responses show that even students who do not decide to major in CS can benefit from taking CS classes.

7 Discussion

My study aimed to discover areas in which undergraduate students are being attracted to or deterred from majoring in CS.

To answer (RQ1), all students perceive a typical computer scientist the same way with no statistical difference between any groups. This shows that the stereotype of a computer scientist does not change by major or gender.

To answer (RQ2), female students who do not study computer science consider themselves, on average, more outgoing and social than they perceive a typical computer scientist. On average, male computer science majors consider themselves the same as a typical computer scientist. Thus, in combination with the majority of CS students being male, this data implies that similarity in self-perception and perception of CS encourages students to study CS.

To answer (RQ3), male CS students feel a stronger sense of belonging than their female CS peers. The students who do not study CS, do not indicate a difference in sense of belonging.

To answer (RQ4), on average, a student's rating of their first CS class is correlated to their decision to study or not to study CS. On average, students who do not major in CS disagree to some extent more frequently.

8 Future Work

In retrospect, there are a few changes I would make on my survey. In order to gauge belonging of CS majors before they declared, I would ask the question as *My CPSC 110 self felt comfortable in CPSC 110*. My survey did not make a clear distinction between a student's current sense of belonging and their previous sense of belonging. I would also ask participants for their comfort with programming before they took CPSC 110. There are surprising differences between male and female students who do not study CS.

9 Conclusions

In this paper, I focused on four groups of students at UMW: male CS majors, female CS majors, males with other majors and females with other majors. The trends in responses per group were fairly consistent with previous research. There were strong similarities in students who do not study CS as well as females regardless of major. In accordance with other research, gender and majors are correlated for the CS students. Based on this research, UMW student's perception of a typical computer scientist is statistically insignificant to their choice in major. However, self-perception and the difference between perceptions is significant.

Almost half of male and female students who do not major in CS felt that, to some extent, they did not belong in their CS classes.

Male students who do not study CS also had a considerably different distribution of responses to *I consider my first CS class to be an overall positive experience;* They are the only category with *disagree* responses. Male and female students who do not study CS are the only two categories that have rating of *strongly disagree* and males chose it more often than females.

This research gives hope that when a student becomes an undergraduate, it is not too late for universities to help merge the gap. The relatively small quantity of negative responses for student's first CS class implies that there is a chance to spark or maintain a student's interest. However, the statistical significance between males and females in CS cannot be truly quantified with a sample of UMW undergraduates.

10 Acknowledgments

There are three people who were key in this project as well as my time at UMW.

> Dr. Jessica Zeitz, my thesis advisor and mentor, has been a constant source of support and encouragement. You inspire me with your passion for your students and the subject of this thesis. Although not discussed in this thesis, role models are commonly cited as a way to mend the gender gap. To me, you are the epitome of a female role model both personally and professionally.
>
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>
> Dr. Ron Zacharski, who I have had the privilege to lab aide for over the last two years. Your ability to come up with interesting ways to teach basic CS concepts like for loops and arrays is truly a gift. I hope that if I ever get around to teaching an introduction to CS course in the future, that my students will laugh and enjoy it as much as yours.

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Appendix A – Survey

Section 1: Introduction

My name is Mikaela Goldrich, and I am an undergraduate at the University of Mary Washington. I am inviting you to participate in a research study for my honors thesis under the supervision of Dr. Jessica Zeitz from the University of Mary Washington Department of Computer Science. Involvement in the study is voluntary, so you may choose to participate or not. I am interested in learning more about factors that influence undergraduate students to major in computer science. I am looking for undergraduate students who have taken or are currently taking at least one computer science course at UMW. You will be asked to complete a series of survey questions. This will take approximately 10 minutes of your time. All of your responses will remain anonymous; this means that we have no way of connecting any of what you say to who you are. If any of the questions make you feel uncomfortable, you may end your participation in the study at any time. The benefit of this research is that you will be helping us to understand the factors that encourage or discourage students to study computer science. We do not anticipate that you will encounter any lasting negative consequences as a result of your participation in this study. If you do not wish to continue, you have the right to withdraw from the study, without penalty, at any time. If you have any questions or concerns, please contact Mikaela Goldrich at mgoldric@mail.umw.edu. This study has been approved by the institutional review board of the University of Mary Washington. Questions or concerns can be addressed to me, or my faculty sponsor (Dr. Zeitz jzeitz@umw.edu) as well as the chair of the Institutional Review Board (Dr. Jo Tyler jtyler@umw.edu). By clicking the link to continue, you are stating that (1) all of your questions and concerns about this study have been addressed, (2) you choose, voluntarily, to participate in this research project and (3) that you are at least 18 years of age.

Section 2: Major & Minor Information

Q1_1: What is your major? Please check all that apply. (If you know which major you will declare but have not officially done so, please select what it will be)

- Accounting (1)
- ....
- Women's and Gender Studies (38)
- Undecided (39)

Q2: Are you minoring in any of the following?

- ○ Computer Science (1)
- ○ Data Science (2)
- ○ Cyber Security (3)
- ○ None of the above (4)

Section 3: Self-perception and perception of CS

For the following questions, please choose the number that best represents your response.

Q3: In my opinion, a typical computer scientist is...

		1	2	3	4	5	6	7	8	9	10	
Q3_1	Masculine	o	o	o	o	o	o	o	o	o	o	Feminine
Q3_2	An expert with computers	o	o	o	o	o	o	o	o	o	o	A person with broad interests
Q3_3	Antisocial	o	o	o	o	o	o	o	o	o	o	Social Butterfly
Q3_4	Shy	o	o	o	o	o	o	o	o	o	o	Outgoing
Q3_5	A man	o	o	o	o	o	o	o	o	o	o	A woman

Q4: I consider myself to be...

		1	2	3	4	5	6	7	8	9	10	
Q4_1	Masculine	o	o	o	o	o	o	o	o	o	o	Feminine
Q4_2	An expert with computers	o	o	o	o	o	o	o	o	o	o	A person with broad interests
Q4_3	Antisocial	o	o	o	o	o	o	o	o	o	o	Social Butterfly
Q4_4	Shy	o	o	o	o	o	o	o	o	o	o	Outgoing
Q4_5	A man	o	o	o	o	o	o	o	o	o	o	A woman

Section 4: Belonging

Q_5: In my CS class, I feel/felt confident...

		Not confident									Very confident
		1	2	3	4	5	6	7	8	9	10
Q5_1	That I will do well in the class overall	——————————|———————————									
Q5_2	Asking questions in class	——————————|———————————									
Q5_3	When the professor calls on me, even if I did not raise my hand	——————————|———————————									

Q6: In my favorite class, I feel confident...

		Not confident									Very confident
		1	2	3	4	5	6	7	8	9	10

Q6_1	That I will do well in the class overall	——————————|—————————— —
Q6_2	Asking questions in class	——————————|—————————— —
Q6_3	When the professor calls on me, even if I did not raise my hand	——————————|—————————— —

Q7: Please answer the following questions.

		Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Somewhat Agree (4)	Agree (5)	Strongly agree (6)
Q7_1	Speaking in any of my classes makes me anxious	o	o	o	o	o	o
Q7_2	I intend to go into a CS related field after college	o	o	o	o	o	o

Q8: Please respond according to your experiences in CS classes in general.

		Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Somewhat Agree (4)	Agree (5)	Strongly agree (6)
Q8_1	I feel like I belong in class.	o	o	o	o	o	o
Q8_2	I often go to office hours to get help because I do not feel comfortable asking questions in class.	o	o	o	o	o	o
Q8_3	I often have questions but do not ask them.	o	o	o	o	o	o
Q8_4	Class moves too quickly for me to understand all the material.	o	o	o	o	o	o

Section 5: First CS Class

Q9: Roughly how many students of your same gender were in your first CS class at UMW?

- ○ 1
- ○ 2
- ○ 3
- ○ ...
- ○ 21+

Q10: Please respond according to your experience in your first CS class.

		Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Somewhat Agree (4)	Agree (5)	Strongly agree (6)
Q10_1	I registered for the class to satisfy a general education requirement.	o	o	o	o	o	o
Q10_2	I registered for the class because I was interested in the subject.	o	o	o	o	o	o
Q10_3	I often have questions but do not ask them.	o	o	o	o	o	o
Q10_4	I consider the class to be a positive experience overall.	o	o	o	o	o	o
Q10_5	If I didn't know people in my class I would have dropped it.	o	o	o	o	o	o
Q10_6	I knew people that had registered for the class, so I decided to try it with them.	o	o	o	o	o	o

Section 6: Group Work

Q11: Please answer the following questions in regard to group work in your CS class

		Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Somewhat Agree (4)	Agree (5)	Strongly agree (6)
Q11_1	I am/was typically the only group member of my gender.	o	o	o	o	o	o
Q11_2	I have felt my opinion or work was undervalued.	o	o	o	o	o	o
Q11_3	I have felt that other members doubted my ability without reason.	o	o	o	o	o	o
Q11_4	I prefer to work with a group or a partner on assignments.	o	o	o	o	o	o
Q11_5	Working out problems with classmates helps me understand the material.	o	o	o	o	o	o
Q11_6	I have felt that other members doubted my ability without reason.	o	o	o	o	o	o

Section 7: Mentors

Q12: Please answer the following questions.

		Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Somewhat Agree (4)	Agree (5)	Strongly agree (6)
Q12_1	One of my parents/guardians working in STEM made me more interested in CS.	o	o	o	o	o	o
Q12_2	One of my siblings being interested in STEM made me more interested in CS.	o	o	o	o	o	o

Q13: In my major, I found a mentor(s).

- ○ Yes (1)
- ○ No (2)

Q14: Please answer the following questions.

		Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Somewhat Agree (4)	Agree (5)	Strongly agree (6)
Q14_1	I feel comfortable with my mentor(s) that share(s) my gender.	o	o	o	o	o	o
Q14_2	I feel comfortable with my mentor(s) that do not share(s) my gender.	o	o	o	o	o	o
Q14_3	The gender of my mentor(s) does not affect my comfort.	o	o	o	o	o	o

Q15: Please share any other information regarding your experiences in CS.

____

Section 8: Gender & Enrollment

Q16: What is your birth gender?

- ○ Male
- ○ Female
- ○ Other ______________________________________

Q17: What gender do you identify with?

- ○ Male
- ○ Female
- ○ Other ______________________________________

Q18: How old are you? _______

Q19: When was your first semester at UMW?

○ Fall 2012	○ Spring 2013
○ Fall 2013	○ Spring 2014
○ ….	○ Spring2018

Q20_1: Did you take or are you currently taking CPSC 110?

- ○ Yes
- ○ No

Q20_2: What semester?

○ Fall 2012	○ Spring 2013
○ Fall 2013	○ Spring 2014
○ ….	○ Spring2018

Q21_1: Did you take or are you currently taking CPSC 220?

- Yes
- No

Q21_2 What semester?

○ Fall 2012	○ Spring 2013
○ Fall 2013	○ Spring 2014
○	○ Spring2018

Section 9: Conclusion

Thank you for taking the time to complete this survey!
As a reminder, all of the data you provided is anonymous. No one, myself included, can link your responses back to you. If you have any questions or would like to know the results of our study, please contact Mikaela Goldrich (mgoldric@mail.umw.edu).

If you have any concerns about your participation in this study, you can also contact my faculty advisor, Dr. Jessica Zeitz (jzeitz@umw.edu) or the chair of the Institutional Review Board, Dr. Jo Tyler (jtyler.umw.edu).
If you would like more information about factors that influence the gender gap, please see:

Wang, Jennifer, et al. "Gender Differences in Factors Influencing Pursuit of Computer Science and R elated Fields." Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education - ITiCSE '15, 2015, https://static.googleusercontent.com/media/research.google.com/en/pubs/archive/43820.pdf

Thank you again for your participation.
Q22: Do you still wish to have your data included in this study?

- Yes
- No