Confidence in Computing: A Career Preparatory Course for Undergraduate Students

A Technical Report
presented to the faculty of the
School of Engineering and Applied Science
University of Virginia

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Abstract

What are the effects of a career preparatory course on increasing the self-efficacy and career expectations of computer science students who, prior to undergraduate studies, have relatively low self-confidence, social support, and computing experience?

Research from the undergraduate course offered for the University of Virginia (UVA) and UVA's College at Wise in the Fall of 2020 and Spring of 2021 called *Tools of the Trade* hopes to answer questions revolving around gender, race, and computing background. The course content is designed for students early in their computing studies with less exposure to industry experience or computing role models in their lives. With the financial assistance from a grant front the State Council of Higher Education for Virginia (SCHEV) and coordination from Tom Horton and Jacob Somervell, the Computer Science Associate Department Chair from UVA and Department Chair from UVA Wise respectively, this asynchronous one-credit class is taught by undergraduate students from both schools. Research conducted by Mara Hart, Jonathan Gordon, and Andrew Ni measures the self-efficacy of students before and after completion of the course curriculum.

1 Course Structure

The goal was to measure student improvement throughout the semester in terms of professional development and self-confidence. One constraint of this course is that it was an asynchronous, online class due to the COVID-19 pandemic and may have resulted in disengagement. It was also only a 1-credit course which means that we could only expect 3 hours/week dedicated to this course which forces the teaching staff to limit depth into the introduced topics. For Fall 2020, we administered a survey at the end of the course, asking

students what effect they believe the course had on different aspects of confidence in computing. For Spring 2021, a survey was administered in the middle of the course to ask students how they feel in terms of confidence and re-administered that same survey at the end of the course and used unique, anonymous identifiers to relate the two datasets.

The course itself was taught with two different methods. The Fall semester featured weekly topics that were chosen to enhance the clarity of CS tools in the workforce. With each topic, there was an accompanying YouTube video(s), ranging from 15 minutes to 45 minutes total, as well as a weekly assignment which students were given a week and a half to complete unless there were extenuating circumstances. These assignments were typically guided with a demo video that walked through a similar problem. For each of these weekly assignments, students were only required to earn a Satisfactory in 8 assignments out of 12 to pass the course. For each assignment, a student could earn a Satisfactory (correct and completed work), Unsatisfactory (attempted work, but either not fully completed or correct), or Incomplete (no work attempted). Outside of these weekly assignments, students were expected to create three professional development activities that involved attending workshops, participating in practice interviews, attending hackathons, or more.

The Spring semester structure was changed to a 3-module styled class. There were 11 assignments, split into 4, 3, 4 for each module. Instead of weekly released content, materials were released in modules, expected to be done a month apart. The professional development activities were then changed into a points system where a student had to earn 8 points with varying activities ranging from 1 to 3 points. For example, a 3 point activity included attending a hackathon while a 1 point activity was updating their Handshake profile. A study by Kapoor and Gardner-McCune (2019) provides insight on how undergraduate students can develop their

"professional identity" through "reflection on their career goals" and "engagement in professional development."

This class was also created with the intention of packaging up the material to distribute across different universities or organizations. All course materials, such as course notes, slides, and assignments, were migrated to GitHub to ensure an open-source environment that allows for transparency and seamless updates, with the goal that students of all backgrounds can learn valuable industry skills and improve their self-efficacy in computer science.

2 Review of Research

The main responsibility of the research team was to monitor and assess the self-efficacy of enrolled students throughout the semester, using surveys. Using Qualtrics, a data collection and analysis software tool, the team designed and released survey questions that could gauge students' self-confidence and anonymously track their responses. Questions from the 2019 Data Buddies survey and personal identifiers (eg. gender, race/ethnicity, etc.) were made consistent among all surveys to keep records standardized in the analysis. To retain the anonymity of student survey responses, each participant was assigned a unique key identifier that they used to answer the Qualtrics survey forms during and after course completion.

The majority of the questions on the surveys came from the Data Buddies department report, a yearly survey of computing students across over one hundred PhD-awarding institutions (CRA, 2019). Questions from the Data Buddies survey include questions on background in computing, academic confidence, and technical self-identification. We felt that these questions were most relevant to our goal of assessing the self-efficacy of students as the course progressed. As there was interest in the effects of the course by race, gender, and prior computing

experience, responses were grouped by each of these categories and individual analysis was performed on each one, in addition to an analysis of the general trend of student responses over time.

The success of the project lies in the data collected from students throughout the course. Interpretation of survey responses from both Fall 2020 and Spring 2021 students shed light on the issue of self-efficacy in computing undergraduate students with the help of pivot tables. Exporting results into Google Sheets, the team used Google Sheets' pivot-table tool to aggregate and organize survey results for analysis.

One of the goals of this project was to determine the effects of the course on women and students with low prior computing experience, specifically. There is a wealth of research discussing how these two groups relate and why they may have lower scores in areas of confidence and self-efficacy. Alshahrani et al. (2018) found that discrepancies between men and women choosing to study computing may be heavily influenced by a lack of prior experience, social support, self-efficacy, or outcome expectations in women. They cite Taylor and Mounfield (1994), who found that prior experience in computing strongly correlates with female undergraduate success in a computer science major. Given the overwhelmingly male makeup of high school computing courses, women may simply not have enough exposure to the subject to choose it as a field of study (College Board, 2020). Lack of prior exposure may impact self-perception of computing skills and amplify feelings of low confidence and self-efficacy in women (He and Freeman, 2010). However, even when women performed equally to men in computing tasks, they indicated lower levels of confidence in self-assessments (Liberatore and Wagner, 2020). This is significant, as noted by Alshahrani et al. (2018), as "most people are attracted to, and pursue, tasks and fields in which they are confident."

Another goal for the research team was to analyze the effectiveness of the course on different ethnic groups. Dillon et al. recognized that African-Americans are one of the underrepresented groups in the field of computer science, citing that their representation in computing is not proportional to the U.S. population. Weng and Murphy (2018) attribute the CS diversity gap to imposter syndrome, when an individual does not recognize their achievement as an internal sense of success, and stereotype threat, when someone believes that they are conforming to stereotypes based on social groups, among other factors. The preexisting lack of racial diversity and misconceptions of the computing field have also dissuaded underrepresented minority groups from achieving or even pursuing a computing degree (Weng & Murphy, 2018). Sax et al. (2018) study the important role faculty in the computer science department have on feelings of belonging in racial and gender minority groups.

3 Fall 2020 Student Survey Analysis

The Tools of the Trade course taught in the Fall 2020 semester consisted of 30 students that were required to complete a Qualtrics survey at the end of the semester. The questions regarding computing-related feelings were followed by how the course influenced their answers with the following answer choices: Strongly Hindered, Hindered, No Effect, Strengthened, and Strongly Strengthened. Sections 3.1-3.3 explain survey results and analysis based on ethnicity, gender, and experience level.

3.1 Course Influence on Students of Varying Ethnic Backgrounds

Is race or ethnicity a factor in how the class affected students?

Before analyzing survey results associated with race and ethnicities, general guidelines regarding the categorization of races had to be agreed on to maintain consistency. Students were

categorized in agreement with the Integrated Postsecondary Education Data System (IPEDs). This meant Middle Eastern or North African students were categorized as White students and students self-identifying as two or more races were categorized as multiracial students. The following decisions yielded the spread in Table 3.1.1.

Race/Ethnicity	Count of Students
White	12
Asian	9
Hispanic or Latino	3
Black or African American	3
Multiracial	3
Grand Total	**30**

Table 3.1.1

Because our course focuses on students with minimal background in the technical field, we studied their prior experiences based on survey responses to group them into three categories: high, mid, and low or no experience. The questions used to deduce the following results revolved around having taken AP Computer Science courses, learned computer science languages, engaged in technical courses or workshops, and more. Section 3.3 dives further into students' prior experience and analysis of the course's influence on this data. As shown in Table 3.1.2, all of the Black or African American and multiracial students were categorized into the low or no experience category. Of the 7 students that had high experience levels, 5 of them were White. Over half of the students in every ethnic group were placed in the low or no experience group. Thus, the Fall 2020 class roster predominantly consisted of students with low or no experience except 5 White students.

Experience Level				
Race/Ethnicity	Low or No Experience	Mid Experience	High Experience	Grand Total
Asian	7	1	1	9
Black or African American	3	0	0	3
Hispanic or Latino	2	0	1	3
Multiracial	3	0	0	3
White	7	0	5	12
Grand Total	**22**	**1**	**7**	**30**

Table 3.1.2

Using the questions extracted from the 2019 Data Buddies survey referenced above, we focussed on identifying student self-perceptions and how the course influenced their feelings about their responses. Tables 3.1.3-3.1.15 display the spread of responses from the Fall 2020 class based on race/ethnicity.

When prompted the statements “I see myself as a computing person” and “I feel like I belong in computing”, all students that identified themselves as being multiracial agreed with this statement and stated that the course strengthened their feelings about these statements. None of the students disagreed or strongly disagreed with the statement. Black or African American students either agreed or strongly agreed with these statements and they all believed that the course strengthened their feelings on their initial response. More than half of the White students agreed or strongly agreed with these statements and were almost evenly split between believing that this course had no effect and believing that this course had strengthened their feelings. Survey results from Tables 3.1.3-3.1.6 reveal that White students were not as influenced by the course compared to other racial groups when asked questions about being a computing person and belonging in this category.

I see myself as a computing person						
Race/Ethnicity	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Asian	0	0	3	5	1	9
Black or African American	0	0	0	2	1	3
Hispanic or Latino	0	0	1	2	0	3
Multiracial	0	0	0	3	0	3
White	0	0	3	4	5	12
Grand Total	**0**	**0**	**7**	**16**	**7**	**30**

Table 3.1.3

I see myself as a computing person - Post Course Influence						
Race/Ethnicity	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Asian	0	0	2	7	0	9
Black or African American	0	0	0	3	0	3
Hispanic or Latino	0	0	0	3	0	3
Multiracial	0	0	0	3	0	3
White	0	1	6	5	0	12
Grand Total	**0**	**1**	**8**	**21**	**0**	**30**

Table 3.1.4

I feel like I belong in computing						
Race/Ethnicity	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Asian	0	1	3	4	1	9
Black or African American	0	0	0	2	1	3
Hispanic or Latino	0	0	1	2	0	3
Multiracial	0	0	0	3	0	3
White	0	0	5	5	2	12
Grand Total	**0**	**1**	**9**	**16**	**4**	**30**

Table 3.1.5

I feel like I belong in computing - Post Course Influence						
Race/Ethnicity	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Asian	0	0	3	6	0	9
Black or African American	0	0	0	3	0	3
Hispanic or Latino	0	0	1	2	0	3
Multiracial	0	0	1	2	0	3
White	0	0	6	6	0	12
Grand Total	**0**	**0**	**11**	**19**	**0**	**30**

Table 3.1.6

Responses to questions relating to being an outsider and feeling welcomed in computing with regards to race are shown in Tables 3.1.7-3.1.10. Out of the 6 students who believed they felt like an outsider, 4 of the students were White. However, 2 out of the 3 students who disagreed with this statement were also White. All students who identified as being Hispanic and multiracial did not agree with this statement. Referring to the course influence of being an outsider, more than half of all Asian, Black or African American, multiracial, and White students felt that this course did not affect their responses. None of the students felt that the course strongly influenced their outsider feelings. With regards to the statement of feeling welcomed in computing, most Asians and White students either agreed or strongly agreed with this statement and felt that this course strengthened their feelings about it. 2 out of 3 Black or African American and multiracial students felt welcomed in computing and all of those students felt that the course had strengthened their feelings about their response. The spread of responses from Tables 3.1.7-3.1.10 do not reveal an obvious pattern or allow us to draw specific conclusions based on student ethnic groups.

I feel like an outsider in computing						
Race/Ethnicity	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Asian	1	3	4	1	0	9
Black or African American	0	1	1	1	0	3
Hispanic or Latino	0	1	2	0	0	3
Multiracial	0	1	2	0	0	3
White	2	5	1	4	0	12
Grand Total	**3**	**11**	**10**	**6**	**0**	**30**

Table 3.1.7

I feel like an outsider in computing - Post Course Influence						
Race/Ethnicity	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Asian	0	3	5	1	0	9
Black or African American	0	0	3	0	0	3
Hispanic or Latino	0	2	1	0	0	3
Multiracial	0	1	2	0	0	3
White	0	2	9	1	0	12
Grand Total	**0**	**8**	**20**	**2**	**0**	**30**

Table 3.1.8

I feel welcomed in computing						
Race/Ethnicity	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Asian	0	0	1	7	1	9
Black or African American	0	0	1	2	0	3
Hispanic or Latino	0	0	3	0	0	3
Multiracial	0	0	1	2	0	3
White	0	0	4	6	2	12
Grand Total	**0**	**0**	**10**	**17**	**3**	**30**

Table 3.1.9

I feel welcomed in computing - Post Course Influence						
Race/Ethnicity	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Asian	0	0	0	8	1	9
Black or African American	0	0	0	3	0	3
Hispanic or Latino	0	0	2	1	0	3
Multiracial	0	0	0	3	0	3
White	0	0	2	9	1	12
Grand Total	**0**	**0**	**4**	**24**	**2**	**30**

Table 3.1.10

Regarding the statement "I do not have much in common with the other students in my computing classes", most students disagreed with this statement including 7 out of the 12 White students and 2 out of the 3 multiracial students. However, 3 out of the 9 Asian students and 1 student from the Black or African American and Hispanic or Latino categories either agreed or strongly agreed with this statement. Excluding multiracial students, over half of every ethnic group of students in the class believed that this course did not affect their response to this statement.

I do not have much in common with the other students in my computing classes						
Race/Ethnicity	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Asian	0	3	3	2	1	9
Black or African American	0	0	2	1	0	3
Hispanic or Latino	0	1	1	1	0	3
Multiracial	0	2	1	0	0	3
White	0	7	2	3	0	12
Grand Total	**0**	**13**	**9**	**7**	**1**	**30**

Table 3.1.11

I do not have much in common with the other students in my computing classes - Post Course Influence						
Race/Ethnicity	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Asian	0	2	4	3	0	9
Black or African American	0	1	2	0	0	3
Hispanic or Latino	0	0	3	0	0	3
Multiracial	0	1	1	1	0	3
White	1	1	9	1	0	12
Grand Total	**1**	**5**	**19**	**5**	**0**	**30**

Table 3.1.12

Tables 3.1.13-3.1.15 revolve around academic confidence with regards to race. Most students were confident in being able to learn a new programming language on their own with more than half of all Asian, Black or African American, multiracial, and White students either agreeing or strongly agreeing with the statement as shown in Table 3.1.13. However out of the 2 students that disagreed, one student was Asian and the other student was White. Referring to Table 3.1.14, most students also felt confident in introducing themselves to new peers and colleagues at professional meetings except for 2 students of Hispanic or Latino and White background who had doubts. When asked about their confidence in completing their computing degree, all students agreed with this statement, and over half of the White and Hispanic or Latino students strongly agreeing with it.

Please indicate how confident you are in the following statement: "I can quickly learn a new programming language on my own"						
Race/Ethnicity	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Asian	0	1	3	4	1	9
Black or African American	0	0	1	1	1	3
Hispanic or Latino	0	0	2	1	0	3
Multiracial	0	0	1	2	0	3
White	0	1	1	8	2	12
Grand Total	**0**	**2**	**8**	**16**	**4**	**30**

Table 3.1.13

Please indicate how confident you are in the following statement: "I can introduce myself to new peers/colleagues at professional meetings."						
Race/Ethnicity	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Asian	0	0	2	7	0	9
Black or African American	0	0	0	3	0	3
Hispanic or Latino	0	1	0	2	0	3
Multiracial	0	0	0	2	1	3
White	0	1	2	8	1	12
Grand Total	**0**	**2**	**4**	**22**	**2**	**30**

Table 3.1.14

Please indicate how confident you are in the following statement: "I can complete an undergraduate degree in computing."						
Race/Ethnicity	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Asian	0	0	0	6	3	9
Black or African American	0	0	0	2	1	3
Hispanic or Latino	0	0	0	1	2	3
Multiracial	0	0	0	2	1	3
White	0	0	0	5	7	12
Grand Total	**0**	**0**	**0**	**16**	**14**	**30**

Table 3.1.15

Given the spread of students by ethnic groups, finding trends from Tables 3.1.2-3.1.15 was quite difficult with Black or African American, Hispanic or Latino, and multiracial groups totaling 3 students each. However, while the number of students in each racial category was quite small, the most interesting results in the analysis from Tables 3.1.2-3.1.15 yielded the following observations:

- In terms of prior experience, over half of the students in every ethnic group were placed in the low or no experience group (Table 3.1.2).
- When asked questions relating to being a computing person and belonging in the field, White students had less of an influence from the course compared to other racial groups (Tables 3.1.3-3.1.6).

- Excluding multiracial students, over half of every ethnic group of students in the class believed that this course had no effect on their feelings about the statement: “I do not have much in common with the other students in my computing classes” (Tables 3.1.11-3.1.12).
- Every student felt confident about completing their undergraduate degree and over half of the White and Hispanic or Latino students felt strongly about it (Table 3.1.15).

3.2 Course Influence on Female vs. Male Students

At the end of Fall 2020 - the pilot of CS 1501, 30 students (12 female and 18 male) filled out a survey targeting their feelings regarding computing after the class as well as their perceived impact of the course on these feelings. These 6 questions largely focused on a self of belonging and confidence regarding the computing world.

First, they chose whether they strongly disagreed, disagreed, neither disagreed nor agreed, agreed, or strongly agreed with whether or not “[they] see [themselves] as a computing person.” By the end of the class, no students said they do not see themselves as a computing person, but 3 of 12 females and 4 of 18 males were neutral in regards to the statement. Seven of 12 females and 9 of 18 males, approximately half for both samples, agreed with this statement, whereas only 2 of 12 females and 5 of 18 males, a 10% increase in the male sample, strongly agreed with this statement. The number of male students (15 of 18) who felt the course influenced their self-perception was 10% higher than female students. For both males and females, about 25% (3 of 12 females, 5 of 18 males) believed that this class had no effect. One female believed this class hindered her self-perception whereas 8 of 12 females (66.67%) and 13 of 18 males (72.22%) believed this class strengthened their self-perception.

I see myself as a computing person						
Gender	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Female	0	0	3	7	2	12
Male	0	0	4	9	5	18
Grand Total	**0**	**0**	**7**	**16**	**7**	**30**

Table 3.2.1

I see myself as a computing person - Post Course Influence						
Gender	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Female	0	1	3	8	0	12
Male	0	0	5	13	0	18
Grand Total	**0**	**1**	**8**	**21**	**0**	**30**

Table 3.2.2

The second question we asked was "I feel like I belong in computing" done on the same scale as the previous question. Though 1 female student vs. no male students disagreed with the statement, 9 of 12 female students (75%) and 10 of 18 male students (55.56%) believed the course strengthened their sense of belonging, showing that in this aspect, more females had an increased positive self-perception due to this course.

I feel like I belong in computing						
Gender	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Female	0	1	4	6	1	12
Male	0	0	5	10	3	18
Grand Total	**0**	**1**	**9**	**16**	**4**	**30**

Table 3.2.3

I feel like I belong in computing - Post Course Influence						
Gender	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Female	0	0	3	9	0	12
Male	0	0	8	10	0	18
Grand Total	**0**	**0**	**11**	**19**	**0**	**30**

Table 3.2.4

Thirdly, we focused on "otherness" that students in the computing field may feel. By the end of the course, only 2 of 12 female students and 4 of 18 male students agreed with feeling like an outsider in computing, as well as only 2 of 18 male students feeling like the course had strengthened this "otherness" feeling.

I feel like an outsider in computing						
Gender	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agreed	Grand Total
Female	0	5	5	2	0	12
Male	3	6	5	4	0	18
Grand Total	**3**	**11**	**10**	**6**	**0**	**30**

Table 3.2.5

I feel like an outsider in computing - Post Course Influence						
Gender	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Female	0	5	7	0	0	12
Male	0	3	13	2	0	18
Grand Total	**0**	**8**	**20**	**2**	**0**	**30**

Table 3.2.6

The fourth question looked into how much students identified with computing as a part of who they were. 5 of 12 female students answered that they either disagreed or strongly disagreed that computing is a big part of who they are, whereas only 4 of 18 male students disagreed, none strongly disagreeing. After taking the course, it was found that most students (10 of 12 female

and 11 of 18 male students) self-reported no effect from the course as well as one male student felt that the course hindered this feeling.

Computing is a big part of who I am						
Gender	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Female	1	4	5	2	0	12
Male	0	4	9	4	1	18
Grand Total	**1**	**8**	**14**	**6**	**1**	**30**

Table 3.2.7

Computing is a big part of who I am - Post Course Influence						
Gender	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Female	0	0	10	2	0	12
Male	0	2	11	5	0	18
Grand Total	**0**	**2**	**21**	**7**	**0**	**30**

Table 3.2.8

The fifth question focuses on the feeling of welcomeness in the computing field. No students disagreed with the statement “I feel welcomed in computing.” With 8 of 12 female students (75%) and 12 of 18 male students (66.67%), the feeling at the end of the course appears to be consistent across gender. This is the same for the course influence on this statement as 11 of 12 female students felt this course strengthened or strongly strengthened this feeling as well as 15 of 18 male students.

I feel welcomed in computing						
Gender	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Female	0	0	4	7	1	12
Male	0	0	6	10	2	18
Grand Total	**0**	**0**	**10**	**17**	**3**	**30**

Table 3.2.9

I feel welcomed in computing - Post Course Influence						
Gender	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Female	0	0	1	9	2	12
Male	0	0	3	15	0	18
Grand Total	**0**	**0**	**4**	**24**	**2**	**30**

Table 3.2.10

Lastly, we asked whether or not students believed they had much in common with other students in their computing class. 6 of 12 female students and 7 of 18 male students disagreed with the statement "I do not have much in common with the other students in my computing classes." While 2 of 12 female students and 5 of 18 male students agreed and 1 of 18 male students strongly agreed with this statement, 4 of 12 female students and 5 of 18 male students neither agreed nor disagreed. A majority of the students, 6 of 12 female students and 13 of 18 male students, believed this course did not affect their perception of common traits or interests. Five of 12 females and 1 of 18 males believed this course either hindered or strongly hindered this connection to the above statement while 1 of 12 females and 4 of 18 males believed it strengthened this feeling. To clarify, hindering this feeling implies that this course has reduced the student's feeling of "otherness."

I do not have much in common with the other students in my computing classes						
Gender	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
Female	0	6	4	2	0	12
Male	0	7	5	5	1	18
Grand Total	**0**	**13**	**9**	**7**	**1**	**30**

Table 3.2.11

I do not have much in common with the other students in my computing classes - Post Course Influence						
Gender	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
Female	1	4	6	1	0	12
Male	0	1	13	4	0	18
Grand Total	**1**	**5**	**19**	**5**	**0**	**30**

Table 3.2.12

While the number of students in our sample size was limited, when analyzing the self-perceived effect of this class, it was found that female students are more likely to be positively influenced by this course. In the case of a sense of belonging, female students are more likely to feel like they do not belong in the world of computing. Across the board, the percentage of positive impact on female students is always greater than the percentage of positive impact on male students with the exception of seeing themselves as a computing person. The most interesting results from this analysis were the following:

- In Table 3.2.2 (I see myself as a computing person - Post Course Influence), 75% of female students vs 72.22% of male students felt the course had strengthened or strongly strengthened this feeling.
- In Table 3.2.4 (I feel like I belong in computing - Post Course Influence), 75% of female students vs 55.56% of male students felt the course had strengthened or strongly strengthened this feeling.
- In Table 3.2.6 (I feel like an outsider in computing - Post Course Influence), 41.67% of female students vs 16.67% of male students felt the course had reduced or strongly reduced this feeling, meaning that they felt less of an outsider.
- In Table 3.2.8 (Computing is a big part of who I am - Post Course Influence), 16.67% of female students vs 27.78% of male students felt the course had strengthened or strongly strengthened this feeling.

- In Table 3.2.10 (I feel welcomed in computing - Post Course Influence), 91.67% of female students vs. 66.67% of male students felt the course had strengthened or strongly strengthened this feeling.
- In Table 3.2.12 (I do not have much in common with the other students in my computing classes - Post Course Influence), 41.67% of female students vs. .056% of male students felt the course had reduced or strongly reduced this feeling.

3.3 Course Influence by Prior Experience

One of our research questions was how this course would affect students from different levels of prior computing experience. To evaluate the effects of the course on students from all experience levels, we split up students into categories of "low or no experience," "mid experience," and "high experience." Sorting into categories was performed via a point system based on prior exposure to computing, such as taking AP Computer Science in high school or independently learning a programming language. Since enrollment in the course was prioritized based on low levels of experience/self-efficacy, most students fell in the "low or no experience" category. The overall makeup of the course was 22 students with "low or no experience," 1 student with "mid experience," and 7 students with "high experience."

Data from the Fall 2020 survey shows that the course had a net positive impact on students from all levels of prior computing experience. Before the course, most students agreed with the statement "I see myself as a computing person" (Table 3.3.1). A majority also expressed feelings of belonging and being welcome in computing, with about a third of students saying they neither agreed nor disagreed with these statements (Tables 3.3.2, 3.3.3). After taking Tools of the Trade, 70 percent of students (21 of 30) reported the course as strengthening their identity

as “computing persons” (Table 3.3.4). Moreover, 63 percent of students (19 of 30) reported increased feelings of belonging in computing, and over 86 percent (26 of 30) said that the course made them feel more welcome in the field (Tables 3.3.5, 3.3.6). The course had more of an effect on students from a lower experience background, as shown by higher proportions for these measures among that group.

I see myself as a computing person						
Experience Level	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
High Experience	0	0	3	2	2	7
Low or No Experience	0	0	4	13	5	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**0**	**7**	**16**	**7**	**30**

Table 3.3.1

I see myself as a computing person - Post Course Influence						
Experience Level	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
High Experience	0	0	3	4	0	7
Low or No Experience	0	1	5	16	0	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**1**	**8**	**21**	**0**	**30**

Table 3.3.4

I feel like I belong in computing						
Experience Level	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
High Experience	0	0	3	3	1	7
Low or No Experience	0	1	6	12	3	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**1**	**9**	**16**	**4**	**30**

Table 3.3.2

I feel like I belong in computing - Post Course Influence						
Experience Level	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
High Experience	0	0	4	3	0	7
Low or No Experience	0	0	7	15	0	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**0**	**11**	**19**	**0**	**30**

Table 3.3.5

I feel welcomed in computing						
Experience Level	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
High Experience	0	0	3	3	1	7
Low or No Experience	0	0	7	13	2	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**0**	**10**	**17**	**3**	**30**

Table 3.3.3

I feel welcomed in computing - Post Course Influence						
Experience Level	Strongly Hindered	Hindered	No Effect	Strengthened	Strongly Strengthened	Grand Total
High Experience	0	0	2	5	0	7
Low or No Experience	0	0	2	18	2	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**0**	**4**	**24**	**2**	**30**

Table 3.3.6

A majority of students also expressed high outcome expectations and confidence in their computing skills, though these results were more pronounced in students from higher experience backgrounds. Nearly all students agreed with the statements “I can pass my computing courses,” “I can learn the foundations and concepts of computing,” “I can find employment in an area of computing interest,” and “I can complete an undergraduate degree in computing.” However, while 5 out of 7 students from high experience backgrounds agreed with the statement “I can do well in a computing-related contest,” students from low experience backgrounds did not agree

with the statement by a 2-to-1 margin (Table 3.3.7). Low experience students also displayed some doubt about quickly learning a programming language on their own when compared to high experience students (Table 3.3.8). While most students gave positive responses about finding a job in the computing industry, they were less likely to see themselves as capable researchers or presenters (Tables 3.3.9, 3.3.10). It is important to note that unlike the questions in Tables 3.3.1-3.3.6, these questions did not ask respondents to give both a pre and post score, so responses to these questions only indicate students' feelings at the end of the course.

Please indicate how confident you are in the following statements "I can....": - do well in a computing-related contest (e.g., programming contest, robotics contest, hackathon)						
Experience Level	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
High Experience	0	1	1	5	0	7
Low or No Experience	0	7	7	7	1	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**8**	**8**	**13**	**1**	**30**

Table 3.3.7

Please indicate how confident you are in the following statements "I can....": - quickly learn a new programming language on my own						
Experience Level	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
High Experience	0	1	1	3	2	7
Low or No Experience	0	1	7	13	1	22
Mid Experience	0	0	0	0	1	1
Grand Total	**0**	**2**	**8**	**16**	**4**	**30**

Table 3.3.8

Please indicate how confident you are in the following statements "I can....": - find employment in an area of computing interest						
Experience Level	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
High Experience	0	0	0	5	2	7
Low or No Experience	0	1	2	16	3	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**1**	**2**	**22**	**5**	**30**

Table 3.3.9

Please indicate how confident you are in the following statements "I can....": - be a capable researcher in computing						
Experience Level	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Grand Total
High Experience	0	0	4	3	0	7
Low or No Experience	0	3	9	9	1	22
Mid Experience	0	0	0	1	0	1
Grand Total	**0**	**3**	**13**	**13**	**1**	**30**

Table 3.3.10

The above results show that the Tools of the Trade course was effective in increasing students' feelings of belonging within computing, as well as bettering their outcome expectations and self-efficacy, all important indicators of academic persistence in a field. The effect on students' sense of belonging was especially pronounced in students with lower experience levels, while higher experience students showed greater overall confidence in their skills. Nearly all students reported having high outcome expectations regarding working in the computing industry, though fewer students had assurance in their ability to perform research. Whether the course's focus on industry tools and practices had any influence on this result is unclear.

4 Spring 2021 Student Survey Analysis

The Tools of the Trade course taught in the Spring 2021 semester consisted of 19 students that were required to complete 2 Qualtrics surveys, one released about a month into the semester and another at the end of the semester. Contrary to the Fall 2020 survey format, the questions regarding computing-related feelings asked how students currently felt about the statements provided in both surveys and analysis was conducted on the changes in answers between the two. Sections 4.1-4.3 explain survey results and analysis from the Spring 2021 students.

In the surveys issued in the Spring 2021 course, we performed the same breakdown of students into categories of "low or no experience," "mid experience," and "high experience." However, the students enrolled in the course nearly all fell in the "low or no experience" category, with only one student being deemed "high experience" (Table 4.0.1). For this reason, we could not draw any meaningful conclusions about the course's effect on Spring 2021 students from different experience backgrounds, so we did not perform this specific analysis. In addition, the spread of ethnicity groups shows over half of the class identifying as being Asian and White and only 1 student of Hispanic or Latino background (Table 4.0.2). Due to the limited representation of certain ethnicities, we also decided not to make major generalizations based on race/ethnic background for this semester's class.

Experience Level				
Race/Ethnicity	Low or No Experience	Mid Experience	High Experience	Grand Total
Asian	4	0	0	4
Multiracial	3	0	0	3
Black or African American	2	0	1	3
Hispanic or Latino	1	0	0	1
White	8	0	0	8
Grand Total	**18**	**0**	**1**	**19**

Table 4.0.1

Race/Ethnicity	Count of Students
Asian	4
Multiracial	3
Black or African American	3
Hispanic or Latino	1
White	8
Grand Total	**19**

Table 4.0.2

4.1 Calculating Impact

With the Spring 2021 data broken up into 2 parts, mid-semester and end-of-semester survey, we set out to assess the changes in individual survey results. Using the unique code that students were required to generate in the surveys, we matched each student's answers while maintaining their anonymity and combined their records in a central database. Due to inconsistencies in unique codes for some students, we had to cut down the total records to 14 students. To quantify changes in student data, we assigned numerical values to each response for relevant questions in the following manner:

- Strongly Agree: 5
- Agree: 4
- Neither Agree nor Disagree: 3
- Disagree: 2
- Strongly Disagree: 1

We then calculated what we labeled the *impact* by subtracting the mid-semester survey values from the end-of-semester values. The only exception is the statement "I feel like an outsider in computing" where the point values were reversed so Strongly Agree was equated to 1 and Strongly Disagree was equated to 5. An overall *impact* score was assigned to relevant survey

questions by taking the sum of every individual value. Note that this overall impact score does not reflect the count how many students have an individual zero impact score, since their zero does not affect the sum. Thus it only reflects the number and amount of change for students whose score on a question changed.

4.2 Analyzing Impact

Survey questions with a positive overall *impact* were assumed to be correlated with a strengthened influence from the course and a negative overall *impact* was associated with a hindered influence from the course. Tables 4.2.1-4.2.6 show the result of our analytical process.

The statement "I feel welcomed in computing" yielded the highest overall *impact* with a score of +4 as shown in Table 4.2.1. Of the 9 students with reported 0 or no *impact*, more than half of those students had already agreed with this statement. The one student with an *impact* of +2 changed their feelings from disagree to agree. This leads us to believe that, for some students, this course has strengthened their confidence of feeling welcomed in computing.

I feel welcomed in computing	
Impact	Count
+4	0
+3	0
+2	1
+1	3
0	9
-1	1
-2	0
-3	0
-4	0
Overall Score	**4**

Table 4.2.1

Tied for second highest overall *impact* were the statements "Computing is a big part of who I am" and "I can introduce myself to new peers/colleagues at professional meetings". Only 3 out of the 10 students that had no *impact* on feeling that computing is a big part of who they are had agreed or strongly agreed with this statement and 4 of those students had either disagreed or strongly disagreed. Of the 3 students that had a positive *impact* score on that statement, 2 had changed their answer to agree. Given the spread, it is hard to say exactly how the course may have influenced their feelings about "Computing is a big part of who I am". When prompted the statement of being confident in introducing themselves to new peers and colleagues, 2 students had changed their answer from "disagree" to "agree". All of the students that had no impact from that statement had already "agreed" or "strongly agreed" before the course's influence. Therefore, even with both statements scoring an overall value of +3, the course may have had a greater influence on the statement about being confident in "introducing themselves to new peers/colleagues at professional meetings" than the other statement.

Computing is a big part of who I am	
Impact	Count
+4	0
+3	0
+2	1
+1	2
0	10
-1	1
-2	0
-3	0
-4	0
Overall Score	**3**

Table 4.2.2

I can introduce myself to new peers/colleagues at professional meetings	
Impact	Count
+4	0
+3	0
+2	2
+1	1
0	9
-1	2
-2	0
-3	0
-4	0
Overall Score	**3**

Table 4.2.3

On the other side of the spectrum, the statement "I feel like an outsider in computing" received the lowest overall *impact* with a score of -6, as shown in Table 4.2.4. Here, a negative impact score indicates that fewer students agreed with feeling like an outsider, indicating a positive effect from the course. Notably, one student changed their response from "strongly agree" to "disagree" with regard to this statement, and another student changed from "agree" to "disagree." In the initial mid-semester survey, more students agreed than disagreed with feeling like an outsider. At the course's conclusion, however, only three students agreed with the statement, with half of students disagreeing and the rest indicating neither agreement nor disagreement.

I feel like an outsider in computing	
Impact	Count
-4	0
-3	0
-2	0
-1	0
0	11
+1	1
+2	1
+3	1
+4	0
Overall Score	**6**

Table 4.2.4

Tied for second lowest *impact* were the two statements: “I can pass my computing courses.” and “I can be successful in a graduate computing program” (Tables 4.2.5, 4.2.6). These results indicate that some students felt less confident in their ability to succeed in a computing major after taking the course. One student changed their feelings from “strongly agree” to “strongly disagree” with regard to the statement “I can pass my computing courses,” and changed their response from “agree” to “strongly disagree” with regard to the statement “I can be successful in a graduate computing program.” We recognize that this one student’s strong changes of opinion on these questions may be due in part to factors unrelated to the Tools of the Trade course. Apart from this student, the rest of the results were mixed, with about the same number of students experiencing a positive impact (“disagree” to “agree”) as a negative impact (“agree” to “disagree”). Most students expressed no change in their thoughts on these statements.

I can pass my computing courses.	
Impact	Count
+4	0
+3	0
+2	1
+1	0
0	10
-1	2
-2	0
-3	0
-4	1
Overall Score	**-4**

Table 4.2.5

I can be successful in a graduate computing program.	
Impact	Count
+4	0
+3	0
+2	1
+1	3
0	5
-1	3
-2	0
-3	2
-4	0
Overall Score	**-4**

Table 4.2.6

Results for all statements not discussed in Tables 4.2.1-4.2.6 showed a low value net impact from the mid-semester survey to the end-of-course survey, indicating the course did not have much of an effect on respondents' feelings regarding those statements. After reviewing and analyzing statements with the highest value *impact* score, we compiled major findings about the course's influence on them below:

- Students have generally felt that this course has strengthened their feelings of feeling welcomed in computing (Table 4.2.1).

- ❖ The course may have had a greater influence on the statement about being confident in "introducing themselves to new peers/colleagues at professional meetings" than feeling like "Computing is a big part of who they are", even with both statements scoring an overall value of +3 (Tables 4.2.2-4.2.3).
- ❖ Fewer students identified with feeling like an outsider at the end of the course. In the initial mid-semester survey, more students agreed than disagreed with feeling like an outsider. At the course's conclusion, only three students agreed with the statement, with half of students disagreeing and the rest indicating neither agreement nor disagreement (Table 4.2.4).
- ❖ Some students felt less confident in their ability to succeed in a computing major after taking the course. Apart from one outlier, however, the results were mixed, with about the same number of students experiencing a positive impact as a negative impact (Tables 4.2.5-4.2.6).

5 Conclusion

Comparing data from the Fall 2020 semester and Spring 2021 semester, students generally indicated that the Fall course had a more significant impact than the Spring course on feelings of belonging and self-efficacy. We theorize that these results may be influenced by some of the following factors. Firstly, the makeup of students differed quite significantly between the Fall and Spring semesters. While 7 out of the 30 students in the Fall semester fell into the "high experience" computing background category, only 1 out of 19 students in the Spring semester was deemed to be "high experience," with the remaining students being "low or no experience." In addition, the majority of students in the Fall semester expressed feelings of belonging and confidence in their computing skills even prior to taking the course, whereas most students in the

Spring described themselves as “outsiders” to computing before the end of the course. These pre-existing attitudes may be difficult to change, and could result in the course having less of an impact on students who enter the course with relatively low self-efficacy.

Another potential factor in the discrepancy between the two semesters is the change in course content and structure. The Fall semester course covered a breadth of topics at a high level, generally spending one week on each industry topic. After receiving course feedback from students, we made the decision in the Spring to spend more time covering some topics in more detail. A few of the topics from the Fall course that were omitted from the Spring course include IDEs; Bash and command line interfaces; and build tools. Spring topics that were covered in more depth than the Fall include resume-writing and LinkedIn; Git and GitHub; and databases. Though these changes were made at the suggestion of Fall students, it is possible that the students in the Spring course could have benefited from or found more interest in a broader range of topics. Anecdotally, some students struggled with or disliked using GitHub -- spending two weeks on this topic may have turned off or impacted these students negatively.

Additionally, each topic in the Fall course was paired with a weekly assignment. The Spring course packaged topics into four month-long modules, at the end of which all intra-module assignments were due. Extending due dates to the end of the month instead of the end of the week may have caused Spring semester students to fall behind on their lectures and assignments, resulting in negative feelings or reactions to the course when a module’s due date approached due to a buildup of work. Finally, though both courses were delivered remotely and asynchronously, we theorize that the virtual setting of the course negatively impacted students, perhaps more so for students in the Spring than the Fall. Remote learning and dealing with the

COVID-19 pandemic has been a struggle for nearly all students, and frustrations continue to rise as these poor circumstances persist.

The target audience of the course content was students with low self-efficacy and self-confidence in the computing field. With this in mind, we planned to make observations on particular underrepresented students with regards to race/ethnicity and gender. The Fall 2020 class consisted of 30 students of various backgrounds which allowed us to make generalizations for these underrepresented groups and the course's effects on their feelings toward computing-related confidence statements. However, the Spring 2021 class of 19 students prevented the research team from making the same observations due to inconsistent survey results and the limited size of under-represented groups.

Regarding race/ethnicity, we found that, for both Spring and Fall classes, over half of the students in every ethnic group were considered to have low or no experience in the computing field which confirmed our target audience. We also observed that, when prompted statements of being and belonging in computing, non-White students had more of an impact from the course in the Fall 2020 semester. Regarding gender for the Fall 2020 semester, we found that in our class, with the exception of the statement “Computing is a big part of who I am”, that female students felt more of a positive impact than male students. Due to the small sample size for Spring 2021, gender was not considered as a subgroup. We saw that, by the end of the Fall semester, every student, regardless of race or gender, felt confident in completing their current degree program regardless of background.

6 Future Work

When creating this course, we thought of ways to make this course applicable not just to the students at the UVA or UVA Wise, but instead all college students who want to learn more about the world of computing. Our course is flexible in how it is structured, but is intended to have portions that consist of a lecture, demo (optional), and assignment. Because of this, the course staff has created a GitHub repository that uses Jekyll to convert Markdown files to HTML files to be hosted on GitHub pages, making sure it is accessible to any who desire to use it. The repository is intended to be for instructors to package on their own, adding any additional materials as needed (i.e. syllabi, grading scale, etc.), before distributing to students.

Looking forward, we hope that the material created from the *Tools of the Trade* course can reach a wider audience for both academic institutions and independent learners. Our next steps include reaching out to local community college professors about incorporating the course and expanding course topics as more relevant tools emerge in the technology industry. With the help of open-source applications, we encourage more people outside of the staff to continue to improve on what *Tools of the Trade* can offer. Using cost-effective and publicly accessible content, we strive to open doors for learners of any background and prior experience and expose them to fundamental industry tools without the need of a formal education.

References

Alshahrani, A., Ross, I., & Wood, M. I. (2018). Using Social Cognitive Career Theory to Understand Why Students Choose to Study Computer Science. *Proceedings of the 2018 ACM Conference on International Computing Education Research*. doi:10.1145/3230977.3230994

College Board. (2020). Program Summary Report 2020.

Computing Research Association, Center for Evaluating the Research Pipeline. (2019). 2019 Data Buddies Department Report - University of Virginia. https://cra.org/cerp/data-buddies/

Dillon, E. C., Gilbert, J. E., Jackson, J. F., & Charleston, L. V. J. (2015). The State of African-Americans in Computer Science – The Need to Increase Representation. *Computing Research Association*, *27*(8). https://doi.org/https://cra.org/crn/2015/09/expanding-the-pipeline-the-state-of-african-americans-in-computer-science-the-need-to-increase-representation/

He, J., & Freeman, L. A. (2010). Are men more technology-oriented than women? The role of gender on the development of general computer self-efficacy of college students. *Journal of Information Systems Education*, *21*(2), 203.

Kapoor, A., & Gardner-McCune, C. (2019). Understanding CS Undergraduate Students' Professional Identity through the lens of their Professional Development. Proceedings Of The 2019 ACM Conference On Innovation And Technology In Computer Science Education. https://doi.org/10.1145/3304221.3319764

Liberatore, M. J., & Wagner, W. P. (2020). Gender, Performance, and Self-Efficacy: A Quasi-Experimental Field Study. J*ournal of Computer Information Systems*. doi:10.1080/08874417.2020.1717397

Sax, L. J., Blaney, J. M., Lehman, K. J., Rodriguez, S. L., George, K. L., & Zavala, C. (2018). Sense of Belonging in Computing: The Role of Introductory Courses for Women and Underrepresented Minority Students. *Social Sciences, 7*(8). https://doi.org/https://doi.org/10.3390/socsci7080122

Taylor, H.G., & Mounfield, L. C. (1994). Exploration of the relationship between prior computing experience and gender on success in college computer science. *Journal of educational computing research*, *11*(4), 291-306.

Weng, J., & Murphy, C. (2018). Bridging the Diversity Gap in Computer Science with a Course on Open Source Software. 2018 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT). https://doi.org/10.1109/respect.2018.8491720