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An Investigation of Students' Motivation, Self-Esteem and Their Academic Achievement/Retention for Financially Disadvantaged Computer Science Undergraduate Students

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Abstract

STARS (Supporting Talented African American Undergraduates for Retention and Success) is an NSF funded program to improve retention and graduation among students seeking computer science degrees at a minority serving institution. This project focuses on students from underrepresented minority group, low-income family. STARS program has four primary categories of support, which include academic, social, career, and financial. The current study considers the STARS program students and non-STARS counterparts, for STARS students, the majority of students showed higher level of STEM self-esteem and academic motivation compared with their non-STARS counterparts. Furthermore, scholars self-report in survey and focus group interview indicated that their higher level of self-esteem and stronger academic motivation attribute to the different levels of support from this program.

Keywords: Self-esteem, Motivation, Academic Achievement, Retention, African American.

1. Introduction

According to a 2023 report by the National Center for Science and Engineering Statistics entitled "Diversity and STEM: Women, Minorities, and Person with Disabilities"(National Center for Science and Engineering Statistics, 2023), the subgroup of the US population consisting of African-Americans made up only 9% of the science, technology, engineering, and mathematics (STEM) workforce in 2021 which is well beneath the 13% representation of this group in the total workforce. On the other hand, White non-Hispanics accounted for 68% of the STEM workforce, which is higher than their 63% representation in the total workforce. Asians, which form only 11% of the total workforce, were exceedingly well represented since they formed 21% of the STEM workforce (NCSES, 2023). Therefore, the lack of diversity in the computer science workforce has become a challenge for the U.S higher education.

However, studies have found that around 40% of students planning computer science (CS) majors end up switching to other subjects or in failure of getting any degrees. Dropout rates as high as 30-40% are rapidly becoming the norm for computer sciences programs (Clinging, 2006). At our institution, STEM education has been a distinctive strength over the years. In fact, it is the largest producer of African-Americans with baccalaureate degrees in science and engineering in the southeast area of U.S. This is not surprising as data from the university's Office of Institutional Effectiveness and Evaluation indicate that: (a) for five academic years, approximately 67% of the University's incoming freshmen classes majored in STEM areas with a respectable average high school GPA for the group of 3.3 out of 4; (b) most STEM majors (70%) graduate within 5 years; and (c) as compared to the end of the 1990's, STEM departments have two-fold higher retention rates.

Currently, the disparity still exists in the number of bachelor's degrees awarded to racial minority in STEM major, the number of high school students that are prepared to enroll in university computer science programs is declining (NSF, 2023). Though computing related technology has gained a reputation of importance in daily life, only 1.7% of freshmen believed that they would enter CS professions (Proyor et al., 2011). Given the retention problem with attrition in undergraduate computer science degree programs, even though at successful STEM producer, computer science

program at our institution still faces the STEM fields student retention problem. In order to attract and retain academically talented minority and underrepresented computer sciences students from low-income family, we proposed a project entitled "Supporting Talented African American Undergraduates for Retention and Success (STARS)". The project was funded by the NSF Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEM).

2. Theoretical Foundations

There is a "retention gap" between the number of minority students who express a desire to pursue STEM disciplines and the number of such students that are retained in STEM programs. To address the nation's needs, the retention rates of underrepresented minorities in CS programs across the country must increase (NSF 2005). Many studies (e.g., Astin, 1984; Bean, 1980, 1983; Tinto, 1993; Deci & Ryan, 1985; Niemiec & Ryan, 2009) already found out that social and psychological factors contribute to individual choices to study a STEM discipline and research on practices in such areas as recruitment and retention. We will briefly examine literature regarding the psychological constructs related to retention.

Self-esteem is described as an individual's perception of his or her overall worthiness; it is also a form of self-acceptance, personal appreciation and subjective respect of one's own (Donnellan, Trzensiewski & Robins, 2011, Morganett, 2005). Previous studies indicated that higher level of self-esteem could promote resilience in response to adversity pressure and challenges in life (Celik, Cetin, & Tutkun, 2015), whereas low level of self-esteem lead to poor aspirations in education and achievement for individuals' subsequent life course (Fang, 2016). Many studies have looked at college students' self-esteem, the results are contradictory, and also should be interpreted with caution due to methodological limitations. For instance, some empirical evidence showed that self-esteem is a weak, unreliable predictor of academic achievement (Bachman & O'Malley, 1986; Corcker & Luhtanen, 2003; Maruyama, Rubin, & Kingsbury, 1981; Rosenberg, Schooler, & Schoenbach, 1989; Skaalvik & Hagtvct, 1990). However, some other studies indicated that the high self-esteem is associated with educational achievement (Marsh, Byrne, and Yeung, 1999; Sadaat, Ghasemzadeh & Soleimani, 2012).

2.1. Motivation

Literature on academic motivation discusses three motivational dimensions or orientations -- intrinsic motivation, extrinsic motivation, and amotivation (Brouse, Basch, LeBlanc, McKnight, & Lei, 2010). Petersen et al. (2009) tested a possible model for predicting academic success among disadvantaged students, and they discovered that extrinsic factors might include earning good grades or avoiding negative outcomes and punishments. They also noted that intrinsically motivated students will be propelled to engage freely, without any external rewards or punishments. Such motivation may be evidenced by qualities such as curiosity, exploration, and spontaneity (Petersen et al.,2009). Students who are motivated believe that their own behavior is out of their control and as a result they may stop trying (Petersen et al., 2009). Self-determination theory asserts that intrinsic motivation is maintained by three basic psychological needs, which include the need for autonomy, the need for competence, and the need for relatedness (Deci & Ryan, 1985; Niemiec & Ryan, 2009). Intrinsic motivation is linked by some researchers to better adjustment and better academic performance than extrinsically motivated peers (e.g., Sarrazin, Tessier, Pelletier, Trouilloud, &Chanal, 2006; Ryan & Deci, 2009). In addition, Javidi & Sheybani (2017) investigated students in the two HBCUs computer science programs, they also noticed that the important characteristics of students who persist in the CS field are related to their intrinsic motivation.

When students enter college, many students find science boring, difficult, and irrelevant to their day-to-day life (Paul et al., 2020). This causes a decrease in the number of student studying and entering computer science fields. Due to the low interest of students in understanding STEM, it is imperative to find strategies that will help motivate the student to pursue STEM. Because motivation generates the interests that help students take control of their learning, it is also will provide them with greater independence through challenging opportunities. Thus, it is very important for the researchers to better understand students' motivation in the STEM field (Duckworth & Quinn, 2009; Gutman & Schoon, 2013; Rojas et al., 2017). Both motivation and self-esteem are utmost necessary characteristics for the student to stay focused in STEM field.

As tons of research indicated that many factors contribute to students' persistence at the undergraduate level, our program was designed to integrate interventions that address the different factors contribute to computer science program retention. Currently, there is very little research on African American in computer science. Our research will add to the insight already gained and provide confirmation or refinement of those previous studies and addressing the research gap. It will also provide stakeholders at higher education institutions with clearer ways to understand and support for computer science undergraduate students.

3. STARS Program Background

Historical Black College and Universities (HBCUs) play important role to attracting, retaining, and graduating African-American students compared with predominantly white institutions (PWIs) (Washington, et al., 2015). Our institution is a private, historically black college/universities (HBCUs) located in the southeast area of U.S. Our institution with 98% of students in 2023 identifying as black alone. Students selected for the S-STEM program must earn a minimum of a 3.0 high school GPA and also come from a low-income family (students who receive Pell grant will be considered as a low-income family).

The purpose of STARS program was to increase the quality and undergraduate students completing a Bachelor of Science degree from the computer science department. The STARS program provides four years of financial, academic, professional and personal development support to the S-STEM scholars. Each S-STEM scholar could receive up to $10,000 per year for four years. To better help minority students' retention in the CS program at our institution; we launched the STARS project in 2022. We have recruited the two cohorts of scholars, which includes six computer science freshmen for the first cohort in 2022-2023 and five computer science freshmen for the second cohort in 2023-2024. In this project, we developed different types of activities, including academic and career mentoring, academic advising and early retention alert support, professional development seminars, research experience program, and high school outreaching. Faculty and peer mentors from inside and outside our institution conducted mentoring workshops for the S-STEM scholars in spring 2023 and spring 2024. The computer science faculty on the project provided guidance on the curriculum sequence and recommended appropriate courses to take each semester for ensuring the scholars complete their degrees in four years. The education researcher on the project met every scholar regularly to offer personalized advice and support. The peer-led introductory coding and python seminars facilitate learning community building. The S-STEM scholars were involved in the academic year and summer research experience programs and address real world problems with latest technologies such as deep learning and quantum computing. The scholars were involved in high school outreach activities, which is beneficial for development of the leadership skills and perceiving the value of computer science.

The current study consists of conducting surveys for the STARS scholars and Non-STARS scholars and interview with some STARS scholars of computer science students. We aim at collecting their perceptions and understanding the challenges they face to motivate their academic achievement and retention.

4. Methodology and Procedures

4.1. Participants

The project officially started on October 1, 2022. We began recruiting the first cohort of participants immediately. To be eligible, scholars must earn a minimum of a 3.0 high school GPA, come from a low-income family, and have demonstrated financial need. Applicants were also required to submit a resume, up to two reference letters, and SAT or ACT scores. Through document reviews and interviews, we selected six scholars for the first cohort in spring 2023 and five scholars for the second cohort in 2023-2024 academic year. For the non-STARS students, we collected the data from the regular computer science classes in spring 2024. 14 first-year and second-year non-STARS students finished the same survey as the STARS scholars. Participants were instructed to complete an online questionnaire survey through Google Forms. All research activities for this project were approved by University's Institutional Review Board.

4.2. Measurements

Self-liking/self-competence Scale-Revised (SLCS-R), Tafarodi & Swann, 2001). This measurement examines the global self-concept which includes two important dimensions: self-competence and self-acceptance. The SLCS-R consists of 16 items to assess the two dimensions of self-esteem, which contains 8 items for each of the dimensions. Sample items such as: " I feel satisfied with myself", "I do well in a number of things". Participants are required to answer on a 5-point Likert scale ranging from 1=strongly disagree to 5=strongly agree.

The Academic Motivation Scale (AMS) (Vallerand et al., 1992, 1993) consists of five subscales assessing amotivation, external regulation, introjected regulation, and intrinsic motivation. Each scale included four items which were possible responses to the questions such as "I chose CS as my major because with only a high school degree I would not find a high-paying job later on." Responses choices for each item were rated on a 5-point Likert scale.

Students' academic achievement: To determine S-STEM scholars' academic achievement, we examined all scholars' overall GPAs at the end of spring semester, 2024. According to the GPA records, 9 out of 11 scholars overall GAP ranged from 3.04 to 4.0. Though two of students' GAP below 3.0, they will still commit to pursuing their CS degrees. For non-STARS computer science students, their GAP ranged from 1.0-4.0.

For the interviews, a qualitative method was used for exploratory research, which is also a tool for listening in detail in a natural context and in the free form possible. The purpose of interview was to aware students' characteristics and feeling about the program. For the current study, we interviewed some STARS scholars whose cumulative GAP is on the margin of 3.0. The purpose of the interview was to gain some insights on the academic challenges of these students. The researcher conducted a semi-structured interview with 5 STARS scholars. The interview questions such as why they chose computer science as their major, what are the biggest challenges for them to pursue their degree? How do they like STARS program? What can the program improve for the next academic year?

5. Findings

Quantitative results: Independent sample T test results indicated that students at STARS programs showed higher level of motivation (I chose CS as my major because I want to have a good life later on), and higher level of self-esteem (I am very comfortable about myself) compared with non-STARS students. (see Table 1 and table 2).

Items	S-STEM scholars (n=11)		Non-scholars (n=14)	
	Mean	SD	Mean	SD
I tend to devalue myself	2.91	0.94	2.64	0.92
I am highly effective at the thing I do.	3.82	0.60	3.79	0.69
I am very comfortable with myself.	4.00**	0.44	3.57**	0.94
I am almost always able to accomplish what I try by.	4.00	0.44	4.00	1.04
I am secure in my sense of self-worth	3.91	0.71	4.00	0.67
It is sometimes unpleasant for me to think about myself.	2.82	1.16	2.43	1.15
I have a negative attitude toward myself.	2.27	1.01	2.14	1.01
At times, I find it difficult to achieve the things that are important to me.	3.09	1.04	3.00	1.03
I feel great about who I am	4.18	0.60	3.79	0.89
I sometimes deal poorly with challenges	2.73	1.00	3.07	1.21

I never doubt my personal worth	3.91	0.83	2.93	0.99
I perform very well at many thing	3.64	0.64	3.71	0.61
I sometimes fall to fulfill my goal	3.64	1.03	3.51	0.85
I am very talented	4.00	0.63	3.86	0.66
I do not have enough respect for myself	2.18	0.98	2.21	0.89
I wish I were most skillful in my activities	3.82	0.87	3.79	0.69

Table 1. Descriptive statistics for motivation items ** $p<0.05$

Furthermore, we compare the retention rate of STARS cohort and non-STARS cohort, we found out that the retention rate of STARS cohort and non-cohort demonstrated a higher level of CS retention rate for STARS scholars, indicating the effectiveness of the STARS program in retaining African American students from low-income families (See Table 3). In the Fall of 2022, a total of 32 students were admitted to the CS department. As of June 2024, 14 students were retained in the program (44 % retention rate). On the other hand, 100% of the first STARS cohort remained in the CS department. In fall 2023, a total number of 32 students were admitted to the CS, and 21 of them remained in the program as of June 2024 (66 % retention rate). STARS Scholars' retention rate is higher at 100 %.

Table 2. Descriptive statistics for Self-Esteem items

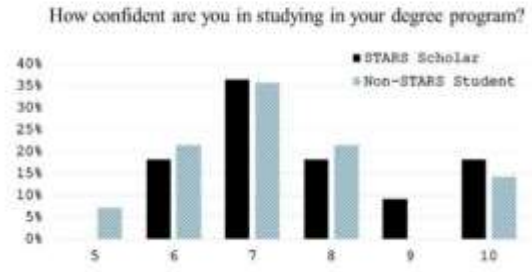
Items	S-STEM scholars (n=11)		Non-scholars (n=14)	
	Mean	SD	Mean	SD
I chose CS as my major because with only a high school degree I would not find a high-paying job later on.	3.55	1.04	3.93	1.27
I chose CS as my major because I experience pleasure and satisfaction while learning new things.	3.91	0.54	4.43	0.65
I chose CS as my major because I think that a college education will help me better prepare for the career I have chosen.	4.36	0.50	4.57	0.51
I chose CS as my major because of the satisfaction I feel when I am communication my own ideas to others.	3.73	0.79	3.71	0.73
I chose CS as my major because of the fact that when I succeed in this field, I feel important.	3.55	1.04	4.00	0.78
I chose CS as my major because I want to have the good life later on.	4.27**	0.47	3.86**	0.95
I chose CS as my major because that will help me make a better choice regarding my career orientation.	4.09	0.30	3.79	0.98
I choose CS as my major because to prove to myself that I am capable of completing my college degree.	3.27	0.91	3.43	1.16

** $p<0.05$

Table 3. Retention Rate Comparison between STARS Scholars and Non-STARS Scholars

	STARS Scholars	CS Students
2022-2023 Cohort	100%	44%
2023-2024 Cohort	100%	66%

In the survey, we have several items asked students how confident are they study in their program, how much they think they belong to the community of computer science, most of the students' answer ranged from 7-10, we did find difference between STARS scholars and non-STARS students, most of the STARS scholars' level of confidence ranged from 7-10, it is a little higher compared with non-STARS students. Furthermore, the STARS scholars also showed higher level of sense of belong to the community compared with their counterparts (see Figure 1 and Figure 2).



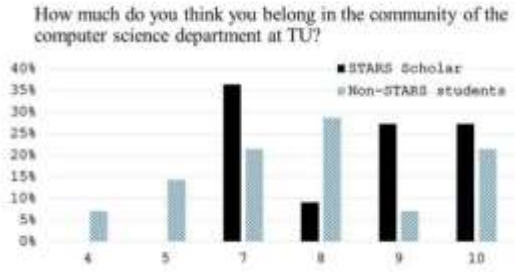


Figure 1: Students' confident level Figure 2: Students' sense of belong

Qualitative results: There are a few factors that influence retention at an institution and department level. To learn about these factors, qualitative data was solicited during a focus group interview. The STARS scholars talked about their specific challenge that could impact retention is their mathematics and programing course learning. Some STARS scholar mentioned that the STARS program tutors and peer learning group helps a lot for their mathematics and programing course studies. In addition, some of them mentioned about the sense of belonging to the computer science program and institution communities, faculty-student interaction, caring professors are very important factor influence their achievement and persistence at school.

6. Conclusion and Discussion

The purpose of this study was to investigate how our STARS program support African American students pursue their CS degree. The substantial research has been conducted in this area and found that different practices can be applied to retain diversity in the computer science field.

In this study, we were mostly interested in investigating how our STARS program can better help undergraduate students stay in the CS programs. It seems that the students participated in the STARS program have stronger intrinsic motivation compared with their peers in the CS programs, higher level of self-esteem compared with non-STARS students, STARS scholars also showed their better cumulative GPA, higher level of sense of belong to the computer science program at our institution, higher level of confidence, and also have a higher level of retention rate. Similarly, many previous studies already found out that many factors contributed to the student retention for college students. For example, Javidi'& Sheybanis (2017) found out that awareness of students' characteristics or feelings about the program is the important predictor for retention. They also found out that the sense of belonging to peer collaborations/motivations, faculty-student interaction, faculty-student interaction, caring faculty, academic support such as tutoring, academic advising, and mentoring, summer research opportunities, faculty encouragement and involvement. Students mentioned that a sense of belonging and fitting into the program as important motivational factors affecting student persistence. Other students emphasized on the fact that at HBCUs, African

Americans have a sense of engagement, connection, and acceptance which they believed that they could never have at a predominantly white institution.

Apparently, student retention in CS programs still is a big problem, the main question of educators can increase students' interests and motivation in CS endures. The finding from this investigation illuminates the significant role that self-esteem and motivation play in the academic achievement and persistence of computer science students, particularly those from financially disadvantaged backgrounds. The STARS program at our institution demonstrates a successful model for providing targeted support that fosters both self-esteem and motivational factors among participants.

In addition, the differences observed between STARS scholar and non-STARS undergraduates underscore the potential area for improvement for the latter group. Developing initiatives to raise awareness and access to existing resources may help bridge the retention gap. Previous studies on why students drop CS has highlighted the multi-dimensional nature of this issue. Kinnunen and Malmi (2006) found the students who dropped out of one CS course cited a lack of time and motivation as the primary reasons for doing so. There are many factors influence retention rate at CS program, such as perceived difficulty of the subject, challenges around time management, and a preference for another subject. Similarly, Petersen et al. (2012) found similarly reasons such as lack of time, poor study skills, and prioritization of other subjects.

In summary, fostering self-esteem and motivation is vital in supporting the academic journey of computer science students, particularly those from underrepresented backgrounds. We strongly believe that our STARS program not only provide academic, career, and financial support but also develop students' adequate academic motivation, self-esteem, and institutional commitment.

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