

# Considerations for Switching: Exploring Factors behind CS Students' Desire to Leave a CS Major

Amanpreet Kapoor

Computer & Info. Science & Engineering  
University of Florida, Gainesville, FL, USA 32611  
kapooramanpreet@ufl.edu

Christina Gardner-McCune

Computer & Info. Science & Engineering  
University of Florida, Gainesville, FL, USA 32611  
gmccune@ufl.edu

## ABSTRACT

Understanding undergraduate students' academic, professional and social experiences in computer science (CS) degree programs is critical to retaining students in these programs. This paper presents findings from an exploratory study aimed at empirically investigating the academic, social, and professional experiences that influence CS students to consider switching out of their major. We surveyed 96 CS undergraduate students at the University of Florida and examined their experiences during their degree program. The data were categorically analyzed to identify factors that influenced students to consider switching out of a CS major. We found that students who considered switching out of a CS major experienced gender biases in the classroom, had negative or neutral satisfaction with computing courses, and felt that the assignments and projects were not relevant to the coursework. We also found that females were twice as likely to consider leaving a CS major as compared to males. Several factors significantly affected female students: perception of the presence of gender biases in the classroom, not receiving timely feedback, negative satisfaction in coursework, and negative team experiences. We conclude by discussing these findings in light of retention theories and literature.

## CCS CONCEPTS

- **Social and professional topics** → Computing education

## KEYWORDS

Retention, Gender, CS Enrollments, Professional development

## ACM Reference format:

Amanpreet Kapoor, Christina Gardner-McCune. 2018. Considerations for Switching: Exploring Factors behind CS Students' Desire to Leave a CS Major. In *Proceedings of 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE'18)*. ACM, New York, NY, USA, 6 pages. <https://doi.org/10.1145/3197091.3197113>

---

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from [Permissions@acm.org](mailto:Permissions@acm.org).

ITiCSE '18, July 2-4, 2018, Larnaca, Cyprus  
© 2018 Association for Computing Machinery.  
ACM ISBN 978-1-4503-5707-4/18/07...\$15.00  
<https://doi.org/10.1145/3197091.3197113>

## 1 INTRODUCTION

The Bureau of Labor Statistics in the United States projects that by 2020 there will be 1.4 million computer science related jobs available and only 400,000 computer science graduates with the skills to apply for those jobs [10]. Industry jobs in Computer Science are projected to grow at 13% over the next decade [9]. Thus, the current educational system in the United States is facing challenges in preparing enough computer science students to satisfy this demand. One reason is the lack of a systematic mechanism to attract more students to major in CS as well as to retain them during their CS degree program. A report from the US Education Department's National Center for Education Statistics found that 28 percent of CS bachelor's degree pursuers who entered college in 2011-12 had changed their major at least once by 2014 [14]. In addition, prior studies have shown that students who think about switching out of a CS major were the students who actually left [17]. Thus, there is a possibility that the students who are frequently considering leaving a CS major, will leave a CS major in the future. Therefore, it is necessary to understand the factors that lead to these thoughts and retain students in their CS major by ensuring that they have a positive experience in our CS degree programs.

In this paper, we describe a study focused on better understanding the academic, social, and professional experiences of undergraduate students that led them to consider switching out of their CS major. These factors pertained to CS student's perceptions of their academic experience as well as their social and professional involvement and were taken from prior research in student retention [1, 2, 18, 19], and the publicly available Student Experience of the Major Survey developed by researchers at the University of California-Irvine and the National Center for Women & Information Technology (NCWIT) [16]. The knowledge from this study can help us better understand the necessary steps to foster a positive experience during a CS degree program. Such knowledge has the potential to retain students in undergraduate CS degree programs.

## 2 BACKGROUND

### 2.1 Theories on Student Retention

There are two frequently cited theories for understanding why some students persist and others change major: Tinto's theory of student departure [18, 19] and Astin's Input-Environment-Outcome (IEO) Model [1, 2]. Tinto's model emphasized that students' leaving an academic degree program should be regarded as a process [18, 19]. Unlike other studies that focused on a students' psychological traits such as ability

and interests, Tinto's model highlights the importance of institutions in creating environments that retain students. Tinto's variables of interaction within college environments included academic factors (e.g., intellectual development and grade performance) and social factors (e.g., interaction with faculty and staff, friends, extra-curricular activities, support groups, and faculty support) [11, 18, 19].

Astin's Input-Environment-Outcome (IEO) Model [1, 2] is considered as a guiding framework for summative assessments in higher education and represents a middle ground between sociology and psychology in explaining why students drop-out of a major. In Astin's theory, the psychological influence is recognized by the importance of students' active involvement in their learning, while the sociological influence is reflected by the institution's critical role in providing a nourishing environment to its students to prevent drop-outs. Astin's Input-Environment-Outcome (IEO) model suggests that the outcome (O) in an educational program such as student persistence or student completion depends on a student's input (I) and the educational environment (E) provided by the educational institutions. The input factors include personal qualities that the students come with when joining the program like student demographics, degree aspiration, life goals, etc. The environmental characteristics refer to "the student's actual experiences during the educational program" like curriculum, institutional climate, teaching style, extracurricular activities, etc. [1, 2]. A student's persistence in a degree program is thus linked to a student's ability to be actively involved in the institutional environment.

## 2.2 Retention Studies in CS

Studies in CS retention literature have focused on comparing students who majored in CS with those who left a CS major [5, 17]. Also, some studies have focused on retaining and attracting females and underrepresented students [5, 7, 8]. This section highlights some of the key findings pertaining to factors that the leavers perceived were present during their CS degree program at different universities. A report by Computing Research Association on Recruitment and Retention of Undergraduate Students in CS revealed that the students who leave a CS major faced three primary challenges: the difficulty of coursework, unwelcoming environment, and loss of interest in computing [17]. Similarly, Biggers et al. [5] found that female students switched out of a CS major if they felt they didn't belong, were unhappy with their grades or felt that there was an excessive workload. Conversely, they also found that stayers were adequately prepared, positively influenced by high school teachers, and more confident when they entered the degree program.

Cphoon et al. [7] identified conditions within CS departments that foster higher retention of women such as better faculty attitude, teaching styles, and the presence of more female faculty. In a study to understand the factors that influenced introductory students to persist, Barker et al. [3] found student-student interaction, pace/workload/prior experience, as well as male gender as the three key factors that were predictors of intention to major. In another study, Barker et al. [4] found meaningful assignments, student-faculty interaction, and

collaboration on programming assignments to be predictors of commitment to a CS major. Overall, Tinto's and Astin's models of retention align well with the academic, and social factors that have been identified in CS Retention studies.

## 2.3 Professional Identity Development

In line with Astin's concept of involvement and factors such as degree aspiration, and life goals, professional identity development plays a role in students' expectations of degree programs. Professional identity enables a person to be technically competent, self-confident, and experience a sense of belongingness to the profession. Thus, membership in social groups within CS is not restricted to a student's participation within a university, but also to various communities of practice [13] a student engages in during the entire degree program. Experiences outside academia including industry internships, leading an organization or a project, research experiences for undergraduates, and participations in outreach or hackathons are some of the factors that encompass CS communities of practice and leads to a student's professional identity development. Thus, we need to understand the impact these experiences have on students' belongingness as they move between our CS degree programs and the larger CS communities of practice. In the study presented in this paper, we used the factors identified in these three areas of literature to explore why students considered leaving their CS major.

## 3 METHODS

### 3.1 Study Design

In Spring 2016, we conducted a survey-based study at the University of Florida, United States. This study was aimed at understanding several academic, social, and professional factors that led CS undergraduate students to consider switching out of a CS major. We designed a survey to collect data on students' perception of the institutional environment, social supports, and their personal involvement in professional endeavors during their CS undergraduate degree program. In this study, we focused on exploring the following research questions:

**RQ1.** What are the academic, social, or professional factors that influence CS students to consider leaving a CS major?

**RQ2.** What are the academic, social, or professional factors that influence male and female CS students to consider a leaving CS major?

**RQ3.** What impact do different academic, social, or professional experiences have on male and female CS students' thoughts to consider leaving a CS major?

### 3.2 Participants Recruitment

Students were recruited from our university's CS1, data structures, software engineering, and senior design courses, as well as Human-Computer Interaction and several CS technical electives. The CS undergraduate degree program offered at our university allows students to major in CS, Computer Engineering (CE) or Digital Arts and Sciences. The students can choose a major when they start college but can change at any time. The survey participants were given extra credit for participating in this study - not more than 1% towards their final

grade based on pre-approval by the respective course instructors. The second author was one of the instructors who offered extra credit in the software engineering course, but the data was collected by the first author and not shown to the second author until after grades were submitted for the course.

### 3.3 Participants

The average age range of the study participants was 18 to 23 based on the enrolled CS undergraduate population at the University of Florida. The details of the survey respondents are as follows: 148 students responded to our survey, 102 students completed more than 94% of the survey (Completion Rate: 68.9%), 45 students completed less than 68% of the survey, and 1 participant did not consent to research. Out of the 102 students, 1 participant did not specify gender and 5 students did not major or minor in CS or CE. Thus, this paper will report data collected from the 96 survey participants who completed more than 94% of the survey and indicated the following majors: CS (60.4% n=58), CE (33.3%, n=32) or double majored in CS and another subject (4.2%, n=4), or minored in CS (2.1%, n=2). Other demographic details are shown in Table 1.

**Table 1: Demographics of Survey Participants**

Academic Standing (By Year)					Gender	
Year 1	Year 2	Year 3	Year 4	Year 5-6 <sup>th</sup>	Male	Female
16.7% n=16	13.5% n=13	30.2% n=29	34.4% n=33	5.2% n=5	77.1% n=74	22.9% n=22

### 3.4 Data Collection

We gained consent from the Institutional Review Board at our university and used Qualtrics to administer the survey. The participants were asked to complete a consent form prior to the survey. The surveys were completed on average within 32 minutes. For this paper, we focused our analysis on 30 multiple choice questions from the survey pertinent to answer our research questions, and two demographic questions to better understand the impact of academic, social, and professional factors on students' consideration to switch out of a CS major. These academic factors pertained to a student's integration with their university's academic culture and included factors gauging classroom climate, student-faculty interaction, collaborative learning, overall satisfaction, and sexism and racism in the classroom. Factors relating to social integration included membership in organizations or clubs, student relationships with peers, experiences in a team, and campus climate. Professional factors included students' experiences in leadership, internships and research. Some of these factors were taken from the NCWIT Student Experience of the Major Survey [16].

We asked the participants to answer most of the questions using a four-point scale to measure their opinions. For one question that measured their overall satisfaction in computing courses, we used a five-point Likert scale. Also, for six questions, we used binary responses (Yes or No). These six questions pertained to a student's experience in an activity. If the students answered 'Yes', they were further asked to share their experiences in that activity. These activities were experience of working in teams, holding leadership positions, CS courses in high school, participation in research, membership in

organizations, and working in professional internships. We use representative quotes describing students' experiences from these qualitative questions to corroborate our claims for the quantitative findings from this study.

### 3.5 Data Analysis

To answer our three research questions, we adopted three different methods. First, to answer RQ1., we analyzed the association between each of the 30 academic, social, and professional factors (independent variables) and the students' consideration to switch out of their CS major (dependent variable). Our dependent variable, students' consideration to switch out of a CS major had two levels - Students who consider leaving a CS major (these students responded 'often' or 'sometimes') and Students who rarely or do not consider leaving a CS major (these students responded 'rarely' or 'never'). We also recoded our independent variables merging survey codes to form two or three levels (see Table 2). We merged the Likert scale responses from four or five categories to two or three categories respectively, to ensure fewer categories for our frequency analysis as our sample size was small. This helped us in achieving better statistical power.

**Table 2. Coding of Collected Data**

Question Type	Original Survey Code	Merged Code
Satisfaction Question	Extremely Happy, Somewhat Happy	Happy
	Neither Happy nor Unhappy	Neutral
	Extremely Unhappy, Somewhat Unhappy	Unhappy
Agreement Questions	Strongly agree, Somewhat agree	Agree
	Strongly disagree, Somewhat disagree	Disagree
Frequency Questions	Sometimes, Often	Yes
	Rarely, Never	No
Ordinal questions	0-3 hours, 3-7 hours	Few hours
	7 -10 hours, 10 hours and greater	More hours

We performed a frequency analysis of the merged codes in IBM SPSS package. We created contingency tables to summarize our data and performed Fisher's Exact test of Independence to understand whether the two variables: the consideration to switch a CS major, and each of the 30 factors are dependent or independent. We used  $p <= 0.05$ ,  $\alpha = 5\%$  to reject our null hypothesis that the two variables are independent. We further measured the associations (effect sizes) for our statistically significant results by computing the Cramer's V coefficient (range 0-1). This coefficient is used to determine the magnitude of effect size for association between two nominal variables. Cohen suggested that the magnitude of effect size can belong to three categories: small=0.10, medium=0.30, and large=0.50 [6].

Our next step was to better understand the factors that specifically influenced the students from the respective male and female populations to consider switching out of a CS major. For this, we disaggregated our data by gender and performed Fisher Exact Test on both male and female populations separately. Thus, we compared females who considered leaving a CS major to females who did not consider leaving a CS major, and males who considered leaving a CS major to males who did not consider leaving a CS major. This helped us in answering RQ2.

Finally, to understand the differences between the impact of the experiences on male and female students' consideration to leave a CS major and answer RQ3., we adopted a third approach. In 6 of the 30 factors, we asked students if they had prior experiences in teams, leadership, internships, etc. We performed a Fisher's Exact test of Independence on gender and our dependent variable, controlling our data for presence of each one of the experiences. Thus, we compared the impact of experiences between males and females who had had an experience and elaborate on these findings in Section 4.3.

**4 FINDINGS**

We found that most of the students (90.6%, n=87) reported that they belonged to a CS major. Although the students felt that they belonged in a CS major, 33.3% of the 96 students (n=32) considered switching out of a CS major. The remaining 66.7% of 96 students (n=64) never or rarely considered switching out of a CS major. Section 4.1 summarizes the factors that influenced CS students to consider leaving a CS major. Further, we found that females were twice as likely to consider switching out of a CS major as compared to males. 54.5% female students (n=12) and 27.0% male students (n=20) considered leaving a CS major. The factors which specifically influenced male and female CS students to consider switching out of a CS major are described in Section 4.2. Finally, in Section 4.3 we describe how academic, social and professional experiences differed for both genders and influenced them to persist or switch a CS major.

**4.1 Factors Influencing CS Students to Consider Switching Out of a CS Major**

In comparing students who considered switching out of a CS major to students who did not consider switching out, using Fisher's Exact test we identified 3 out of the 30 factors influenced the students to consider switching out of a CS major. These three factors were the presence of gender biases in the classroom, non-relevance of assignments and projects to the coursework, and 'negative' or 'neutral' overall satisfaction in computing courses. We summarize these results in Table 3.

**4.2 Factors Influencing Male & Female CS Students to Consider Switching Out of a CS Major**

We further disaggregated our data for male and female participants. We found that male students, who reported that they 'Often' or 'Sometimes' spent non-school time with other CS peers, were more prone to consider switching out of a CS major when compared with male students who infrequently spent non-academic time with CS peers (see Table 4). The other 29 factors were not statistically significant when comparing these two male sub-groups: males considering switching and males not considering switching. On the other hand, female students who considered switching responded 'neutral' or 'negative' overall satisfaction with computing courses, felt the presence of gender biases in the classroom and indicated that did not receive timely feedback on assignments and projects (see Table 4). Further, the effect sizes for all three factors were large (Cramer's V > 0.5) which signifies that the factors are prominent and significant.

**Table 3: Factors influencing CS students to consider switching out of a CS major**

Factors		Influence		Effect Size	Fisher's Test
		Switch	Persist	Cramer's V	p-value
Gender Biases in Classroom	Yes	61.5% n=8	38.5% n=5	0.237	0.028
	No	28.9% n=24	71.1% n=59		
Relevance of assignments & projects to coursework	Yes	30.3% n=27	69.7% n=62	0.227	0.039
	No	71.4% n=5	28.6% n=2		
Overall Satisfaction with Computing Courses	Positive	25.0% n=16	75.0% n=48	0.262	0.040
	Neutral	41.7% n=5	58.3% n=7		
	Negative	55.0% n=11	45.0% n=9		

**Table 4: Factors influencing Male and Female CS students to consider switching out of a CS major**

Factors		Influence		Effect Size	Fisher's Test
		Switch	Persist	Cramer's V	p-value
<b>Males</b>					
Non-school time spent with peers	Yes	38.5% n=15	61.5% n=24	0.272	0.035
	No	14.3% n=5	85.7% n=30		
<b>Females</b>					
Receiving Timely feedback	Yes	20.0% n=2	80.0% n=8	0.633	0.008
	No	83.3% n=10	16.7% n=2		
Overall Satisfaction with Computing Courses	Positive	35.7% n=5	64.3% n=9	0.537	0.029
	Neutral	66.7% n=2	33.3% n=1		
	Negative	100.0% n=5	0.0% n=0		
Gender Biases in Classroom	Yes	100.0% n=6	0.0% n=0	0.559	0.015
	No	37.5% n=6	62.5% n=10		

**4.3 Comparing the Influence of Academic, Social & Professional Experiences on Male and Female Students' Considerations to Switch Out of CS Major**

Finally, we analyzed the data by performing a Fisher's Exact test on gender and students' consideration to switch out of a CS major. We controlled our dataset for the presence of an experience by excluding participants who did not have an experience. These experiences were working in a team, holding a leadership position, experience with computing in high school, organization memberships, internships and research. We found that experiences in a team, leadership, and internship had different effect on male and female students with respect to their consideration to switch a CS major (see Table 5). To understand these differences, we use representative quotes of male and female CS students who considered leaving and those who did not consider leaving.

First, when controlling for presence of **leadership experience**, we found that female students were more likely to consider leaving a CS major when compared to males. 21.4% of the 42 males (n=9) who held a leadership position considered switching a CS major when compared to 66.7% of the 12 females (n=8) who held a leadership position and considered switching out of a CS major. In our qualitative data, we found that both males and females shared positive experiences of leading a team, but females wished to move into management after their positive experiences, while males preferred staying into technical development. The following are representative quotes describing students' leadership experiences:

A female student in her senior year who **sometimes considered leaving** her CS major reported, "I enjoy leading a team rather than following one, a majority of the time. It has helped me realize that I would like to hold a position where I can lead people". Another female student, a junior who **often considered switching** out of her CS major commented, "I learned that I am better at management than I am at pure coding". Some female students also reported having difficulty leading a team. One female student, a senior who **often considered switching** out of her CS major reported, "Leading in computer science is difficult. As a female, I find it difficult to gain respect. Most see females as lacking information in computer science".

**Table 5: Difference in the impact of experiences on male & female students with respect to their consideration to leave a CS major**

Controlled Experience	Gender	Influence		Effect Size	Fisher's Test
		Switch	Persist	Cramer's V	p-value
Internship Experience	Male	16.7% n=5	83.3% n=25	0.468	0.008
	Female	66.7% n=6	33.3% n=3		
Team Experience	Male	25.0% n=16	75.0% n=48	0.295	0.012
	Female	57.9% n=11	42.1% n=8		
Leadership Experience	Male	21.4% n=9	78.6% n=33	0.405	0.005
	Female	66.7% n=8	33.3% n=4		

On the other hand, the male students enjoyed leadership experience but preferred to stay in development/ technical roles. "I enjoy helping others and letting others learn from my experiences but having to forge through the red tape that's present in any form of organization is purely aggravating to me. I expect myself to more enjoy an advanced development role, without the leadership minutiae", wrote a male student, in his junior year who **never considered switching** a CS major.

Second, when performing the Fisher's Exact Test of Independence and controlling for **internship experiences**, we found that male students who interned were less likely to consider switching when compared to female students. We also asked the students to describe their internship experience in the survey. A majority of the male students described their internship experience as positive. A senior year male student who **never considered switching** out of a CS major reported, "It has given me experience as well as encourage me to stay with

computer science". Females, on the other hand, were split with either a positive experience to stay in the major or an experience that made them realize that they do not want to work in a certain area or a position in the industry. A senior year female student who **sometimes considered switching** a CS major reported, "It helped me understand how the industry works actually. I did realize that I might not want to do the work I was doing in my internship but look at something else".

Last, when performing the Fisher's Test, and controlling for **team experiences**, we found that females who considered switching out of their CS major shared negative experiences of working in a team. They commented about the lack of scaffolding by the degree programs on how to work in teams, and difficulty in dealing with slacking team mates. "I have had mixed experiences working in teams. Most of the time, my team members don't pull their own weight, so I end up doing a majority of the work, which can be frustrating", shared a sophomore female who **sometimes considered switching** a CS major. Also, both males and females shared positive aspects of working in a team which included communication, collaboration, and preparation for working in the industry. A sophomore female student who **rarely considered switching** a CS major wrote, "In working with teams for CS projects, I've learned a lot about personality types and strategies to get work done. Agile project management in software development is really interesting and I'm more encouraged to pursue my CS degree". Also, a male sophomore who **never considered switching** out of a CS major shared, "I now think that working with teams is essential in CS/CE, especially since professional workplaces use teams to work on large scale projects".

The other experiences: research, organization memberships, and experience with computing in high school were statistically insignificant (p>=0.05).

## 5 DISCUSSION

Prior studies in retention in CS undergraduate degree programs focused on suggesting measures to lower the attrition rates by comparing stayers with leavers [5, 17]. Our study focuses on improving CS students' overall experience in their degree program by understanding the differences between students who considered switching out of a CS major and those who did not consider switching a CS major. Further, we also found that over 90% of the surveyed students reported that they belonged to a CS major. Thus, there were other factors that influenced CS majors to consider switching rather than belongingness, technical ability, and/or interest in their CS major. Our study found several factors that influenced CS undergraduate students to consider switching their major:

- The relevancy of assignments and projects to coursework.
- Presence of gender biases in the classroom.
- Overall satisfaction with computing courses.

Our findings are consistent with previous studies that claimed leavers indicated irrelevance of assignments to the real world [4, 5], and female leavers perceived the presence of gender biases, and racism in the classroom [15, 17] as well as reported poor teaching or curriculum [5, 15]. Further, our findings for female students who considered leaving and reported negative overall satisfaction with CS courses, not receiving timely feedback, and

gender biases in the classroom are consistent with prior studies in CS retention literature [4, 5, 7, 8, 15, 17]. Thus, our findings confirm that these factors are consistent across multiple university populations and across time.

However, our finding relating to male students' consideration to switch out of their CS major when spending frequent non-school time is contradictory to prior findings in retention literature that suggested that student-student interaction is a key criterion that determines the intention to persist or drop-out [3]. Both Tinto's model of student departure [18-19] and Astin's IEO model [1, 2] suggested that once a student makes a social connection with their peers, their next step is centered on academic involvements. Also, we found that 75% of the 20 male students who considered switching out of CS (n=15) reported that they spent less than seven hours per week per course on the assignments and projects. Thus, there is a possibility that the male students who frequently spent non-school time with their CS friends are not devoting ample time for their coursework. This suggests that they may need to either spend more academic time focusing on studying in groups or dedicate more time to studying by themselves.

Finally, we found that the presence or absence of several academic, social, and professional experiences have different influences on male and female students' consideration to switch out of a CS major. We found that most female students who considered switching major had negative experiences in an internship or a team, or a positive experience in leadership. Females' inclination to consider switching out of a CS major or pursuing management careers after having a positive leadership experience can be attributed to the fact that prior research has shown that women are more inclined to pursuing technical management in their careers [12]. Other findings on the influence of team, leadership and internship experiences on retaining CS students are not described in CS retention literature.

## 6 LIMITATIONS

The findings presented in this paper represent a snapshot of the current experiences of a subset of a sample of CS student population at the University of Florida. Further, the participants were students who only considered switching out of their CS major but never actually left the major. Additional longitudinal data is required for tracking participants over the four years in a degree program to understand how these factors varied over students' matriculation in the CS degree program. In the future, additional data on students' GPA, family background, and ethnic diversity might help to better characterize the population.

## 7 CONCLUSION

To conclude, our study found several factors that influenced CS students to consider switching out of a CS major. Most of these factors were similar to the factors reported by students who actually left a CS major as in prior studies. Our findings differ from other studies in the literature and contribute to the growing field of retention literature by adding an additional factor to retain students in CS. And this new factor, spending frequent nonacademic time with computing friends, negatively influences male students' persistence within a CS degree program. Also, we found that males and females who considered switching out of a CS major reported differences in their

experiences with working in teams, holding leadership positions, and participation in industrial internships. Focused qualitative studies are required to understand the role these experiences play in retaining the students. In addition, our findings suggest a new set of questions to conduct further research: What does it mean if students who frequently consider switching out of a CS major stay in a degree program? Do such students leave the pipeline in the industry by shifting their jobs to other fields like management? If this is the case how we are going to make up for the demand of CS graduates in the job market?

## REFERENCES

- [1] Astin, A.W. 1984. Student Involvement: A Developmental Theory for Higher Education. *Journal of College Student Personnel*. 25, 4, 297–308.
- [2] Astin, A.W. 1991. *Assessment for excellence: the philosophy and practice of assessment and evaluation in higher education*. New York: American Council on Education/Macmillan.
- [3] Barker, L. J., McDowell, C., & Kalahar, K. 2009. Exploring factors that influence computer science introductory course students to persist in the major. In *Proceedings of the 40th ACM technical symposium on Computer science education - SIGCSE '09* (New York, New York, USA, 2009), 153-157. DOI: <https://doi.org/10.1145/1508865.1508923>
- [4] Barker, L., Hovey, C.L. and Thompson, L.D. 2014. Results of a large-scale, multi-institutional study of undergraduate retention in computing. In *Frontiers in Education Conference (FIE)*, IEEE, 1-8. DOI: 10.1109/FIE.2014.7044267
- [5] Biggers, M., Brauer, A., and Yilmaz, T. 2008. Student Perceptions of Computer Science: A Retention Study Comparing Graduating Seniors with CS Leavers. *ACM SIGCSE Bulletin*, 402–406. DOI: <https://doi.org/10.1145/1352322.1352274>.
- [6] Cohen, Jacob, 1988, *Statistical power and analysis for the behavioral sciences* (2nd ed.), Hillsdale, N.J., Lawrence Erlbaum Associates, Inc.
- [7] Cohoon, J.M. and Aspray, W. 2006. *A critical review of the research on women's participation in postsecondary computing education. Women and Information Technology: Research on Underrepresentation*. The MIT Press, Cambridge, MA, 2006, 138–180.
- [8] Cohoon, J.M. 2001. Toward improving female retention in the computer science major. *Communications of the ACM*. 44, 5 (May 2001), 108–114. DOI: <https://doi.org/10.1145/374308.374367>.
- [9] Computer and Information Technology Occupations: U.S. Bureau of Labor Statistics. Retrieved from <https://www.bls.gov/ooh/computer-and-information-technology/home.htm>. Accessed: 2018-01-21.
- [10] Computer Science is for Everyone! | whitehouse.gov. Retrieved from <https://obamawhitehouse.archives.gov/blog/2013/12/11/computer-science-everyone>. Accessed: 2018-01-21.
- [11] von Destinon, M. 1988. Chicano Students: Applying Tinto's and Astin's Theories. Retrieved from: <https://files.eric.ed.gov/fulltext/ED301129.pdf>. Accessed: 2018-01-21.
- [12] Kapoor, A. and Gardner-McCune, C. 2018. Understanding Professional Identities and Goals of Computer Science Undergraduate Students. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education - SIGCSE '18* (Baltimore, MD, USA), 191-196. ACM. DOI: <https://doi.org/10.1145/3159450.3159474>
- [13] Lave, J. and Wenger, E. 1991. *Situated learning: Legitimate peripheral participation*. Cambridge university press.
- [14] Leu, K., 2017. *Beginning College Students Who Change Their Majors within 3 Years of Enrollment. Data Point*. NCES 2018-434. National Center for Education Statistics. Retrieved from <https://files.eric.ed.gov/fulltext/ED578434.pdf>. Accessed: 2018-01-21.
- [15] Seymour, E. and Hewitt, N.M. 1997. *Talking about Leaving: Why Undergraduates Leave the Sciences*. Boulder, CO: Westview Press.
- [16] Student Experience of the Major (SEM): [https://www.ncwit.org/sites/default/files/resources/sem\\_survey\\_in\\_a\\_box\\_0.pdf](https://www.ncwit.org/sites/default/files/resources/sem_survey_in_a_box_0.pdf). Accessed: 2018-01-21.
- [17] Tamer, N.B. and Stout, J.G. 2016. *Recruitment and Retention of Undergraduate Students in Computing: Patterns by Gender and Race/ Ethnicity*. Retrieved from: [https://cra.org/ceip/wp-content/uploads/sites/4/2017/05/CS\\_Recruitment\\_Retention.pdf](https://cra.org/ceip/wp-content/uploads/sites/4/2017/05/CS_Recruitment_Retention.pdf). Accessed: 2018-01-21.
- [18] Tinto, V. 1997. Classrooms as Communities: Exploring the Educational Character of Student Persistence. *The Journal of Higher Education*. 68, 6, 599–623.
- [19] Tinto, V. 1993. *Leaving college: rethinking the causes and cures of student attrition*. University of Chicago Press.