

Exploring Factors that Influence Underrepresented Students to Persist in Computer Science

Noura Albarakati
Department of Computer
Science and Statistics
University of Rhode Island
Kingston, Rhode Island, US
nalbarakati@uri.edu

Lisa DiPippo
Department of Computer
Science and Statistics
University of Rhode Island
Kingston, Rhode Island, US
ldipippo@uri.edu

Abstract— Women and ethnic minorities remain underrepresented in Computer Science (CS) major. The goal of this study is to examine the persistence among underrepresented students (URS) in introductory CS courses. This full paper describes an exploratory study to identify which non-cognitive factors such as academic performance satisfaction, learning assistance, peer interaction, and sense of belonging may help in predicting URS's intention to persist in CS major. Results suggest that academic performance satisfaction plays an important role in students' persistence in general. Also, studying with peers may increase women's intention to persist in CS. However, academic support has a negative association with ethnic minorities' persistence in the major. These findings can be used to make decisions to improve students' retention in CS. Implications of these results are discussed.

Keywords— persistence; retention; attrition; gender gap; race gap; survey; quantitative analysis; undergraduate students; computer science.

I. INTRODUCTION

While still few women and ethnic minorities (URM) consider studying computer science, unfortunately, many of those who begin their studies in computer science (CS) never earn a degree in it, choosing to switch to a different major instead [1][2][3]. Academic performance, lack of prior programming experience, and social aspects are significant barriers to underrepresented students (URS) in CS [4]. In this study, we explore other factors that may predict URS' intention to persist in an undergraduate computer science major, and how those factors may influence underrepresented students and overrepresented students experience differently at the University of Rhode Island. To answer this question, a survey instrument was created to collect students' data in introductory CS classes during the 2018-2019 academic year. Those introductory classes were chosen because they are the classes after which students and especially URS are most likely to leave the major. This survey was focused to

collect non-cognitive factors such as academic performance satisfaction, learning assistance, peer interaction, and sense of belonging. This study uses multivariate and regression analyses to identify the strongest predictors of students' intention to persist in the department of computer science at the university of Rhode Island. Those results may help decision makers to select solutions with the greatest potential to improve retention rate in our department.

II. LITERATURE REVIEW

Tinto, who developed one of the first models for studying student attrition and persistence in higher education, defined student attrition as "a longitudinal process of interactions between the individual and the academic and social systems of the college during which a person's experiences in those systems...continually modify his goals and institutional commitments in ways which lead to persistence and/or to varying forms of dropout" [5]. Tinto's definition emphasized how student attrition can involve many intersectional factors. Research has shown different reasons for students leaving computer science in general. Many reasons which include personal, social, and/or seriocomic factors, play a major role in students dropping or switching to other majors [6].

Many women start a computer science major with an inadequate background from high school in the subject, which causes them to struggle to perform as well as their peers who have computer science experience. Hence some women lose confidence in their ability to be successful and subsequently lose interest in the major [7]. Feeling that one doesn't belong, combined with being a minority in the classroom and confronting various gendered stereotypes, results in a loss of confidence for women, which can then lead to switching majors. In their Carnegie Mellon experience [8], authors stated that women transfer out of computer science more than men before the third year due to a loss of interest. They claimed that the drop of confidence precedes the drop of interest. They think that the low confidence in women is usually driven not by low

academic performance, but by them comparing themselves unfavorably with others. Another study evidenced another prominent factor in women's decisions to consider leaving STEM studies is the hostility directed at them by their male peers and faculty members, and the refusal of them to take women seriously ends up initiating an intimidation reaction, which could lead women to leave the program [9].

For URM, research suggests that the lack of computer experience and the perception that computer science is for geeks and nerds were the two significant barriers [4]. Another study also explained that URM students who have not been exposed to family members who are successful in technology-related fields or have a role model are unlikely to major in STEM [10]. Researchers also suggested that URM students are more likely to come from low-income families, and they might not have access to the academic resources that help support students through their higher education [11].

III. RESEARCH QUESTIONS

In this section we define the two research questions that we address in this paper relative to URS' intention to persist in computer science:

1. How do intention to persist in CS introductory classes and other exploratory factors vary by gender and URM status?
2. Do these factors predict URS intention to persist? How do these results look compared to overrepresented students?

IV. MEASURES

A survey instrument was used to collect students' data (N=208) in the first two CS introductory classes in two consecutive semesters of 2018-2019 academic year at the University of Rhode Island. Those two classes were chosen as students and especially URS were most likely to leave after taking them as 49% of students who switched majors between 2014 and 2019, not including students who dropped out of school completely, did so in the first year of the program. Moreover, 56% of women and URM who left, did so after taking the first two CS courses. The survey was administered anonymously so students could answer honestly and freely. Table 1 shows a description of the data. The survey response rate was 66%.

A. Dependent Variable (*intention to persist*)

The outcome variable is a single item, which measured students' expectation to continue in the CS program for the next semester, and it was adapted from a previous study [12]. Response options ranged from 1 to 5, with 1 = completely certain I won't return next semester, 2 = fairly certain I won't return next semester, 3 = undecided, 4 = fairly certain I will return next semester, and 5 = completely certain I will return next semester. This variable was treated as continuous since it has five categories [13].

B. Independent Variables (*Explanatory Factors*)

Independent variables were drawn also from the survey conducted at the end of the two CS introductory classes. Data such as demographics, sense of belonging, performance satisfaction, and academic support were collected.

1. Demographics

To measure gender, students were asked to select one of the following options: female, male, or other. Due to small numbers of students who selected others, they are excluded from these analyses, and gender was recoded as a dichotomous measure (0 = male; 1 = female). To measure race, students selected one or more of the following: White, African American, Hispanic/Latino, American Indian/Alaska Native, Other. Students identifying with at least one of the following were counted as URM: African American; Hispanic/Latino; Native American/Native, Hawaiian/ Pacific islander. White/Caucasian and Asian students were coded as majority in the context of computing. Due to small sample sizes, we used a dichotomous measure of URM status for analyses (0 = Majority; 1 = URM). The socioeconomic status was excluded from this study as 35% of students chose not to respond to this question.

2. Sense of Belonging

This variable is a three-item measure of sense of belonging based on respondents' agreement with the following: "I feel like I 'belong' in computing", "I feel like an outsider in the computing community" (reverse-coded), and "I feel welcomed in the CS major community". Students responded to each of these items on a five-point scale (1 = strongly disagree, 5 = strongly agree). This measure was adapted from an existing measure [14], which focuses on the sense of belonging in the computing context. For descriptive analyses, sense of belonging was measured by adding the three items together to create a scale ranging from 3 (low sense of belonging) to 15 (high sense of belonging). The Cronbach's alpha for this measure was 0.80.

3. Performance Satisfaction

This one-item scale was adapted from an existing measure [15]. The scale was modified to fit CS students. In this study, performance satisfaction was measured by asking students to rate their level of satisfaction with their academic performance on a 5-point scale (1 = completely not satisfied, 5 = completely satisfied).

4. Academic Help

We examined many academic skills' factors such as study hours, studying with others, asking for help by meeting with professor, TA, or tutor. Academic help factors, which were meeting with professor, TA, or tutors for help, were the only ones that showed significant results among students. Those variables were combined to measure the frequency of academic support students received. Each item had responses ranging from 1 to 5, with 1 = never, 2 = once a semester, 3 = 1-2 times a month, 4 = once a week, and 5 = more than once a week. The three variables were added together to create a scale ranging

TABLE 1. DESCRIPTIVE STATISTICS FOR ALL KEY VARIABLES

	Male (N=172) M(SD)	Female (N=36) M(SD)	majority (N=156) M(SD)	minority (N=52) M(SD)	Overall (N=208) M(SD)
Intention to Persist	4.53 (0.93)	4.06 (1.37)	4.47 (1.07)	4.38 (0.89)	4.45 (1.03)
Sense of Belonging	3.56 (0.82)	3.08 (0.81)	3.53 (0.83)	3.31 (0.83)	3.48 (0.83)
Performance Satisfaction	3.05 (0.88)	2.83 (0.88)	3.13 (0.84)	2.56 (0.93)	3.02 (0.88)
Academic Help	5.85 (2.74)	6.86 (2.95)	5.74 (2.75)	6.88 (2.77)	6.02 (2.79)
Studying with others	2.83 (1.40)	2.50 (1.59)	2.81 (1.43)	2.65 (1.47)	2.77 (1.44)

from 3 (low help) to 15 (high help), which we called academic help. The Cronbach's alpha for this measure was 0.77.

5. Studying with Others

Students were asked to rank the frequency of studying with others by asking "how often do you study with other students outside of class time". Each item had responses ranging from 1 to 5, with 1 = never, 2 = once a semester, 3 = 1-2 times a month, 4 = once a week, and 5 = more than once a week.

V. RESULTS

RQ.1 How do intention to persist in CS introductory classes and other exploratory factors vary by gender and URM status?

Two-sample Hotelling's T^2 -test [16] was used to test the difference of all variables based on gender and race respectively (using the "Hotelling" package in R[17]). *post hoc*, pair-wise analysis with Bonferroni correction was carried out to examine the between-group differences as shown in Table 2.

Women. Based on gender, the Hotelling's T^2 -test was statistically significant ($F(4,203) = 4.18$; $p\text{-value} < 0.01$). *post hoc* tests indicate that women had a lower intention to persist in CS than men. Women also showed a significantly lower sense of belonging and a higher frequency in asking for academic help compared to their male peers.

URM. The Hotelling's T^2 -test was also statistically significant based on race ($F(4,203) = 3.57$; $p\text{-value} < 0.01$). As we may see in table 2, URM showed no significant difference in their intention to persist in CS. However, they showed less performance satisfaction than their majority peers. URM were also more likely to ask for academic help than their majority peers.

RQ2. Do these factors predict URS intention to persist? How do the results look compared to overrepresented students?

To answer this question, we added two-way interaction terms to a multiple linear regression model. Interaction terms were computed by calculating the gender- or URM-based cross products for all independent variables. Table 3 shows the

standardized regression coefficients (1) when no interactions are included (i.e., main effects), and (2) when the interactions are included to assess how the prediction may vary based on gender and race.

For the main effect of these variables, gender, performance satisfaction, and sense of belonging had a significant impact on students' intention to persist. Women's intention to continue in CS was significantly lower than men. In addition, performance satisfaction and sense of belonging had a significant impact on students' intention to persist in general. The less satisfaction and lower sense of belonging, the less likely students were to persist in computer science.

TABLE 2: RESULTS OF PAIR-WISE ANALYSIS FOR RACE AND GENDER.

	Race	Gender
Intention to Persist	X	**
Sense of Belonging	X	***
Performance Satisfaction	**	X
Help	**	**
study with others	X	X

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; X indicates non-significance.

In addition, tests for interaction effects revealed that studying with others and academic help have a significant interaction based on gender and race respectively. As shown in figure 1, tests for interactions by gender revealed that studying with others was a significant positive predictor of the intention to persist for women as the more they study together the more they may persist in the major. Also, figure 1 shows that studying with others helped URM, but the result was not significant. Moreover, tests for interactions by race revealed that the

frequency of asking for help was a significant negative predictor of the intention to persist for URM, but it was not significant for majority students.

added two-way interaction terms computed by calculating the gender- or URM- based cross products for all factors to examine the extent to which effects might be unique for women and URM.

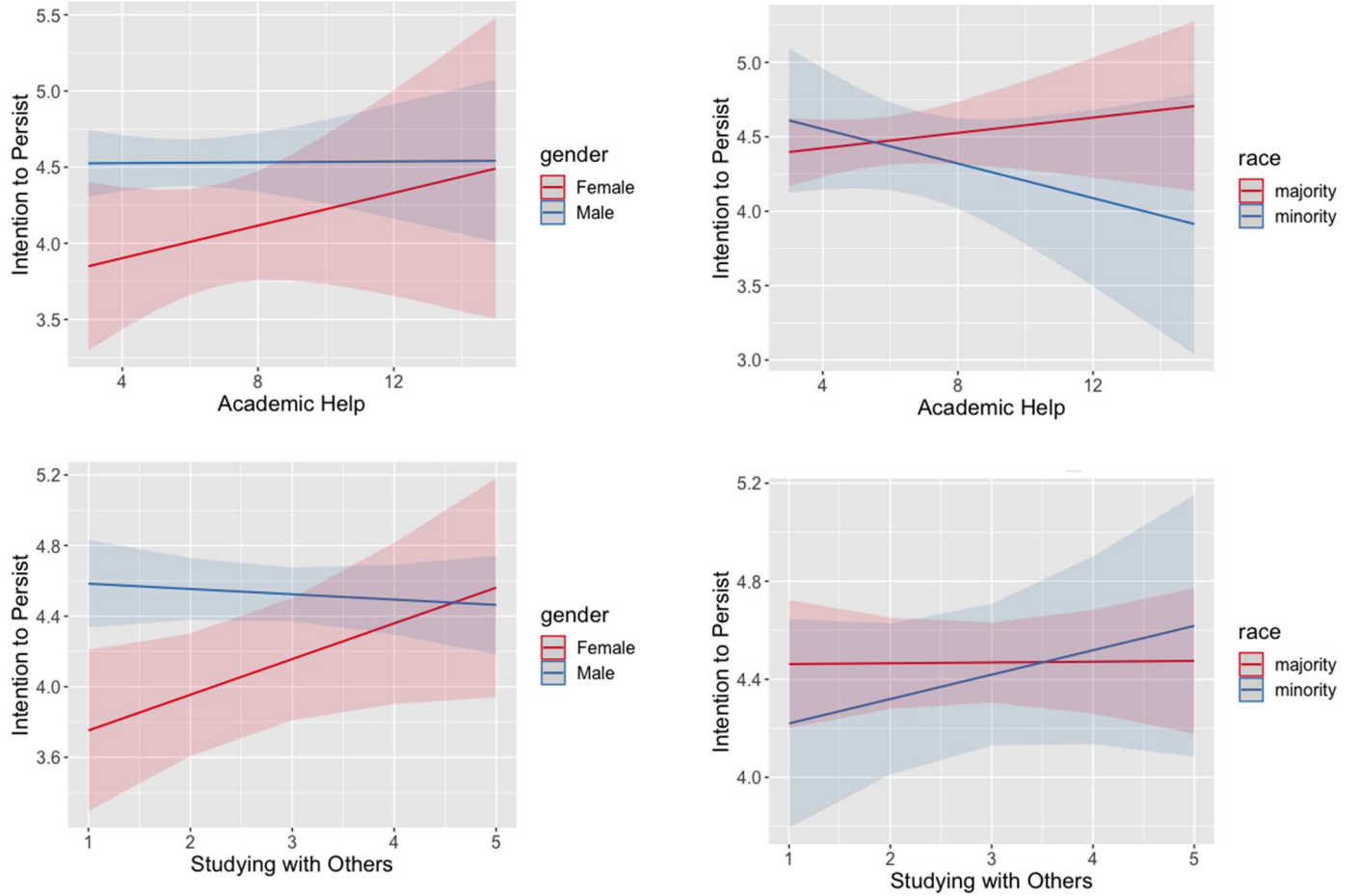


Fig. 1. Factors' prediction based on gender/race

I. DISCUSSION AND IMPLICATION

This study measured many aspects of in-major experience of students who took introductory computer science classes at one university. We used regression analyses to provide some understanding as to which aspects of the URS's experience were predictive of intention to persistence in CS. The results of this study provided support for prior research into URS persistence and new findings to help researchers and practitioners re-consider the ways they think about the retention of URS in our computer science department.

Intention to Persist. We conducted multivariate and regression analyses to examine relationships between many factors, which we thought would make a difference, and intention to persist in CS major. In particular, we were interested in understanding which factors might play a role in URS intention to persist in the major. Those factors, as shown in Table 3, were gender, race, sense of belonging, performance satisfaction, academic help, and studying with others. We first examined the main effects of these factors on students' intention to persist, then we

When examining the main effects of the regression to find the best predictors of intention to persist for all students in introductory CS classes, results revealed that performance satisfaction was the strongest predictor. That is, if students are satisfied with their performance compared to others, they may persist in the major in general. These results confirmed prior study which says students who are highly integrated academically are more likely to persist and complete their degree [18]. Sense of belonging also played an important role in students' intention to persist. The increase in students' feeling like they belong to the intellectual and social community of CS may lead to more persistence in the major, and that is also consistent with research that suggests that sense of belonging can improve the academic resilience of computer science students, thus improving retention [19].

TABLE 3: MULTIPLE LINEAR REGRESSION RESULTS

	Main Effect	Gender Interactions	Race Interactions
Constant	2.51 (0.41)	2.69 (0.41)	2.03 (0.42)
Gender: Female	-0.32** (0.18)	-0.86* (0.47)	-0.37** (0.18)
Race: URM	0.08 (0.16)	0.1 (0.16)	1.53* (0.9)
Sense of Belonging	0.16** (0.09)	0.18*** (0.09)	0.19*** (0.1)
Performance	0.15*** (0.04)	0.14*** (0.04)	0.18 *** (0.04)
Help	0.02 (0.03)	0.02 (0.03)	0.04* (0.03)
Studying with others	0.03 (0.05)	-0.03 (0.06)	0.01 (0.06)
Sense of Belonging		-0.26 (0.25)	-0.03 (0.2)
Performance		-0.01 (0.09)	-0.13 (0.08)
Help		0.01 (0.01)	-0.14** (0.06)
Studying with others		0.24** (0.13)	0.16 (0.12)
<i>Adjusted R2</i>	<i>0.13</i>	<i>0.14</i>	<i>0.15</i>
<i>F</i>	<i>6.237</i>	<i>4.340</i>	<i>4.625</i>

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. This table shows three different models predicting intention to persist. Bold indicates interaction.

Gender/Race. We unsurprisingly found that the female gender was negatively associated with intending to persist in CS. Reasons for a lower persistence by women were already explained in the literature. Several gender differences can account for the lower intention of women to persist in CS after taking the introductory course. Feeling of isolation, low self-efficacy, and sometimes the hostility directed at them by their male peers and by sometimes faculty could play a role in pushing women out of the major [9][20]. URM, on the other hand, did not show any difference in their intention to persist than their majority peers, which is consistent with previous research [14].

Performance Satisfaction. Performance satisfaction was the strongest predictor of students' intention to leave in general. Results showed that the increase in performance satisfaction makes students 56% more likely to persist in the major. Further research is needed to find if students' performance satisfaction is related to students' GPA or any other factors. When comparing performance satisfaction based on gender and race, we found that URM were less satisfied than the majority, and that could be because of higher self-expectations or worries about contributing to stereotypes[21]. Further research is needed to identify the main reasons for their dissatisfaction. However, interaction effects, when added to the model, revealed no variation of intention to persist based on performance satisfaction for women and URM.

To increase students' satisfaction with their performance, instructors could adopt some active learning pedagogical activities in their classes as collaborative learning may influence students' satisfaction with their learning processes positively especially in introductory programming classes [22][23].

Sense of Belonging. Prior research both in general and in CS, in particular, showed that sense of belonging increases student retention [24], which confirms our results that the increase in sense of belonging leads to an increase in intention to persist in the major. Research also proved that women tend to start CS with a lower sense of belonging [19], which also confirms the multivariate Hotelling's T^2 -test results of women having a lower sense of belonging than men in CS introductory classes. However, this factor did not vary by gender and URM status. This study reaffirmed that college environments matter. Students who perceive more supportive environments feel an enhanced sense of belonging in the major. Therefore, our CS department may consider developing clubs, communities, team-based events (e.g., hack-a-thons), and other activities and organizations to foster the sense of community, especially for women and URM.

Studying with Others. Studying with others did not show any significant results when predicting students' intention to persist in CS in general. However, when interaction terms were added, studying with others was a positive predictor of intention to persist for women. That is, women's intention to stay in the major increases when they study more with their peers. URM also showed an increase in persistence intention when studying with others, but this result was not significant. Thus, our computing department might consider encouraging academic communities and study groups to increase women and URM retention in the major.

Academic Help. Multivariate results showed that women and URM seek out more academic help than others. However, when academic help was added to the regression model to examine the prediction based on gender and race, tests for interactions only revealed that the more URM ask for help, the less likely they are to intend to stay in the major, which contradict previous findings that say academic support and learning assistance help students to persist more in their majors[25]. For women, results

showed that the more they go for academic help, the more they stay in the major as shown in figure 1, yet the interaction was not significant. However, asking for academic help affected URM negatively. The more they go for help, the more they think about leaving the major. Is it because worrying about contributing to stereotypes makes them think about leaving? Or they just cannot find what they are looking for? Or perhaps they need to be incented to seek help earlier than they do. Further qualitative analysis is needed to answer these questions.

VI. LIMITATIONS

The analysis has certain limitations. The collected data are based only on students who volunteered to participate in the study. Also, non-gender binary students were dropped from this study as their numbers were too small to be included. We also acknowledge that women and URM sample size may be too small to make generalized conclusions to the whole population. Plus, the lack of significance of some results may also be due to small sample sizes of women and URM, hence a lack of statistical power. Additionally, all data were students' self-reported, so some data might be randomly selected.

VII. CONCLUSION

Given the results, factors such as performance satisfaction, gender, and sense of belonging played an important role in predicting students' intention to persist in computer science introductory classes. Additionally, when examining students' intention to persist, variation based on gender and race, women who study with others showed a higher willingness to stay in the field. Yet, the more URM asking for academic help, the more they think about leaving the major. For future work, qualitative study and phenomenological analysis will be conducted to evaluate and interpret lived experiences of URS who left the major with the aim of having more elaboration on the presented results and finding more hidden factors.

ACKNOWLEDGMENTS

N. Albarakati would like to acknowledge the financial support from the Saudi Electronic University and the Ministry of Higher Education (Riyadh, Saudi Arabia).

REFERENCE

- [1] J. M. Cohoon, "Recruiting and retaining women in undergraduate computing majors," *ACM SIGCSE Bull.*, vol. 34, no. 2, pp. 48–52, 2002.
- [2] L. Dickson, "Race and gender differences in college major choice," *Ann. Am. Acad. Pol. Soc. Sci.*, vol. 627, no. 1, pp. 108–124, 2010.
- [3] J. J. Ferrare and Y.-G. Lee, "Should we still be talking about leaving? A comparative examination of social inequality in undergraduate patterns of switching majors," 2014.
- [4] S. J. Bock, L. J. Taylor, and P. Zachary E, "Women and Minorities in Computer Science Majors: Results on Barriers From Interviews and a Survey," *Issues Inf. Syst.*, vol. 14, no. 1, pp. 143–152, 2013.
- [5] V. Tinto, "Dropout from Higher Education: A Theoretical Synthesis of Recent Research," *Rev. Educ. Res.*, vol. 45, no. 1, pp. 89–125, 1975.
- [6] T. Beaubouef and J. Mason, "Why the High Attrition Rate for Computer Science Students: Some Thoughts and Observations," *SIGCSE Bull.*, vol. 103, no. 2, 2005.
- [7] R. M. Powell, "Improving the persistence of first-year undergraduate women in computer science," in *SIGCSE '08 - Proceedings of the 39th ACM Technical Symposium on Computer Science Education*, 2008, pp. 518–522.
- [8] A. Fisher and J. Margolis, "Unlocking the Clubhouse: The Carnegie Mellon Experience," in *ACM SIGCSE Bulletin*, 2002.
- [9] R. Varma, "Women in computing: The role of geek culture," *Sci. Cult. (Lond.)*, vol. 16, no. 4, pp. 359–376, 2007.
- [10] E. Chute, "Lack of Diversity Part of Equation in STEM Fields," *Pittsburgh Post-Gazette*, pp. 1–3, 2009.
- [11] N. A. Buzzetto-More, O. Ukoha, and N. Rustagi, "Unlocking the Barriers to Women and Minorities in Computer Science and Information Systems Studies: Results from a Multi-Methodological Study Conducted at Two Minority Serving Institutions," *J. Inf. Technol. Educ. Res.*, vol. 9, pp. 115–131, 2010.
- [12] D. Ingram, "College Students' Sense of Belonging: Dimensions and Correlates," Stanford University, 2012.
- [13] S. E. Harpe, "How to analyze Likert and other rating scale data," *Curr. Pharm. Teach. Learn.*, vol. 7, no. 6, pp. 836–850, 2015.
- [14] K. J. Lehman, K. L. George, L. J. Sax, C. Zavala, J. M. Blaney, and S. L. Rodriguez, "Sense of Belonging in Computing: The Role of Introductory Courses for Women and Underrepresented Minority Students," *Soc. Sci.*, vol. 7, no. 8, p. 122, 2018.
- [15] C. T. Logue, J. W. Lounsbury, A. Gupta, and F. T. L. Leong, "Vocational Interest Themes and Personality Traits in Relation to College Major Satisfaction of Business Students," *J. Career Dev.*, vol. 33, no. 3, pp. 269–295, Mar. 2007.
- [16] H. Hotelling, "The Generalization of Student's Ratio," *Ann. Math. Stat.*, vol. 2, no. 3, pp. 360–378, Aug. 1931.
- [17] J. M. Curran, "Package 'Hotelling' Title Hotelling's T² Test and Variants," 2017.
- [18] V. Tinto, "Taking Retention Seriously: Rethinking the First Year of College," *NACADA J.*, vol. 19, no. 2, pp. 5–9, 1999.
- [19] N. Veilleux, R. Bates, C. Allendoerfer, D. Jones, J. Crawford, and T. Floyd Smith, "The relationship between belonging and ability in computer science," in *Proceeding of the 44th ACM technical symposium on Computer science education - SIGCSE '13*, 2013, p. 65.
- [20] J. Wolfe and B. A. Powell, "Not all curves are the

- same: Left-of-center grading and student motivation,” *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 122nd ASEE, no. 122nd ASEE Annual Conference and Exposition: Making Value for Society, 2015.
- [21] M. A. Beasley and M. J. Fischer, “Why they leave: The impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors,” *Soc. Psychol. Educ.*, vol. 15, no. 4, pp. 427–448, 2012.
- [22] D. M. Teague and P. Roe, “Collaborative learning : towards a solution for novice programmers,” 2008.
- [23] L. Williams, E. Wiebe, K. Yang, M. Ferzli, and C. Miller, “In Support of Pair Programming in the Introductory Computer Science Course,” *Comput. Sci. Educ.*, vol. 12, no. 3, pp. 197–212, 2002.
- [24] L. Barker, C. L. Hovey, and L. D. Thompson, “Results of a large-scale, multi-institutional study of undergraduate retention in computing,” in *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, 2014, vol. 2015-Febru, no. February, pp. 1–8.
- [25] M. Grillo and C. Leist, “Academic support as a predictor of retention to graduation: New insights on the role of tutoring, learning assistance, and supplemental instruction,” *J. Coll. Student Retent. Res. Theory Pract.*, vol. 15, no. 3, pp. 387–408, 2013.