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RESEARCH ARTICLE

The Importance of STEM Sense of Belonging and Academic Hope in Enhancing Persistence for Low-Income, Underrepresented STEM Students

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Abstract

The purpose of this longitudinal investigation was to examine the effectiveness of a comprehensive, integrated curricular and co-curricular program designed to build community, provide academic and social support, and promote engagement in academically purposeful activities resulting in more equitable environments for historically underrepresented, low-income science, technology, engineering, and mathematics (STEM) information technology (IT) students. The study also focused on the role that the sense of belonging and academic hope play in enhancing persistence to degree completion. Program participants had significantly higher persistence rates compared to a matched comparison group. Additionally, STEM-specific belonging and academic hope significantly predicted students' intentions to persist to degree completion in IT. A major finding was that STEM domain–specific belonging was a stronger predictor of persistence than general belonging. Our investigation has implications for the role that cohort-based programs, industry engagement, peer mentoring, proactive advising, undergraduate research opportunities, career preparation, and leveraging need-based financial aid play in ensuring equity in STEM.

Keywords Student success · Retention · Persistence · STEM · Information technology and computing · Underrepresented groups · Economically disadvantaged · Hope · Sense of belonging

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Higher education researchers and policy-makers have focused much attention on how to attract and retain students in competitive science, technology, engineering, and mathematics (STEM) fields. This focus is warranted as about a third of STEM students leave STEM by the end of their first year in college (National Science Board, 2018). According to Bradford et al. (2021), leaving STEM fields may be related to students exploring other majors in college, and yet other systemic factors such as lack of campus resources oriented toward diverse students may be a major factor in explaining why underrepresented minority students leave STEM majors and careers at higher rates than White and Asian students. A recent Pew Research Center report (2021) exploring current trends in STEM degree attainment suggested that equity gaps are unlikely to be substantially narrow as African American and Latinx students are less likely to earn degrees in STEM than in other degree fields. The report points out that "Black students earned 7% of STEM bachelor's degrees as of 2018, the most recent year available, below their share of all bachelor's degrees (10%) or their share of the adult population (12%). The share of Hispanic college graduates with a STEM degree –12%– remains lower than that for all college graduates (15%)" (p. 6). Persisting to degree completion in STEM may also serve to reduce income equity gaps as STEM jobs are projected to grow faster, provide greater earning potential, and produce lower rates of unemployment than non-STEM jobs over the next decade (Rozek et al., 2019). As such, Rozek et al. advocate that providing institutional support and applying psychological theory to improve low-income students' academic outcomes have the potential to enhance the success of under-resourced students in STEM fields and in turn reduce income inequalities.

Although increasing diversity in all STEM fields remains a priority, increasing diversity in information technology fields has been increasingly problematic. Research indicates that the STEM field of information technology has more racial inequality than other STEM fields. According to Newsome (2022), "computer occupations are one of the fastest-growing employment sectors in the United States, and the US Bureau of Labor Statistics projects that the number of jobs in this area will increase three times faster than the average — and faster than many other fields in STEM. But Black, Latino and Indigenous people remain under-represented in computing jobs" (p. 440). Newsome states that Black and Latinx individuals make up almost 13% and 18% of the US workforce; however, they hold only 7% and 8%, respectively, of the jobs in computing. Additionally, despite ongoing recruitment and higher education efforts, Black, Latinx, and low-income students continue to be underrepresented in informatics and computing majors. The proportion of bachelor computer science degrees going to Black students has dropped from more than 11% in 2013 to less than 9% in 2020 (Newsome, 2022).

Students in this study were participating in the Leading Informatics for Tomorrow (LiFT) Scholars Program, a National Science Foundation grant-funded project that supported full-time computing and informatics students who demonstrate financial need and/or are from underrepresented minority backgrounds (Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives). The LiFT Scholars Program was a cohort-based comprehensive, integrated curricular and co-curricular program consisting of a summer bridge program, residential-based learning communities, peer mentoring, proactive advising, community-building

activities, undergraduate research, engagement with industry professionals, and career preparation. The interventions such as cohort-based summer bridge, learning communities, peer mentoring, and undergraduate research with faculty mentoring were designed to help foster sense of belonging to STEM informatics and computing professions. These types of cohort-based interventions have been effective in helping low-income and underrepresented students buffer against feelings of low sense of belonging, isolation, and alienation in competitive STEM majors (Sax et al., 2018). Sax et al. contend that creating supportive environments, at the departmental and peer group level, may help in facilitating students' sense that they belong in the field of computing, improving underrepresented student success in IT and computing professions.

The current study also explored how the entry-to-graduation LiFT program designed to build community, provide academic and financial support, and promote engagement in academically purposeful activities helped students persist to degree completion in competitive STEM IT fields. Researchers have investigated the extent to which cognitive motivational theories (referred to as non-cognitive factors in the higher education literature), such as academic self-efficacy (Chen & Zimmerman, 2007; Han et al., 2021; Luo et al., 2021; van Aalderen-Smeets et al., 2018), self-regulation (Shell & Soh, 2013; Zollman, 2012), effort control (Cromley et al., 2016), and goal setting (Shaw & Barbuti, 2010) affect STEM students' academic performance as well as their intentions to pursue and persist in STEM fields. A cognitive motivational construct that has been understudied in STEM populations is academic hope. Hope is defined as, "the process of thinking about one's goals, along with the motivation to move toward those goals (agency), and the ways to achieve those goals (pathways)" (Snyder, 1995, p. 355). Pathway thinking entails creating a plan to achieve goals or an alternative plan if significant barriers are faced, while agency thinking includes the motivation to achieve them and involves the perceived ability to carry out the plan (Snyder, 2002). Students with high levels of hope have well-defined goals, a belief in their ability to develop effective strategies for reaching those goals, and the essential motivation to use those strategies (Snyder et al., 2008).

The following research questions guided this investigation:

Research question (1). Does participation in the LiFT program enhance students' persistence in IT majors compared to students who do not participate in LiFT?
Research question (2). Does LiFT students' sense of belonging and academic hope significantly predict students' intentions to persist to IT degree completion?
Research question (3). Is sense of belonging in IT a stronger predictor of IT persistence than general sense of belonging?

Literature Review

Importance of Identifying Factors that Promote Persistence in STEM Fields and Reducing Inequities

In an effort to improve the STEM diversity bleak outlook, higher education researchers have investigated what social, academic, and institutional factors significantly predict whether or not students will successfully persist in STEM, attain STEM degrees, and enter into the workforce (Chang et al., 2008; Durkee et al., 2021; Kendricks et al., 2019; Louten, 2022; Hurtado et al., 2010; Riegle-Crumb et al., 2019; Xu, 2018). According to Xu, institutional conditions such as programs, practices, resources, and structural features play a critical role in enhancing the learning and persistence of underrepresented, low-income STEM students. Researchers have empirically identified numerous institutional conditions that are effective in enhancing URM persistence in STEM including providing opportunities for experiential learning experiences such as undergraduate research (Carpi et al., 2017; Hurtado et al., 2010) an emphasis on high-quality accessible instructors and advisors (Xu, 2018), peer mentoring (Rockinson-Szapkiw et al., 2021), early interventions for struggling students (Wetzel & Debure, 2018), and making institutional financial commitments to reduce disparity for low-income students (Estrada et al., 2016).

Holcombe and Kezar's (2020) research underscores the importance of comprehensive, integrated, cohort-based programs of curricular and co-curricular support programs that require the collaboration between faculty and student affairs professionals rather than single-strategy approaches. An example of an integrated cohort approach for STEM students is the Meyerhoff Scholars Program, which provided a summer bridge program, study groups, faculty and peer mentoring, advising support, and undergraduate research (Maton et al., 2016; Stolle-McAllister et al., 2011). Ghazzawi et al. (2021) used a rigorous propensity score matching methodology and found that a STEM Enrichment summer bridge early intervention program was effective in enhancing the retention rates and academic performance among underrepresented Pell-eligible students. These types of cohort-based programs can serve to provide students with the peer networks and academic support they need to be successful in persisting to degree completion.

Taken together, research has shown that institutional practices that offer opportunities for students to establish connections with faculty and other students, succeed in rigorous courses, remain resilient in the face of challenges, persist to degree completion, and attain the habits of mind and skills needed to enter the STEM workforce may serve to reduce the inequities faced by low-income, historically underrepresented (HUR) STEM students. Providing students with opportunities to engage in effective "high-impact" educational practices, such as learning communities, first-year seminars, and undergraduate research, has been advocated to help them feel a sense of belonging and persist, particularly those identified as traditionally underserved populations (Finley & McNair, 2013; Kuh, 2008; Kuh et al., 2013). According to Kuh et al. (2010), educationally effective colleges and

universities intentionally design programs and practices that induce students to participate in them and compel students to engage at a high level.

Sense of Belonging and Promoting Persistence Among Underrepresented, Low-Income STEM Students

Sense of belonging refers to "students' sense of being accepted, valued, included, and encouraged by others (teachers and peers) in the academic classroom setting and of feeling oneself to be an important part of the life and activity of the class" (Goodenow, 1993, p. 80). Sense of belonging has also been defined as "students' perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the campus community" (Strayhorn, 2018, p. 4). Sense of belonging is particularly important in predicting persistence in STEM as past research refers to the chilly environment of STEM fields, whereby many students feel unwelcome and a lack of belonging (Allan & Madden, 2006; Belanger et al., 2020; Chinn, 1999; Settles et al., 2016; Smith et al., 2013). In his extensive review of sense of belonging research, Strayhorn (2011) found that sense of belonging is positively associated with academic performance, retention, and persistence, and it is particularly important for college students from marginalized groups. Other investigations found that socially stigmatized groups were more susceptible to belonging uncertainty (Walton & Cohen, 2007). When marginalized students worry about belonging and something goes wrong, they may feel isolated, criticized, or disrespected. This in turn can increase stress and undermine students' motivation and engagement (Yeager and Walton, 2011). Research within STEM has also shown that students of color have consistently reported less sense of belonging compared to White students (Good et al., 2012; Johnson et al., 2007; Johnson, 2012). However, research has shown that when underrepresented STEM students feel supported and receive social support from institutional interventions, they persist despite obstacles and thrive to attain their learning goals (Williams et al., 2017).

Investigations have shown that several environmental factors, institutional practices, and external cues can impact students' sense of belonging. Kuh et al. (2010) found that the conditions that matter for improving college student academic success and persistence include those that encourage and foster sense of belonging such as positive interactions among students, co-curricular involvement, learning communities, and peer mentoring. More recent research focused specifically on STEM students suggests that institutional practices that promote STEM students' interpersonal relationships, perceived competence, personal interest, and science identity contribute to feelings of belonging (Rainey et al., 2018). Additionally, in their qualitative investigation, Rainey et al. found that STEM students' perceptions of sense of belonging affected their decisions to persist or withdraw from their STEM major.

Although several investigations have been conducted on how STEM students' general sense of belonging to an institution and/or connections to other students and faculty affects STEM students' retention at the institution, relatively few investigations have examined the importance of fostering a domain-specific STEM sense

of belonging on students' persistence in specific STEM majors. There are some exceptions. London et al. (2011) found that students who reported lower belonging in their STEM major were more likely to expect to drop out of their STEM major. Their domain measure of sense of belonging included questions about feelings of comfort and fit within one's STEM major, as well as feelings of comfort and connection to instructors and other students in one's major. In their comprehensive review of key social-psychological factors influencing sense of belonging, Lewis et al. (2016) found that academic belonging can be affected by factors such as social support outside the classroom and the presence of other role models and peers in and outside the classroom that serve to mitigate social stereotypes that "people like me don't belong in STEM." They also concluded that domain- or major-specific STEM belonging may be more predictive of positive academic outcomes compared to general feelings of belonging. Additionally, they point to the need to differentiate general sense of belonging toward an institution from STEM major–specific belonging, particularly when considering the experience of marginalized groups. STEM students may feel like they belong to a particular STEM major or STEM degree–granting department while at the same time feel a low sense of belonging to the overall university or college. STEM major belonging may be the key to help students persist in STEM majors, even if they do not feel a general sense of belonging to the institution outside of their STEM discipline–specific major. The current study explores the relative contributions of general sense of belonging and IT major domain–specific sense of belonging in predicting persistence in IT.

The Role of Academic Hope in STEM Student Persistence

In addition to understanding how institutional factors affect STEM students' sense of belonging and fit, it is critical to understand the factors that keep students on track and in pursuit of their educational goals, or many students will be at-risk for lowering their expectations and failing to attain their educational potentials, especially when facing obstacles (Snyder et al., 2002). Students with high levels of academic hope have well-defined goals, a belief in their ability to develop effective strategies for reaching those goals, and the essential motivation to use those strategies (Snyder et al., 2008). Students with high levels of academic hope are also more resilient to setbacks, such as academic failure in rigorous courses or inability to balance personal and school commitments (Hansen et al., 2014).

Snyder (2002) distinguishes hope theory from other constructs such as optimism, self-efficacy, and self-regulation. Hope is related to other expectancy constructs like self-efficacy, self-regulation, and optimism as these constructs concern expectancies regarding the attainment of future positive states and attaining desired goals (Feldman and Kubota, 2015). Snyder contends that hope is a unique expectancy-value theory because it is "the perceived capability to derive pathways to desired goals and motivate oneself via agency thinking to use those pathways" (p. 249). While self-efficacy is focused on the expectancy that one can perform behaviors, hope is focused on the expectancies that one can attain goals (Snyder, 1995, 2002). Bandura (1977) has contrasted self-efficacy with expectancies of goal outcomes by stating

that "Outcome and efficacy expectations are differentiated, because individuals can believe that a particular course of action will produce certain outcomes, but if they entertain serious doubts about whether they can perform the necessary activities, such information does not influence their behavior." (p. 193). Snyder also contrasts hope with optimistic explanatory styles that reflect the pattern of making external, variable, and specific attributions for negative outcomes. Optimistic goal-directed cognitions are aimed at distancing the person from negative outcomes, while hope theory focuses on reaching future positive goal-related outcomes, and there is an explicit emphasis on the agency and pathways of goal-directed cognitions. The outcome is an important focus in both theories but given more emphasis in hope theory, as individuals with high hope act with agency and develop pathways to attain desired outcomes.

Academic hope has been linked to positive educational outcomes such as academic performance and goal attainment (Feldman et al., 2009; Feldman & Kubota, 2015; Rand & Cheavens, 2009). In their investigation of the role of social support in developing hope in college students, Guthrie and Fruiht (2020) found that supportive relationships can enhance student success through building both connections with the campus community and that fostering hope can also help further increase student achievement and retention. When investigating academic hope among college students, Snyder et al. (2002) found that the academic hope scale scores of incoming freshmen predicted the overall GPA, even while controlling for scores on entrance examinations. Taken together, research suggests that academic hope may be a critical factor in understanding why some students remain committed to their goals, continue to persist in college despite setbacks, and are able to develop and employ effective strategies for attaining desired academic and career goals.

Purpose of the Current Study

This current study focused on (1) whether a cohort-based intervention consisting of high-impact educational practices was effective in enhancing retention and persistence in IT and (2) whether academic hope and sense of belonging were significant predictors of persistence to IT degree completion among LiFT students. Additionally, this study investigated whether fostering a general sense of belonging or IT major–specific belonging was more effective in predicting persistence in IT. IT is part of STEM so IT will be used to mean STEM throughout this study. Our study focused on low-income and/or historically marginalized IT students attending a 4-year public institution and a 2-year community college that served as a pipeline for IT bachelor's degree completion.

The Leading Informatics for Tomorrow (LiFT) Scholars Program was a National Science Foundation (NSF) grant-funded project that supported full-time students who demonstrated financial need and/or were historically marginalized. The program was designed to increase and diversify the IT workforce in the USA. The LiFT Scholars Program was a multi-institutional scholarship and student support program serving underrepresented and underserved students pursuing degrees in informatics and computing through cross-institutional

programming and high-impact practices (HIPs) centered on fostering students' sense of belonging, academic hope, and intentions to persist to IT degree completion and enter the IT workforce. The LiFT scholars benefited from a community of support from peers, staff, faculty, and industry professionals in the information technology (IT) field. As such, the LiFT program interventions were designed to enhance a general sense of belonging to the college and/or university but also a sense of belonging to the IT major. The intent of the comprehensive programming was to allow students to be socially and academically acculturated into the IT environment. The cohort-based programs of summer bridge, residential learning communities, and peer mentoring were centered in IT and designed by the IT department. In other words, the interventions intentionally created opportunities for students to interact and engage with other IT students, peer mentors, department-based advisors, and faculty members. The program was designed so that all LiFT students experienced all components of the program (e.g., undergraduate research and career development planning).

The cohort-based HIPs and IT programming such as industry mentoring, undergraduate research with faculty members, and advising were created to provide students with the role models necessary for students to engage in hopeful thinking. More specifically, the structured curricular and co-curricular support programs were designed to promote academic hope by offering opportunities for scholars to (1) establish positive connections with faculty, advisors, staff, peer mentors, and other students, (2) set realistic learning goals related to their IT major, (3) develop specific strategies for overcoming potential setbacks, (4) actively prepare for a career in IT by reflecting on educational experiences and planning for future success, and (5) seek help in a supportive cohort-based atmosphere. The LiFT program was also designed to foster scholars' academic hope by establishing collaborative partnerships with community-based IT professionals and career services to provide individualized supports based on students' needs and IT career aspirations.

The institutional context coupled with financial support was designed to serve as an effective mechanism to create safe spaces for IT students to develop an IT sense of belonging and hope. This current study tested if LiFT scholars' academic hope and sense of belonging affected intentions to persist to degree completion. The institutional context and programming were also created to provide students with the financial resources, academic support, and welcoming environment they needed to persist to degree completion. Shown in Fig. 1 is the LiFT program theory that guided this study. The LiFT program interventions were informed by theory and designed to enhance LiFT scholars' sense of belonging and academic hope. However, this study only tested if LiFT scholars' levels of sense of belonging and academic hope predicted persistence to IT degree completion. Please note that Fig. 1 is a program theory of the underlying assumptions guiding the program, not all assumptions were directly tested in this study, and we did not have the opportunity to measure the longer-term outcome of how skilled scholars were in the IT workforce due to the timing of the study.

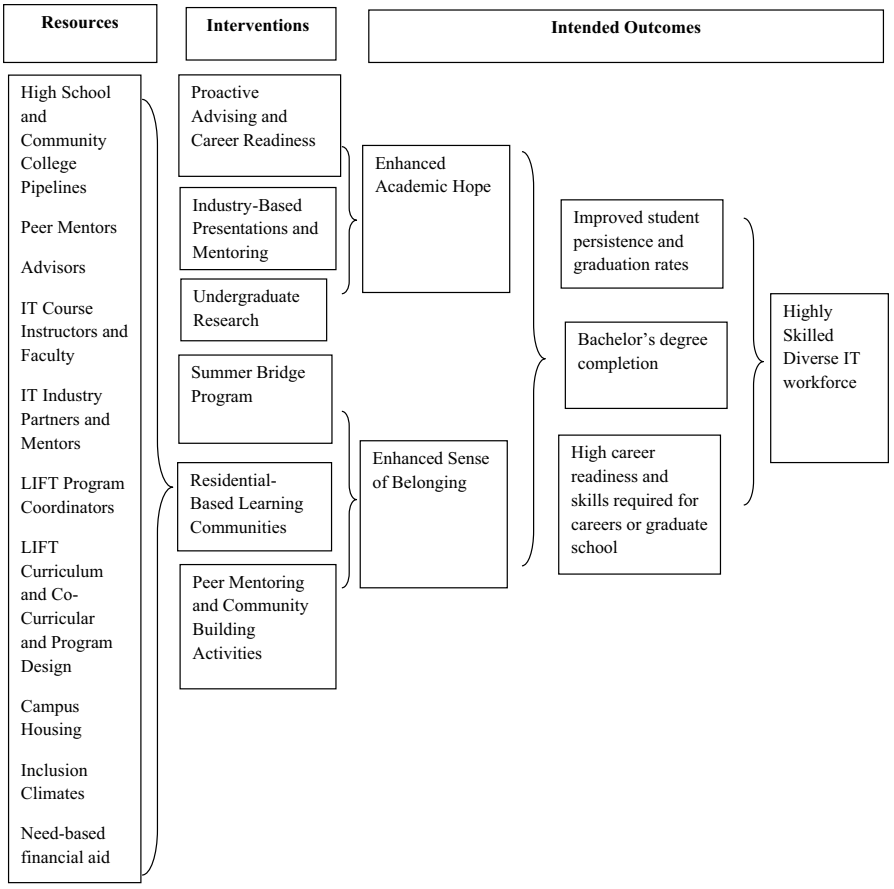

Fig. 1 Leading Informatics for Tomorrow (LiFT) Scholars Program theory for historically marginalized STEM IT students

Method

Research Setting and Interventions

This study focused on students attending college at two campus settings: (1) a large, public, urban, commuter, Midwestern 4-year university and/or (2) a large, urban, public 2-year community college which served as a pipeline or feeder institution for students seeking a 4-year bachelor's degree in information technology at the 4-year university. Students either began at the 2-year community college and transferred to the public 4-year or began at the 4-year university. All participants were seeking a 4-year bachelor's degree in computing and information technology.

The LiFT Scholars Program was a multi-institutional scholarship and student support program serving underrepresented and underserved students pursuing degrees in informatics and computing through cross-institutional programming

and high-impact practices (HIPs) centered on student engagement and developing students' career readiness. HIPs included (a) collaborative, project-based learning approaches, (b) learning communities, (c) summer bridge, (d) a residential-based learning community, (e) peer mentoring, (f) community-building activities, (g) engagement with industry professionals, and (h) post-graduation planning and preparation. The program was designed to provide support for students over 4 years. During their first year, students participate in the summer bridge program and residential living-learning communities to build a foundation of academic and social support. Students participate in the other LiFT program interventions all 4 years (financial/scholarship support, peer mentoring, proactive advising, and career development), while the interventions of undergraduate research and industry mentoring are scaffolded and begin the second year. The program provided IT department–based interventions to enhance LiFT scholars' sense of belonging, success, academic hope, and career readiness.

Data and Procedures

Data were gathered from several sources at different points in time for 170 LiFT scholar cohorts participating in the program during the academic years of 2017–2018, 2018–2019, and 2019–2020. Institutional research and enrollment student record data were used to develop a longitudinal dataset containing all LiFT scholars' demographics (age, gender, ethnicity, first-generation status), degree-granting academic department, major, academic preparation variables that included high school grade point average (HS GPA) and scholastic aptitude test (SAT scores) and financial aid data (Federal Pell Grant eligibility and unmet financial need), and student retention information (reenrollment in subsequent semesters at the institution and reenrollment in the same IT program field or major).

The demographic, school, major, and academic preparation variables were used to find a matched comparison group of 170 students entering during the same cohort years in the same IT department and major who were closely matched on demographics, academic preparation, and financial aid information. The matched comparison group was formed by selecting IT students from the community college or informatics and computing students from the university who began in the same term as LiFT scholars, had similar SAT and HS GPAs within the range of the LiFT program admission criteria, were in the same IT majors, were economically disadvantaged (based on Federal Pell Grant with high levels of unmet need), and/or were from the NSF-defined underrepresented groups. Once the selection criteria were applied there were only 245 remaining, and we then matched the remaining students based on gender, ethnicity, and first-generation status. As such, we used a process of stratifying the observations into groups based on the fixed values of the potential confounding variables to attain a reasonable comparison group. The program admitted all eligible IT students during the academic years studied based on Pell Grant eligibility and levels of unmet need. As such, we were not able to do a 1:1 match based on these criteria because all eligible were selected to participate. Additionally, due to financial aid data restrictions, one of the institutions would not release the

Free Application for Federal Student Aid (FAFSA) data for the non-LiFT students so we were not able to use this as 1:1 matching criteria. The LiFT scholars and the comparison group were matched based on students beginning at the community college 56 (33%) and the 4-year university 114 (67%) for each group of 170. The students who began at the 4-year university had higher HS GPAs and 1-year retention rates than students who began at the community college (73% vs. 65% and 3.44 vs. 2.33, respectively).

Shown in Table 1 in the "Participants" section below, please find the results of the matching process. The matching technique resulted in the LiFT group having significantly higher high school grade point averages (HS GPAs) compared ($M = 3.44$, $SD = 0.43$) to the matched comparison group ($M = 3.27$, $SD = 0.51$) based on independent sample t-test results $t(340) = 1.81$, $p < 0.05$. As such, we employed logistic regression procedures to adjust for HS GPA as a potential confounding variable in our regression models. Due to the selection process used for the program, more sophisticated matching procedures such as propensity score matching (PSM) were not appropriate due to the small sample size (see Cenzer et al., 2020 for a discussion of limitations) and the fact that all eligible students who met the financial need, academic qualifications, and/or NSF definition of underrepresented minorities (URM) (African American, Latinx, American Indians, or Alaska Natives) were selected to participate.

Table 1 Descriptive statistics for the LiFT participants and the matched comparison group

Variable	LiFT participants ($N = 170$)	Comparison ($N = 170$)
Gender:		
Female	30.6%	22.9%
Male	69.4%	77.1%
Race/ethnicity:		
Black/African American	32.4%	30.6%
Latinx	11.2%	6.5%
Asian American	7.1%	5.3%
Two or more races	4.1%	5.9%
White	44.7%	51.2%
Underrepresented	55.1%	47.8%
First generation	36.5%	34.9%
High school GPA	3.43	3.27
	.42	*.51*
SAT (Math & verbal combined)	1128.94	1097.78
	164.92	*155.29*
Low-income status (Pell Grant received)	66.7%	42.9%[a]
	.47	*.49*

Standard deviations are presented in italics

[a]Only 64 students were included due to the lack of financial aid data available for non-LiFT students

An anonymous self-report questionnaire was also administered to all LiFT scholar students to assess the constructs of the general sense of belonging, domain-specific IT sense of belonging, academic hope, and intentions to persist to degree completion in IT. The questionnaire was only administered to the LiFT scholars and not the comparison group students. Data used in the questionnaire analyses included students who had completed 3 years of the program to ensure that the treatment effect was acceptable as some interventions were designed for the students' second or third years (e.g., undergraduate research and career development planning).

Participants

Participants in this study consisted of 170 students participating in the LiFT Scholars Program and a comparison group of 170. Shown in Table 1 are the descriptive statistics for the LiFT participants and the matched comparison group. The 170 LiFT scholars consisted of 30.6% female, 36.5% first generation, 32.4% African American, 11.2% Latinx, 4.1% two or more races, 44.7% White, and 66.7% Federal Pell Grant eligible. The average age was 23.14 (range 17–56). The 170-comparison group consisted of 22.9% female, 34.9% first generation, 30.6% African American, 6.5% Latinx, 5.9% two or more races, 51.2% White, and 42.9% Federal Pell Grant eligible. The average age was 26.21. Compared to nonparticipants, participants were more likely to be underrepresented, first-generation (neither parent attended college), and low-income (received a Federal Pell Grant).

The self-administered questionnaire was only administered to LiFT scholars and not the comparison group, resulting in a sample of 72 and a response rate of 44%. Also, the self-administered questionnaire was an anonymous de-identified self-report measure. As such, we were not able to link the students' questionnaire results to individual students' institutional data or official educational records (e.g., educational records of HS GPA, financial aid information, retention rates, persistence rates). Students were asked to self-report ethnicity and gender. The LiFT questionnaire respondents consisted of 34.8% female, 19.4% African American, 16.7% Latinx, 2.8% two or more races, Asian American 6.9%, and 54.2% White. The sample of LiFT survey respondents was representative of the overall LiFT population in terms of gender distribution and ethnicity distribution but was slightly underrepresented in terms of African American students.

Measures

LiFT Program Participation

LiFT program participation was a single measure and coded as 1 for LiFT and 0 for not LiFT. Students that were coded as LiFT participants were required to participate in all program components and interventions.

Student Persistence in Information Technology Major

One-year, 2-year, and 3-year persistence rates were dichotomous variables indicating whether a student remained enrolled and with the IT major in the following fall semester or spring semester after they began matriculating 1, 2, or 3 years later based on official institutional data. The average 1-year persistence rate in IT for the entire study sample was 67.9%, and the standard deviation was 0.47. The average 2-year persistence rate was 58.4%, and the standard deviation was 0.49. The average 3-year persistence rate was 50%, and the standard deviation was 0.50.

High School Grade Point Average (HS GPA)

HS GPA was based on a scale ranging from 0.00–4.00. The HS GPA was extracted from students' official admissions and educational records. The average HS GPA for the entire study sample was 3.36, and the standard deviation was 0.47.

General Sense of Belonging

In our study, we used Bollen and Hoyle's (1990) first dimension of perceived cohesion: the six-item Sense of Belonging scale. Students were asked to rate their degree of agreement (ranging from 1 = strongly disagree, 2 = disagree, 3 = mostly disagree, 4 = mostly agree, 5 = agree, and 6 = strongly agree). The following items are examples of items used in this study: "I feel a sense of belonging to the campus community," "I feel that I am a member of the campus community," "I feel connected with other students," and "I feel that the campus is very welcoming to students like me." The General Sense of Belonging scale used in this study was found to be highly reliable (six items: $\alpha = 0.95$).

STEM IT Domain–Specific Sense of Belonging

Information technology sense of belonging consisted of a six-item scale adapted from the validated Bollen and Hoyle Sense of Belonging scale: "I feel a sense of belonging to the Information Technology program," "I feel a that I am a member of the Information Technology profession," "The Information Technology profession is a good fit for me," and " I feel connected with other IT students." Students were asked to rate their degree of agreement (ranging from 1 = strongly disagree, 2 = disagree, 3 = mostly disagree, 4 = mostly agree, 5 = agree, 6 = strongly agree). The IT Sense of Belonging scale used in this study was found to be highly reliable (six items: $\alpha = 0.87$).

Academic Hope

The Academic Hope scale (Snyder et al., 1996) was employed, and students were asked to rate their degree of agreement (ranging from 1 = strongly disagree, 2 = disagree, 3 = mostly disagree, 4 = mostly agree, 5 = agree, and 6 = strongly agree). The following items are examples: "If I should find myself in a jam, I could think of

many ways to get out of it." "At the present time, I am energetically pursuing my academic goals." "There are lots of ways around any school-related problems that I am facing now." "Right now I see myself as being pretty successful." The Academic Hope scale used in this study was found to be highly reliable (6 items: $\alpha = 0.88$).

Intention to Persist to Degree Completion in Information Technology

The dependent variable intention to persist to degree completion in information technology was assessed using a self-report single item: "Persist in my Information Technology studies to degree completion (associates, bachelors, masters, professional, or Ph.D.)." The scale ranged from 1 to 5 with 1 = not at all confident, 2 = somewhat confident, 3 = moderately confident, 4 = very confident, and 5 = completely confident.

Gender

Gender was a self-report item on the question where students were asked to indicate if they were male, female, or transgendered. Gender was dummy coded for female = 1 or not = 0. Only one student reported that they were transgendered.

Historically Underrepresented (HUR)

Historically underrepresented was a self-report item on the questionnaire. Students were asked to indicate if they were African American, Latinx, two or more races, and Native American, Asian American, or White. Historically underrepresented (HUR) included African American, Latinx, two or more races, and Native American and was dummy coded for analysis where 1 = HUR and 0 = not HUR.

Analysis of Research Questions and Results

Effects of the LiFT Comprehensive Support on Student Persistence in IT (Research Question 1)

Shown in Table 2 are the 1-, 2-, and 3-year persistence rates for the LiFT participants and the matched comparison group. Chi-square tests of independence were performed to examine the relationship between LiFT participation and persistence rates. LiFT participants had significantly higher 1-year persistence rates compared to nonparticipants X^2 (1, $N = 340$) = 22.7, $p < 0.001$; higher second-year persistence rates X^2 (1, $N = 161$) = 13.14, $p < 0.001$; and higher 3-year persistence rates X^2 (1, $N = 73$) = 1.65, $p < 0.05$.

Logistic regression analyses were performed to ascertain the effects of the LiFT on persistence rates in IT while taking into account the effects of HS GPA. HS GPA was used as a covariate in the model because it has consistently been shown to be a significant predictor of retention (e.g., Reason, 2003), and the LiFT participants had higher HS GPAs compared to the non-LiFT students. Results are shown in Table 3.

Table 2 Persistence rates for the LiFT participants and the matched comparison group

Variable	LiFT participants	Comparison
1-year persistence rate	81.5%	54.2%
	.38	*.50*
2-year persistence rate	75.3%	41.3%
	.43	*.49*
3-year persistence rate	61.1%	38.9%
	.49	*.49*

Standard deviations are presented in italics

Table 3 Hierarchical logistic regression results: LiFT participation and 1-year, 2-year, and 3-year persistence ($N = 340$)

Predictor	1-year persistence			2-year persistence			3-year persistence		
	B	SE *B*	e^B	*B*	SE *B*	e^B	*B*	SE *B*	e^B
Step 1									
HS GPA	.18*	.49	1.20	.86*	.82	2.38	.94*	.95	2.56
Step 2									
LiFT	2.17**	.73	8.76	2.68**	.73	14.63	1.67*	.86	5.31

Control is high school grade point average on a 4.00 scale ranging from 0–4.00. LiFT program (coded as 1 for LiFT and 0 for not LiFT)

*$p < .05$. **$p < .01$

The logistic regression model suggested that LiFT participation significantly predicted 1-year persistence even while taking HS GPA into account $\chi^2(2) = 22.20$, $p < 0.001$. The model explained 26.8% (Nagelkerke R^2) of the variance in the persistence rate and correctly classified 69.4% of cases once HS GPA was taken into account in step 2. LiFT participants were 8.76 times more likely to persist in an IT degree program to the next year. The second logistic regression model suggested that LiFT participation significantly predicted 2-year persistence even while taking HS GPA into account $\chi^2(2) = 21.73$, $p < 0.001$. The model explained 40.9% (Nagelkerke R^2) of the variance in persistence and correctly classified 79.7% of cases once HS GPA was taken into account in step 2. LiFT participants were 14.63 times more likely to persist in an IT degree program to the second year. The third logistic regression model suggested that LiFT participation significantly predicted 3-year persistence even while taking HS GPA into account $\chi^2(2) = 5.89$, $p < 0.05$. The model explained 24.2% (Nagelkerke R^2) of the variance in persistence and correctly classified 71.0% of cases once HS GPA was taken into account in step 2. LiFT participants were 5.31 times more likely to persist in an IT degree program to the third year.

Table 4 Descriptive statistics and Pearson's correlations for questionnaire study variables

Variable	*M*	SD	1	2	3	4	5	6
1. Gender	0.34	0.48	—					
2. HUR	0.38	0.49	.39*	—				
3. General belonging	4.79	1.20	− .14	− .15	—			
4. IT belonging	5.04	1.02	− .08	− .01	.75*	—		
5. Academic hope	4.98	.79	− .11	− .22*	.37*	.39*	—	
6. Intentions to persist	4.30	.94	.02	− .07	.25	.40**	.50**	—

*$p < .05$. **$p < .01$

Table 5 Hierarchical multiple regression results: sense of belonging, academic hope, and intentions to persist to IT degree completion ($N = 72$)

Variable	*b*	SE *b*	*β*
Step 1			
Gender	.10	.27	.05
HUR	− .18	.27	− .09
Step 2			
Gender	.17	.23	.09
HUR	− .08	.23	− .04
General belonging	− .16	.13	− .20
IT belonging	.37	.16	.40**
Academic hope	.50	.14	.42***

$R^2 = .008$ for step 1; $R^2 = .32$ for step 2 ($p < .001$). Gender dummy coded for female = 1 or not = 0. Historically underrepresented (HUR) includes African American, Latinx, two or more races, and Native American (1 = HUR and 0 = not HUR). The beta weight or *b* coefficient is how much more the dependent variable increases (or decreases if *b* is negative) when the dummy variable increases one unit (shifting from 0 = not present to 1 = present)

***$p < .001$, **$p < .01$, *$p < .05$

Effects of Students' Sense of Belonging and Academic Hope on Students' Intentions to Persist to IT Degree Completion (Research Questions 2 and 3)

Table 4 displays the means, standard deviations, and the Pearson product-moment correlation coefficients among the variables. The results of the correlations confirmed that academic hope and IT belonging were significantly positively associated with intentions to persist. HUR was significantly negatively associated with academic hope. Gender was negatively related to IT belonging and general belonging (not significantly). Further, general belonging was not significantly associated with intentions to persist.

A hierarchical linear multiple regression procedure was employed to determine if LiFT participants' levels of sense of belonging and academic hope significantly predicted intentions to persist to IT degree completion. Results are shown in Table 5. Prior to the employment of the regression procedures, tests were conducted,

and histograms were examined to ensure that no assumptions of the regression model were violated. Previous research has shown that STEM women and ethnic underrepresented students tend to experience feelings of alienation and low sense of belonging (Rainey et al., 2018). We accounted for gender and HUR by entering these variables in the first step of the regression model. Results indicated that sense of belonging and academic hope significantly predicted intentions to persist to IT degree completion ($R^2 = 0.32$, $F(5, 63) = 5.34$, $p < 0.001$) even when gender (women) and historically underrepresented students were entered into the model. Results also suggested that a domain-specific sense of belonging to IT significantly predicted intentions to persist to IT degree completion, while general sense of belonging did not significantly predict intentions to persist in IT. Although general sense of belonging was not statistically significant, it was negatively related to intentions to persist in IT in the model once gender and HUR were taken into account. We examined the collinearity statistics tolerance to assess levels of multicollinearity and to determine if the variables of general belonging, IT belonging, and academic hope were operating as distinct variables in the model. The tolerance measures were as follows: 0.97, 0.99, and 0.95. This suggests that the beta coefficients were not affected by the presence of other predictor variables in a model and that multicollinearity was not problematic. Shown in Table 3 are the relative contributions of each variable in the analysis. Results suggested that fostering STEM major–specific IT sense of belonging makes a stronger contribution in predicting students' intentions to persist to IT degree compared to general sense of belonging (Research Question 3).

Discussion

While technology companies across the nation have over and over said they must do better, historically marginalized students (African Americans, Latinx, and low-income students) remain underrepresented in information technology jobs. This study responds to the need to improve the persistence rates of underrepresented and low-income students in the IT field. We found that the low-income, HUR IT students who participated in the comprehensive curricular and co-curricular support LiFT intervention (consisting of summer bridge, leadership and career development, residential learning communities, industry engagement, peer mentoring, proactive advising, undergraduate research opportunities, and leveraging need-based financial aid) had significantly higher persistence rates compared to students who did not participate. Additionally, results suggest that STEM major–specific belonging may be more effective in helping students persist in STEM compared to general sense of belonging. Our findings suggest that STEM students may not feel a high sense of belonging to the overall institution but still intend to persist in STEM majors if they feel a sense of belonging toward a specific STEM field like IT. The importance of STEM-specific belonging has been the topic of prior research on underrepresented students in STEM. For example, Xu and Lastrapes (2022) found that Latinx students' STEM sense of belonging had impacts on their sustained career interest in STEM.

Our results align with previous research on the effectiveness of programs such as the Meyerhoff Scholars Program which focused on an integrated cohort approach for STEM to enhance student success (Maton et al., 2012, 2016). This program also consisted of a summer bridge program, study groups, faculty and peer mentoring, advising support, and undergraduate research. These types of cohort-based programs can serve to provide low-income, underrepresented students with the peer networks and academic support they need to be successful (Ghazzawi et al.). Moreover, our findings support previous research showing that HIPs and early interventions, such as summer bridge programs (Ackermann, 1991; Maples, 2003; Myers & Drevlow, 1982; Walpole et al., 2008), academic advising and peer tutoring (Abrams & Jernigan, 1984; Kulik et al., 1983), and learning communities (Baker & Pomerantz, 2001; Inkelas et al., 2007; Inkelas & Weisman, 2003; Knight, 2003; Pasque & Murphy, 2005; Pike et al., 1997; Purdie & Rosser, 2011; Stassen, 2003; Zhao & Kuh, 2004), are effective in helping students persist in STEM. However, we add to the knowledge base by investigating how these interventions are particularly important for helping IT students persist to IT degree completion.

We also found that academic hope may play an important part in ensuring that low-income, underrepresented IT students persist to degree completion for students attending a 4-year public institution as well as students beginning at a community college that served as a pipeline for IT bachelor's degree completion. Academic hope contributes to multiple components of self-regulation and educational goal pursuit, and our results suggest that it is important in influencing intentions to persist in STEM degree completion. For example, academic hope may enhance early STEM career goal selection and pursuit. However, this goal motivation must be maintained throughout a students' academic experiences to influence persistence to STEM degree completion and career selection (Alexander et al., 2022). Although academic hope has been understudied in STEM college students, Alexander et al. found that hopeful future expectations positively predicted STEM career interest among high- and middle-school girls. Their qualitative results also suggested that academic hope was an important motivation for students pursuing STEM careers, and they discussed their interest in a STEM career as a way to pursue other goals such as entering into careers with financial stability. As such, academic hope may be an important factor in helping STEM students maintain the motivation and self-regulation needed for persisting to STEM degree completion, even when they encounter obstacles such as rigorous course work or financial uncertainties.

Implications for Practice

In recent years, many funding agencies such as the NSF and National Institutes of Health (NIH) have become more interested in supporting research that empirically documents the factors that contribute to improving the persistence rates of students in STEM fields, particularly among low-income HUR students such African Americans, Latinx, and Native Americans. This study has several implications for practice in terms of improving the number of underrepresented and economically disadvantaged students who successfully complete IT degrees and enter the IT workforce.

The results suggest that cohort-based integrated institutional interventions coupled with financial support are effective in promoting IT student retention. The findings have implications for planning successful interventions to address the academic, social, and financial needs of low-income, HUR IT students. It is noteworthy that we were not able to isolate which components of LiFT contributed to specific outcomes. Instead, our results focus on the importance of providing comprehensive cohort-based programs consisting of curricular and co-curricular support in addition to need-based financial aid.

The results may have implications in terms of the importance of considering need-based financial aid since this was a key component of the overall comprehensive LiFT program even though we were not able to isolate this component in our analyses. If HUR low-income STEM students are not provided with need-based financial aid, they may not have the basic necessities (food, clothing, housing) necessary to exert the intellectual effort necessary to meet rigorous course demands. Additionally, a lack of financial resources may limit students' ability to fully engage and reap the benefits of programs and interventions designed to improve their academic success. Scarcity of financial resources can result in what Mullainathan and Shafir (2013) describe as a situation of reduced attention or lack of bandwidth. When the mental bandwidth decreases as a result of scarcity, there is less scope for meeting the academic and social demands of college and a "tunnel vision" on the most immediate and most urgent matters (paying for expenses such as tuition, housing, textbooks). As such, our results point to the necessity of providing financial support coupled with curricular and co-curricular programming.

Due to the fact that the overall cohort-based LiFT program was designed to enhance a sense of belonging in STEM by providing a cohort-based summer bridge, learning communities, peer mentoring, and undergraduate research with faculty mentoring, this type of programming may be effective in low-income and underrepresented students' buffer against feeling isolated and alienated in competitive STEM programs. Sax et al. (2018) contend that dialog and action around improving student success in IT and computing professions have to move beyond the numbers (e.g., of students or employees) and focus on improving the overall climate of inclusion. Results of their study emphasized the importance of creating supportive environments, at the departmental and peer group level, in facilitating students' sense that they belong in the field of computing. Our study took this one step further and examined the importance of sense of belonging in students' decisions to persist in IT majors to degree completion. Comprehensive interventions such as LiFT that contain peer mentoring by other computing/IT students and IT departmental–based programs such as summer bridge, IT-focused residential learning communities, and undergraduate research with IT faculty mentors may be effective strategies for ensuring that students feel like they fit in and belong to the IT field and profession, and this in turn may enhance student persistence to IT degree completion.

Finally, we explored how academic hope may play an important part in ensuring that low-income, HUR students persist in IT to degree completion. Cessna et al. (2018) contend that higher education leaders and scholars should conduct more research on what types of interventions work to prepare marginalized STEM students to do well in rigorous college coursework, instill confidence and agency to

succeed, and facilitate feelings of belonging with the institution and specific major. Institutions that offer comprehensive programming like LiFT containing peer mentoring, industry-based mentoring, and proactive advising strategies (helping students monitor their progress and set attainable, challenging goals) may create spaces of advocacy and support as they strive to accomplish the challenging goal of persisting in IT majors. Our research supports the theoretical framework of hope offered by Snyder et al. (2002). STEM students are often attempting to navigate complex institutional structures and developing plans and motivational strategies for attaining educational and personal goals. Additionally, programs like LiFT institutional context may provide students with the resources, support, and welcoming environment they need to thrive and persist.

Limitations and Future Directions

While our findings replicate and build upon past research regarding the importance of providing comprehensive support for economically disadvantaged, underrepresented STEM students and the relationship between academic hope, sense of belonging, and persistence in IT, it is important to address the limitations of this study. The sample was relatively small and primarily consisted of male, low-income, underrepresented minority IT students at two institutions. As such, the findings may not generalize to larger samples of underrepresented IT students. While the sample was representative of the underrepresented low-income IT students at the institutions, the fact that it was primarily men made it more difficult to fully understand the experience of women IT students.

Due to ethical concerns and logistical constraints, we were not able to randomly assign eligible students (economically disadvantaged and/or historically marginalized IT students) to the LiFT program or not. As such, one of the most serious limitations of this study is that we were not able to employ an experimental design and need to be cautious about making *causal* attributions about the LiFT program and differences in persistence rates. We were able to employ a quasi-experimental design and develop a matched control group of IT, underrepresented, low-income students not participating in the LiFT interventions to investigate the effects on 1-, 2-, and 3-year retention to STEM IT rates. However, our quasi-experimental design did allow us to determine what aspects of the LiFT program *caused* the differences in persistence rates, sense of belonging, and academic hope. The LiFT program was designed to provide comprehensive support for all eligible IT students and to ensure that the LiFT students have the opportunity to participate in all the interventions. In other words, LiFT students participated in all the interventions and were not randomly assigned to different programs or interventions (summer bridge, residential learning communities, leadership and career development, industry engagement, peer mentoring, proactive advising, undergraduate research opportunities, and need-based financial aid support). Instead, the theory-driven LiFT program, by design, consisted of various curricular and co-curricular activities designed to improve students' sense of

belonging, academic hope, and persistence. Additionally, time constraints limited our ability to assess the long-term impacts of the interventions (e.g., IT employment and workforce outcomes).

Future longitudinal and experimental designs are needed to enhance the generalizability and validity of the current findings. Additionally, larger samples with varied experiences among participants would allow for an examination of the unique contributions of interventions on students' levels of sense of belonging, academic hope, and persistence. Understanding if some interventions such as leveraging need-based financial aid or residential learning communities have stronger associations with sense of belonging, academic hope, and persistence rates could help guide the allocation of resources by higher educational practitioners and leaders. More research focusing on women IT students is also needed. Understanding how perceptions of belonging and academic hope affect persistence may be particularly important in male-dominated STEM fields like IT. Banchefsky et al.'s (2019) results suggested that there was a stronger relationship between social belonging and intentions to persist in STEM for women than men. Future studies should also examine the effects of comprehensive interventions on longer-term outcomes such as wage and employment outcomes. After all, the primary purpose of the funding for such programs is to improve the underrepresented minorities in the STEM workforce.

Despite the acknowledged limitations, higher education professionals may find the current findings insightful, particularly if they are attempting to design comprehensive programs to meet the needs of low-income, HUR IT students and improve persistence rates. Increasingly, there is tremendous interest in research that focuses on what factors predict the retention and persistence of low-income, underrepresented STEM college students. Given that many institutions continue to invest resources to ensure the success of *all* students, this study focused on the factors that are relevant for ensuring the success of IT students. Although research has supported many of the factors identified in this present study, what makes this study relevant is that it underscores that academic hope and STEM major–specific sense of belonging are important theoretical frameworks to guide future research and practice in the area of STEM student persistence. Second, this study suggested that academic hope is not a fleeting emotion but plays an important role in ensuring that students attain valued educational goals such as persisting to degree completion. We hope that the recommendations and implications discussed are useful to future researchers and practitioners as they grapple with ways to ensure that economically disadvantaged, historically underrepresented IT students persist to degree completion.

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Declarations

Competing interests The authors declare no competing interests.

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