Investigating Impacts of STARS Program Components on Persistence in Computing for Black and White College Students

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***Abstract*—Persistence is a particularly important topic surrounding computing - 50% of students who begin a computing major do not complete their major [1]. Persistence in computing is an even larger problem for minority students [2]. In this study, we investigate how participation in the STARS program impacts persistence in computing among undergraduate computing students. Using structural equation models based on post-surveys of 1885 students, we found that participation in STARS has a significant impact on increasing persistence among computing students. The relationship between participation in STARS and increasing persistence differs for students by racial-ethnic groups. Overall, STARS significantly impacts persistence by making students more confident in their computing abilities, increasing their career awareness, and providing students with the opportunity to network professionally. Importantly, STARS also influenced persistence indirectly by helping students to be more satisfied with their majors. These findings provide a meaningful basis for future research to investigate how interventions may differentially impact students from different demographic groups.**

***Keywords*—persistence, broadening participation in computing, interventions, undergraduate, computer science education**

I. Introduction

Professions in science, technology, engineering, and math (STEM) are rapidly growing, particularly within the field of computer science [3]. This career field is incredibly lucrative, offering high levels of compensation, yet is still dominated by white men. Men hold 73% of computer science jobs, and 70% of computer scientists are white [3]. These in-demand and well-paying careers could be life-altering, especially for less-privileged individuals, but these positions are still out of reach for many from underrepresented groups, especially for Black, indigenous, and people of color. While considerable attempts have been made to broaden participation in computing, more investigation is needed to understand the best practices that are most effective for student persistence in computing programs, and especially for students who are currently underrepresented in computing.

This study investigates persistence among a large national sample of participants in the Students and Technology in Academia, Research, and Service (STARS) Computing Corps, an effort funded through the National Science Foundation's Broadening Participation in Computing (BPC) program [8]. STARS engages computing faculty and students at colleges, universities, and community colleges in a community of practice [9] [10] with a shared commitment to take action to advance diversity, equity, and inclusion in computing. STARS is a systematic effort that engages institutions of higher education to broaden the participation of women and underrepresented minority groups in computing. STARS is a unique BPC program because its signature STARS Leadership Corps

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(SLC) intervention is locally offered and personally tailored to increase persistence in computing majors and careers. The SLC is the subject of the current study, as we seek to understand how STARS impacts college student persistence in computing. In this study, we investigate how college student participation in the SLC impacts persistence within computing. Evidence has shown that engagement in STARS increases computing persistence [17]–[19], [35]. In this study, we investigate *how* STARS engagement increases persistence across psychosocial constructs related to computing retention and to further our understanding of how these patterns vary by gender and racial/ethnic identity groups.

II. Racial Diversity in Computing

African Americans comprised about 12.4% of the United States population in 2020 [37], but only 1.9% of bachelor's enrollments in computing fields [38], making this group significantly under-represented in the field in the United States. However, Black/African American students have few role models in computing [39] and are often not counseled on the computing career opportunities, and as a result, are unaware of and unable to choose computing career options [4]. Additionally, students from underrepresented groups may not feel a sense of belonging in computing because of stereotypes, such as the prevalence of marketing that depicts socially awkward white men as the norm in computing [12] [13]. A sense of belonging is vital to ensure that students are successful in their undergraduate education and is crucial to persistence within computing majors [12] [13].

By broadening participation in computing, we can ensure that computing serves all individuals [6]. By focusing on recruiting and retaining individuals from underrepresented groups, the computing talent pool can be increased, and these groups can achieve upward mobility through computing careers [41]. However, Black/African American students face a major challenge to pursuing computing - a lack of belonging in computing programs [5]. Additionally, research has shown that mentors, connections to faculty, and role models of color in computing, build relationships that are pivotal to increase persistence among Black/African American students in computing [16].

III. Persistence

We define persistence as student agency and motivation, i.e. student choice to continue in their major [2], rather than by institutional retention. Black/African American students have lower degree completion in STEM, resulting in less diversity in computing [1]. While persistence and commitment to major are not entirely predictive of following a career in computing, research suggests that intentions to persist in a STEM field are predictive of actual persistence in a STEM career [17]. This finding is supported by the *theory of planned behavior*, which states that the most important predictor of actual behavior is the behavioral intention behind that behavior [18]. While many studies about persistence focus on persistence and interest in computing from K-12 to college, there is a need for further studies in persistence in STEM after graduating from college [19]. Persistence is also related to race, with Black/African American students experiencing increased structural and institutional barriers to success and persistence within STEM [1] [13] [20]. Some of the persistence gap is structural, with Black/African American students being less prepared for a STEM major [20]. However, the pedagogical techniques used by STEM faculty are also responsible for lack of persistence among all students, with lecture-based courses allowing for less engagement than discussion-based or laboratory courses [21]. While the low rate of persistence may seem alarming, there are several interventions that are being developed to increase persistence of all STEM students – and specifically for Black/African American students [2] [22]. While these programs, like STARS, use different types of interventions, there is little research on how these experiences may be most impactful for students across a range of identities. The interventions that have shown the most promise include research experiences, networking opportunities, and career exploration [2] [23] [24].

IV. The STARS Computing Corps

STARS offers a variety of programs and events designed to impact student and faculty outcomes and advance BPC research and practice (see Fig. 1). The SLC is the flagship activity for student engagement. From its inception in 2006 until 2016, the SLC has engaged over 2,000 college students and 100 faculty from 53 colleges and universities in computing specific service-learning projects. Through SLC projects, STARS faculty and students collaborate with local, regional, and national partners to broaden participation of underrepresented groups in computing through grades K-20. The SLC is a cohort-based model that encapsulates conference attendance, training, and BPC action as part of student-led, faculty-mentored teams. STARS also provides faculty training, resources, and a community to support student teams to design and implement BPC service learning projects [25] [26] [27]. The STARS model (see Fig. 1) creates a BPC community of practice through tiered mentoring among faculty and students across grades K-20, among college faculty, graduate, and undergraduate students, most of whom mentor students in grades K-20.

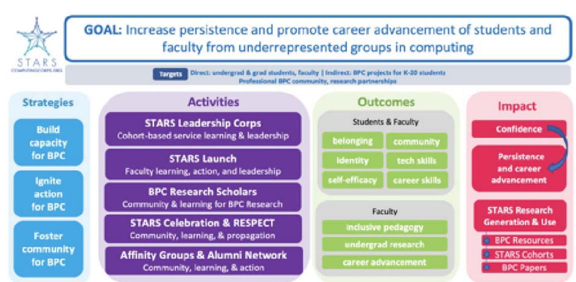

Fig. 1. The STARS Logic Model

STARS student participation typically starts with attendance at the STARS Celebration, where students become inspired and learn to engage in BPC initiatives. The STARS Celebration trains SLC cohorts to create and implement a BPC action plan, adapted to their local contexts and populations, and provides a venue for sharing new BPC practices, resources, and outcomes so that SLC cohorts can learn from each other. Such cohort-based opportunities for training and reflection are critical components for enhancing academic outcomes [23] [29] [30]. The Celebration also builds community, which is particularly meaningful for the success of students from historically marginalized groups [31] [33].

When students return to their college campuses, they work in local cohorts to implement an SLC project, spending about 5 hours a week to design their project, deliver and assess its efficacy, and present the impact at the national STARS Celebration conference. SLC projects include teaching computing through K12 outreach; peer outreach to teach computing to college students; mentoring; research, or internships. For example, STARS students have designed and led Saturday computing workshops and after school programs for middle school students, built college-level peer tutoring programs, and established a network of computing volunteers who work together to support teachers teaching computing in K-12 classrooms. Some STARS colleges and universities work together to address regional needs, for example by holding joint professional networking events for Black computing students.

V. Research Questions

The central research questions guiding this study of persistence among STARS students are:

1) How do the different components of STARS impact persistence in computing?
2) Do these components differ for students by racial/ethnic group?

VI. Methods

This secondary data analysis is from the annual STARS Leadership Corps (SLC) Student Program Evaluation Survey, which has been collected from undergraduate and graduate student SLC participants from 53 universities over the span of 10 years. This survey consisted of items that measured student project engagement, their attitudes towards the STARS program, including how participating in STARS impacted them socially, academically, and professionally.

A. Participants

A total of 1,885 students completed post-surveys after participating in STARS in the SLC for at least one academic term between the Fall of 2006 and Spring of 2017, with 1,596 being undergraduate students, and 259 being graduate students; 674 white/Caucasian and 712 Black/African American. This is a non-random sample of individuals who participated in STARS who completed the survey. To be included in this analysis, respondents had to be undergraduate (associate's or bachelor's degree seeking) or graduate (master's and doctoral degree seeking) students and have completed the entire survey in full.

B. Design and Procedures

The concept of CS persistence has been used in previous research and has been analyzed by utilizing four variables that measure the following: an increased interest in research, an increased interest in graduate school, an increased level of commitment towards their chosen career, and an increased interest in their major [35]. Persistence in this study is operationalized as a latent variable based on these four observed survey variables. All variables were measured using a six-point Likert scale that ranged from 1 ("Strongly Disagree") to 6 ("Strongly Agree"). The items have an alpha level of .89, which shows that they reliably measure the latent concept of persistence. Table 1 features a correlation matrix that displays the correlation of these variables.

TABLE I
Correlation Matrix of the Latent Variable of CS Persist

	Increased Research	**Interest in Graduate School**	**Commitment to Major**	**Increased Interest in Major**
Increased Research	1.000			
Interest in Graduate School	.7343	1.000		
Commitment to Major	.6697	.6006	1.000	
Increased Interest in Major	.6792	.6649	.7507	1.000

To investigate how STARS increases CS persistence, a full structural equation model (SEM) analysis was conducted to analyze the effects of different components of the STARS program on persistence. The model consists of the latent variable of STARS persistence, comprised of the same four variables mentioned above (Table 1). We then analyzed how components of the STARS program impacted STARS persistence. The variables included in this analysis can be found in Table II. Theoretical considerations led to inclusion of indirect paths from some of the variables (e.g. skill development through working with people like them), through a variable that measured if STARS increased a student's satisfaction with their major. The items were taken from the section of the survey that asked students how STARS had acted as a catalyst for these different behaviors. The 15 items have an alpha level of .95, showing that they are a reliable relationship to persistence. The analyzed predictor variables are highly correlated with each other and with persistence, with values ranging from 0.51 to 0.81.

Additionally, after investigating the overall impact of the STARS program, we generated separate SEM analyses on white/Caucasian and Black/African American students to identify possible differences between the two groups as they relate to the STARS program, persistence, and satisfaction with their major. We used the overall model fit indices to refine the models separately for each group.

TABLE II
VARIABLES FROM STARS SLC STUDENT SURVEYS

Variable Name	**If STARS student participation had:**
Satisfied Major	Increased satisfaction with their major
Network Professionally	Provided professional networking
Career Awareness	Increased awareness of career opportunities
Faculty Collaboration	Increased faculty collaboration
Develop Skills	Helped develop computing skills
Improve Performance	Improved their academic performance
More Confident	Built confidence in computing skills
Taught Computing	Facilitated teaching computing
Work with Peers	Increased students' work with peers
Work w. People Like Me	Increased work with people like them

C. Limitations

Self-report surveys have the likelihood of reporting bias. However, we believe that the best way to determine program impacts on participants is to ask them [36]. These surveys were captured over an extended period of time, so we are not attributing causal effects, but rather describing the relationships of factors that contribute to persistence in computer science. The missing data was accounted for within our statistical analyses.

VII. RESULTS

TABLE III
RESULTS OF OVERALL MODEL OF STARS IMPACT ON PERSISTENCE

Variable	Coefficient
Satisfied Major	.381***
More Confident	.139***
Career Awareness	.121***
Network Professionally	.091***
Develop Skills	.062**
Taught Computing	.044**
Improve Performance	.015
Faculty Collaboration	-.002

***p = <.001 **p = <.005

Table III and Fig. 2 show the overall well-fitting model, (RMSEA = .076, CFI/TLI =. 959/.936, CD = .854). The chi-square was significant ($p < .001$) which is likely due to the large sample size. The well-fitting model allows us to theorize as to which components of STARS have the most significant impact on increasing persistence. STARS is a multifaceted program, with each component of the program working in tandem to increase the success of each student.

A. Models for white and Black student groups

As noted above, to understand if the effects of STARS are consistent across groups, we next generated a separate model for Black/African American (fig. 3) and white/Caucasian students (fig. 4). Coefficients for the separate path models learned for each student group for predicting persistence are shown in Table IV. Each model includes coefficients for direct impacts on persistence, and for indirect impacts on persistence mediated by satisfaction with the major. On each row, the larger coefficients for persistence and major satisfaction models are bolded when comparing groups. To analyze how the STARS program impacts persistence for Black/African American students, the well-fitting model (RMSEA = .081, CFI/TLI =. 964/.943, SRMR = .02, CD = .917) was refined. The chi-square was significant ($p < .001$) which is likely due to the large sample size, with n=712 Black students (including 281 Black women). All of the paths included in the model were significant predictors of CS persistence.

Refinement for white/Caucasian students led to a well-fitting model (RMSEA = .077, CFI/TLI = .974/ 956, SRMR = .02, CD = .846). The chi-square was significant ($p < .001$) which is likely due to the large sample size, with n=674 white students (including 257 white women). Five variables were significant direct predictors of STARS persistence, with the most significant being an increased level of satisfaction of major, with each unit increase of level of satisfaction in major predicted to increase persistence by 0.425 units.

TABLE IV
MODEL COEFFICIENTS FOR PERSISTENCE AND SATISFACTION WITH MAJOR FOR WHITE AND BLACK STUDENTS, ALL VALUES P<0.001

	Black (n=712)		***White (n=674)***	
Variable	***Persist Coeff.***	***Sat. Major***	***Persist Coeff.***	***Sat. Major***
Satisfied Major	.405		**.425**	
Career Awareness	.133	.097	.134	**.189**
Network Professionally	**.119**			
Develop Skills	**.079**			
More Confident	.074	**.285**	**.159**	.256
Faculty Collaboration	**.053**	**.110**		
Improve Performance	.050	.064	.054	**.117**
Taught Computing			**.094**	
Work w. People Like Me		**.238**		.159
Personally Rewarding		.173		**.267**

B. Comparing Persistence Models

Similarities. The most important direct factor for persistence for both groups was the impact STARS participation had on satisfaction with students' majors, with each unit improvement in major satisfaction predicting an increase of more than 0.4 on persistence for both groups. Career awareness was similarly important for both groups, with each unit increase of awareness of career opportunities predicted to increase persistence over 0.13. Improved performance had a lower impact, with coefficients near 0.05.

Differences. Comparing the models shows that STARS opportunities to network professionally, to develop skills, and to collaborate with faculty were important for Black students but were not significant predictors of persistence for white students. Confidence was important for predicting persistence for both groups, but had higher impacts for white students with a 1 unit increase in confidence predicted to increased persistence by 0.159 units, but predicted a smaller increase in persistence of 0.074 units for Black students. Helping others understand computing was significant for predicting persistence for white students, but not for Black students.

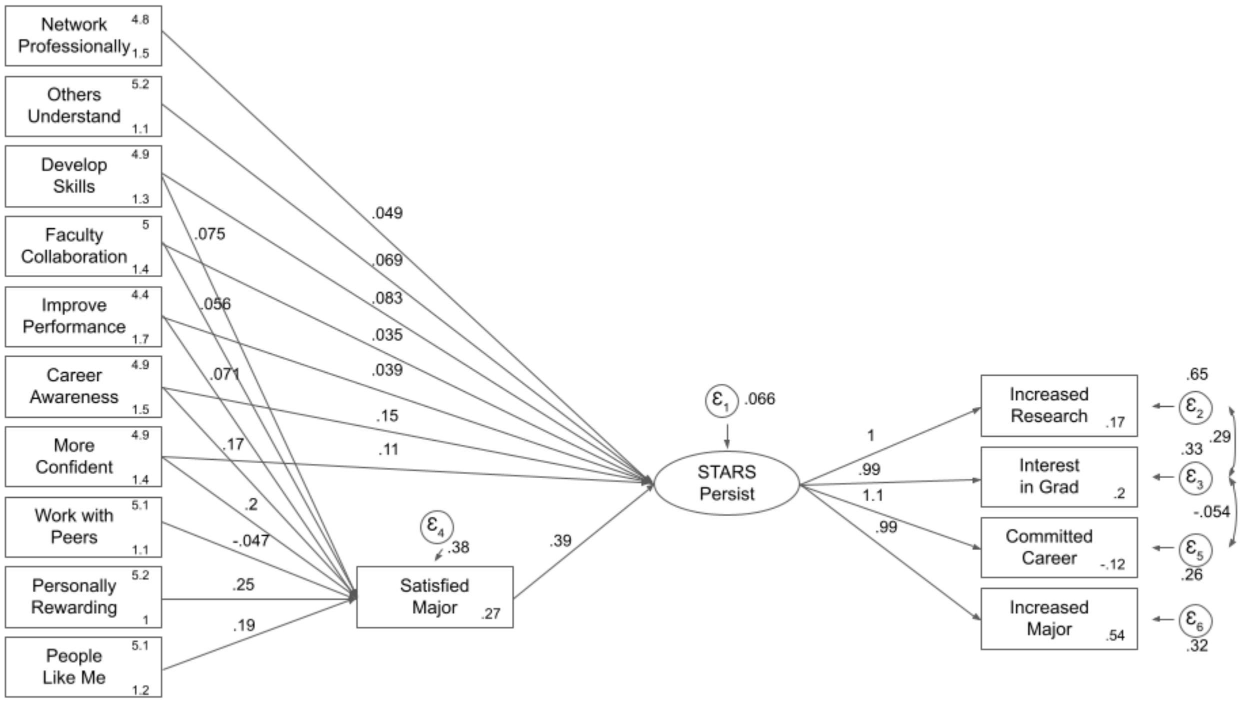

Fig. 2. Overall Persistence Structural Equation Model

C. *Comparing Major Satisfaction Models*

Satisfaction in major was modeled as a mediating factor for persistence, enabling the examination of the extent to which each component predicted CS major satisfaction.

Major Satisfaction model similarities. The models had similar significant factors, including confidence, career awareness, improved performance, working with people like me, and being personally rewarding for both groups. **Confidence** was an important component, with unit changes in confidence increasing major satisfaction similarly by 0.285 for Black students and 0.256 for white students.

Major Satisfaction model differences. For Black students, the extent to which STARS participation improved satisfaction with their major was most impacted (from most to least) by confidence, working with people like me, being personally rewarding, and faculty collaboration as the top factors with coefficients over 0.1. Faculty collaboration did not appear in the major satisfaction model for white students. The ranking of significant features for major satisfaction for white students from most to least was being personally rewarding, confidence, career awareness, working with people like me, and improving performance.

VIII. Discussion

The persistence models showed similarities in that satisfaction with the major and Career Awareness are two top predictors for persistence for both groups, but that Black students have different needs that lead to a higher predicted increase in persistence. These models indicate that Black students felt that the next most important aspects of STARS participation for their own persistence in computing were those related to developing their networks – to one another and to faculty, and their own skills and confidence. On the other hand, for white students, building confidence was more important than awareness of career opportunities, and helping others understand computing was a significant factor for this group as well. These differences in the factors that students felt led to their persistence in computing suggest that interventions may need to be designed to address the different needs for these groups, but also that the flexibility of the STARS Leadership Corps (SLC) allowed the program to be tailored to meet the needs of these diverse groups. The difference in CS Major Satisfaction models between groups point to the need for more research to understand important factors between groups. Surprisingly, if we take being personally rewarding and helping others understand computing as the two factors related to social relevance, these factors are better predictors for major satisfaction for white students in STARS than they are for Black students. Similarly, increased awareness of career opportunities improved major satisfaction more for white students than it did for Black students. STARS provided important opportunities for Black students to develop confidence and work with people like themselves, which were even more important to them for their satisfaction in their major than STARS being personally rewarding. On the other hand, white students found that STARS being personally rewarding, building their

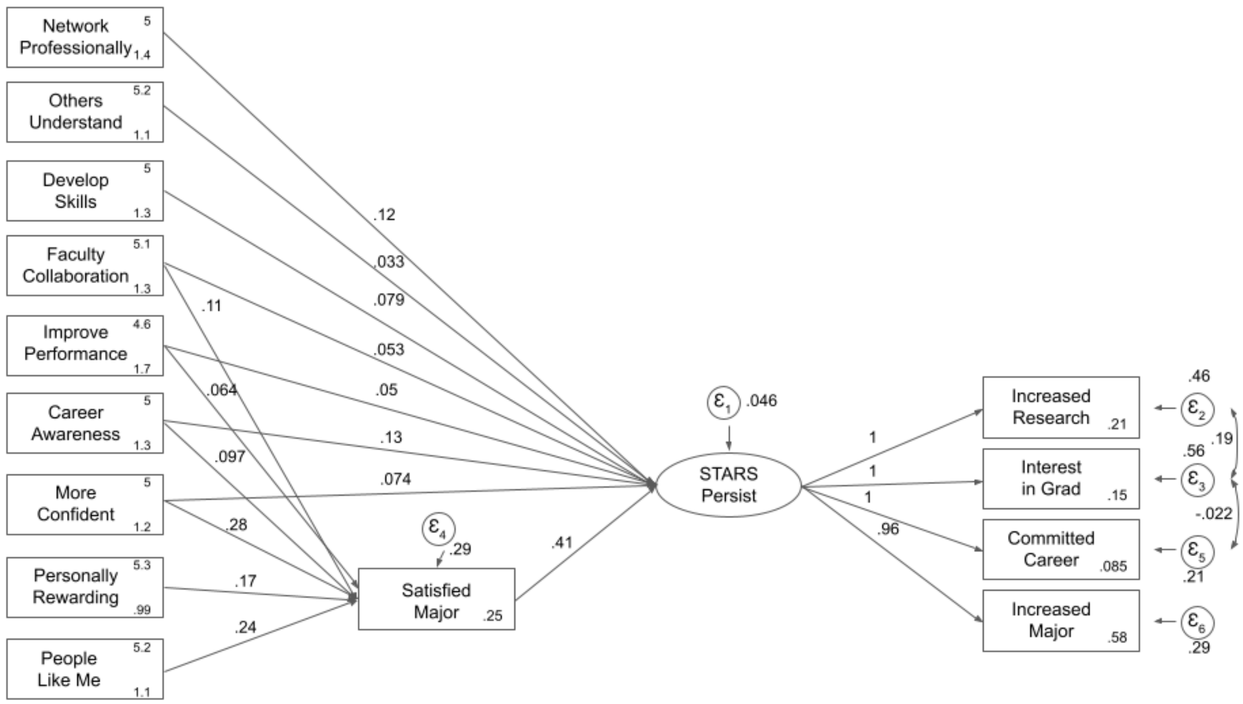

Fig. 3. Persistence SEM for Black/African American students

confidence, and raising career awareness, were more important components than working with people like themselves. These findings corroborate current literature pertaining to the critical need for students who are from underrepresented groups to cultivate the social and scientific capital needed in order to pursue computing [40].

IX. Conclusions

Increasing persistence within computer science is a key issue facing the discipline, especially for Black/African American students. The STARS program is increasing persistence in a meaningful way by offering students experiences outside of the classroom that expose them to other areas of computing. By increasing persistence, the number of computing students who graduate will increase, which fulfills the labor market's needs for computing professionals. Additionally, individuals who haven't previously been able to access careers in computing are able to do so through the confidence STARS has instilled in them. Participation in STARS showed a significant increase in persistence among all participating students, by increasing students' satisfaction with their major, confidence, and awareness of career opportunities. The model shows that by exposing students to networking and career opportunities within computing, STARS is able to increase the likelihood that a student will be committed not only to their computing major, but to their career in computing as well. These findings are important because the more Black/African American students who persist in computing, the more diverse the field can become. Thus, more individuals from a variety of backgrounds will have access to and be able to pursue careers in the field of computing. While it was previously shown that STARS does increase persistence [25] [26] [27], researchers did not understand specifically *how* it was increasing persistence, and whether the mechanisms for impact were different for different groups. With this new understanding of how STARS increases persistence and satisfaction with majors, we can emphasize the importance of the holistic experience that STARS offers, with all the components working together to make a meaningful impact on persistence of computing students. The contribution of this study is the demonstration of a model of how the STARS experience impacts persistence for college students in computing. This dataset offers a large and diverse sample of computing majors who have participated in STARS, which is incredibly valuable. This dataset could be used to further explore what interventions are most beneficial for Black students to further increase computing persistence by utilizing the interventions that are most effective for them. This research offers a necessary starting point for future research by offering a general understanding of how participation in STARS, and other programs designed to catalyze persistence in computing, can impact the psychosocial and identity factors surrounding persistence.

References

[1] Cabell, A.L. (2020). Career search self-efficacy and STEM major persistence. *The Career Development Quarterly, 69*, 158-164.

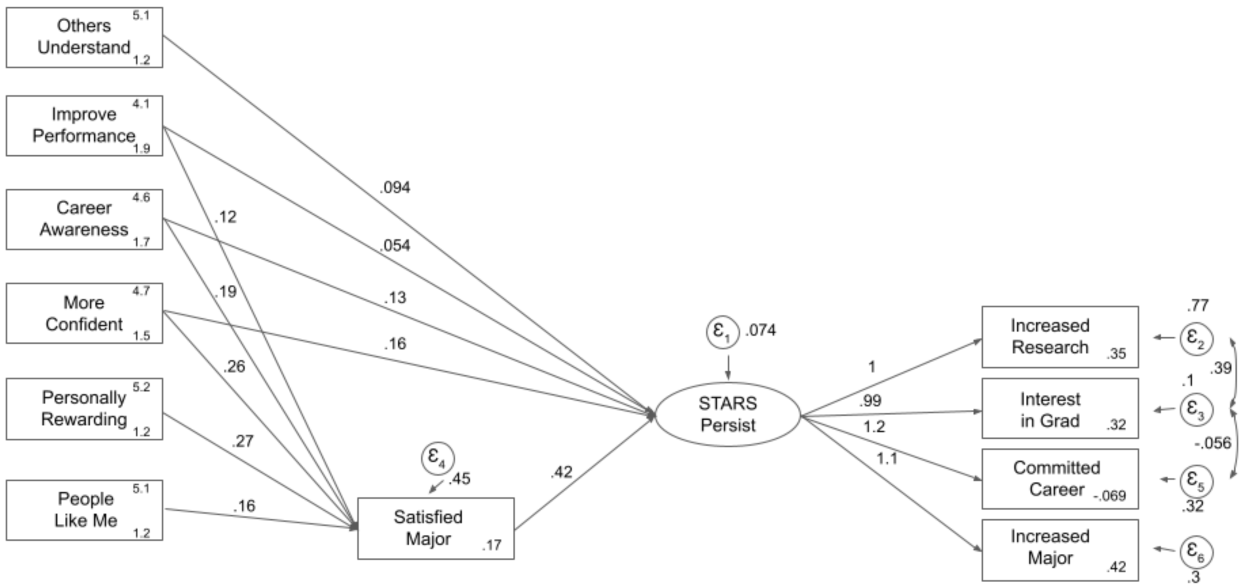

Fig. 4. Persistence SEM for white/Caucasian students

[2] Graham, M.J., Frederick, J., Byars-Winston, A., Hunter, A.B., and Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science, 341*, 1455-146.

[3] U.S. Bureau of Labor Statistics. (2021). Computer and Information Research Scientists. *Occupational Outlook Handbook.*

[4] Fisher, A., and Margolis, J. (2002). Unlocking the clubhouse, the Carnegie Mellon experience. *SIGCSE Bulletin, 34(2)*, 79-83.

[5] Palmer, R.T., Maramba, D.C., and Dancy, T.E. (2011). A qualitative investigation of factors promoting the retention and persistence of students of color in STEM. The *Journal of Negro Education, 80(4)*, 491-504.

[6] Estrada, M., Burnett, M., Campbell, A.G., Campbell, P.B., Denetclaw, W.F., Gutierrez, C.G., Hutado, S., … and Zavala, M. (2016). Improving underrepresented minority student persistence in STEM. *CBE Life Sciences Education, 15(5)*, 1-10.

[7] Narayanan, S., Cunningham, K., Arteaga, S., Welch, W.J., Maxwell, L., Chawinga, Z., and Su, B. (2018). Upward mobility for underrepresented students: a model for a cohort-based bachelor's degree in computer science. *ACM Inroads 9*, 2 (June 2018), 72–78. https://doi.org/10.1145/3210555

[8] STARS Computing Corps. (2021). About Us. Retrieved from http://www.starscomputingcorps.org/about-us/

[9] Wenger, E. (1999). Communities of practice: Learning, meaning, and identity. *Cambridge University Press*.

[10] Dagley, M., and Gerogiopoulos, M. (2015). Increasing retention and graduation rates through a STEM learning community. *Journal of College Student Retention Research Theory and Practice, 18(2)*.

[11] National Science Foundation. (2013). Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013. *National Center for Science and Engineering Statistics*.

[12] Sax, L.J., Blaney, J.M., Lehman, K.J., Rodriguez, S.L., Georgoe, K.L., and Zavala, C. (2018). Sense of belonging in computing: The role of introductory courses for women and underrepresented minority students. *Social Science, 7(122)*, 1-23.

[13] Master, A., and Meltzoff, A.N. (2020). Cultural stereotypes and sense of belonging contribute to gender gaps in STEM. *International Journal of Gender, Science, and Technology, 12*, 152-198.

[14] Seron, C., Silbey, S., Cech, E., and Rubineau, B. (2016). Persistence is cultural: Professional socialization and the reproduction of sex segregation. *Work and Occupations, 43(2)*, 178-214.

[15] Maramba, D.C. (2008). Immigrant families and the college experience: Perspectives of Filipina Americans. *Journal of College Student Development, 49*, 336-350.

[16] Zwolak, J.P., Zwolak, M., and Brewe, E. (2018). Educational commitment and social networking: The power of informal networks. *Physical Review Physics Education Research, 14(1)*, 1-12.

[17] Merolla, D.M., Serpe, R.T., Stryker, S., and Schultz, P.W. (2012). Structural precursors to identity processes: The role of proximate social structures. *Social Psychology Quarterly, 75(2)*, 149-172.

[18] Wanzer, D., McKlin, T., Edwards, D., Freeman, J., and Magerko, B. (2019). Assessing the attitudes towards computing scale: A survey validation study. *ACM SIGCSE Technical Symposium*, Minneapolis, Minnestoa, USA.

[19] Jelks, S.M.R., and Crain, A.M. (2020). Sticking with STEM: Understanding STEM career persistence among STEM bachelor's degree holders. *The Journal of Higher Education, 91(5)*, 805-831.

[20] Griffith, A.L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Cornell University, School of Industrial and Labor Relations*.

[21] Hanauer, D.I., Graham, M.J., and Hatfull, G.F. (2016). A measure of college student persistence in the sciences (PITS). *CBE Life Sciences Education, 15*, 1-10.

[22] Ikuma, L.H., Steele, A., Dann, S., Adio, O., and Waggenspack, W.N. (2017). Large-scale student programs increase persistence in STEM fields in a public university setting. *Journal of English Education*, 1-25.

[23] Payton, J., Barnes, T., Rorrer, A., Buch, K., and Nagel, K. (2016). Launching STARS computing corps: Engaging faculty and student leaders to broaden participation. *Association for Computing Machinery, 7(4)*, 61-64.

[24] Jones, S. (2016). More than an intervention: Strategies for increasing diversity and inclusion in STEM. *Journal for Multicultural Education, 10(1)*, 234-246.

[25] Payton, J., Barnes, T., Buch, K., Rorrer, A.S., and Zuo, H. (2015). The

effects of integrating service learning into computer science: an inter-institutional longitudinal study. *Computer Science Education, 25*, 311 - 324.

[26] Dahlberg, T.A., Barnes, T., Buch, K., and Bean, K. (2010). Applying service learning to computer science: attracting and engaging under-represented students. *Computer Science Education, 20*, 169 - 180.

[27] McKlin, T., Rorrer, A., Fisk, S., and Barnes, T. (2021). The STARS aligned: Intersectional and institutional analyses of 2006-2016 STARS faculty and student surveys. Technical report, *STARS Computing Corps*, Philadelphia, PA.

[28] McGee, E.O., and Bentley, L. (2017). The troubled success of Black women in STEM. *Cognition and Instruction, 35(4)*, 265-289.

[29] Buckley, M., Kershner, H., Schindler, K., Alphonce, C., and Braswell, J. (2004, March). Benefits of using socially relevant projects in computer science and engineering education. *In ACM SIGSCE Bulletin, 36(1)*, 482-486.

[30] Holliday, M.A., and Luginbuhl, D.R. (2004). Peer-centered service learning. *34th Annual Frontiers in Education, FIE* 2004.

[31] Speer, P.W., Peterson, N.A., Armstead, T.L. et al. (2013). The influence of participation, gender and organizational sense of community on psychological empowerment: The moderating effects of income. *American Journal of Community Psychology, 51*, 103–113.

[32] Dagley, M., and Gerogiopoulos, M. (2015). Increasing retention and graduation rates through a STEM learning community. *Journal of College Student Retention Research Theory and Practice, 18(2)*.

[33] Mondisa, J.L., and McComb, S.A. (2015). Social community: A mechanism to explain the success of STEM minority mentoring programs. *Mentoring and Tutoring: Partnership in Learning, 23, (2)*, 149-163.

[34] Williams, B.N., and Williams, S.M. (2006). Perceptions of African American male junior faculty on promotion and tenure: Implications for community building and social capital. *Teachers College Record*.

[35] Fisk, S., Watts, B., Lee, C., Rorrer, A., McKlin, T., Barnes, T., and Payton, J. (2022). Retaining Black women in computing: A comparative analysis of interventions for computing persistence. *Unpublished*.

[36] Lopatto, D. (2004). Survey of undergraduate research experiences (SURE): First findings. *Cellular Biology Education, 3*, 270-277.

[37] U.S. Census Bureau. (2022). 2020 census illuminates racial and ethnic composition of the country. https://www.census.gov/library/stories/2021/08/improved-race-ethnicity-measures-reveal-united-states-population-much-more-multiracial.html.

[38] Zweben, S., and Bizot, B. (2020). Taulbee Survey: Bachelor's and Doctoral Degree Production Growth Continues but New Student Enrollment Shows Declines. *Computing Research News, 33(5)*, 67.

[39] Dillon Jr, E. C., Gilbert, J. E., Jackson, J. F., and Charleston, L. J. (2015). The state of African Americans in computer science-the need to increase representation. *Computing Research News, 21(8)*, 2-6.

[40] Spencer, B., Rorrer, A., Davis, S., Moghadam, S., and Grainger, C. (2021). The Role of 'Intersectional Capital' in Undergraduate Women's Engagement in Research-Focused Computing Workshops. *IEEE Research on Equity and Sustained Participation in Engineering, Computing, and Technology. (RESPECT) 2021 Conference Proceedings*, virtual.

[41] Narayanan, S., Cunningham, K., Arteaga, S., Welch, W. J., Maxwell, L., Chawinga, Z., and Su, B. (2018, February). Upward mobility for underrepresented students: A model for a cohort-based bachelor's degree in computer science. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education* (pp. 705-710).