Can Sending First and Second Year Computing Students to Technical Conferences Help Retention?

An Analysis of National Survey Data

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ABSTRACT

This research examines the relationship between undergraduate computing students' participation in technical conferences and psychological predictors of academic persistence. Studies have shown experiential educational activities, like conferences, encourage students' persistence in STEM; this is especially important for students underrepresented in the field, who are more likely than their well-represented peers to leave their degree programs. In recent years, academic literature has pointed to anecdotal evidence that conference participation for students early in their undergraduate education relates to students' persistence in STEM pathways. Using national survey data, we examine the relationship between conference participation and first and second year undergraduate students' persistence in computer science pathways. This paper presents results from a cross-sectional analysis and a two time-point analysis of national survey data collected from undergraduate students. Overall, we found that first and second year computing majors who attended a technical computing conference reported higher levels of belonging to their field and confidence to persist in their degree program than those who did not attend. We also found that conference participants' levels of belonging and self-confidence is higher than non-participants over time, even after controlling for initial levels at Time 1. Our analyses also showed that conference participation was associated with closing the gap in levels of belonging and self-confidence between students who are underrepresented in computing and those who are well-represented. Empirical results from this paper support anecdotal evidence that conference participation for students early in their undergraduate education may help retain students, and particularly underrepresented students, in computing majors in the long-term.

CCS CONCEPTS

• **Social and professional topics** → **Computing education**; *Race and ethnicity*; *Gender*.

KEYWORDS

student retention; diversity; education research; belonging; self-confidence; technical conferences

1 INTRODUCTION

It is widely known and understood that the field of computer science lacks diversity. Of Bachelor's degrees in computer science awarded in 2015, only 18% went to women and 20% went to students (both men and women) considered underrepresented racial/ethnic minorities (URM) in computing (e.g., Black/African American, Hispanic/Latino(a), and Alaska Natives/Pacific Islanders) [32]. At the graduate level, percentage of PhDs in computing awarded to women and URMs were 23% and 11%, respectively [32]. Although the proportion of women and URMs earning computer science degrees remains relatively low, the field of computing continues to grow each year [33, 46–48]. Further, a recent survey of Americans [15] found that 48% of respondents expect the number of STEM jobs to continually grow in the U.S. over the next decade, and 2 out of 5 believe worker shortages in STEM are at crisis levels. Despite this, less than half of parents in the survey sample encouraged their daughters to pursue STEM careers [15].

There have been several initiatives aimed at recruiting a diverse body of students in computing to help fill the growing needs of the country; most notably, the National Science Foundation (NSF) Directorate for Computer and Information Science and Engineering (CISE) released a Dear Colleague Letter in 2017 solidifying its commitment to broadening participation of underrepresented populations in computing fields [24]. This comes years after NSF's 2012 CISE Strategic Plan for Broadening Participation, which outlined CISE goals to take a leadership role in calling the community to action and raising awareness of issues related to underrepresented populations in STEM [18]. As the nation continues to place high importance on broadening participation of URMs and women, it is critical to understand the factors that relate to the success and retention of these students in the field.

2 EXPERIENTIAL LEARNING AND ENGAGEMENT

Researchers have long sought to understand why some students tend to leave their domain at higher rates than other groups of students; for example, literature has shown that women and URM students tend to leave, or seriously think about leaving [38] STEM fields at higher rates than men and racial majorities [14, 28, 37, 40].

Research shows that students who participate in extracurricular activities are less likely to drop out of school, especially if those activities help socially connect students with peers [30]. Further, experiential educational activities have been found to help students, and especially underrepresented students, persist in STEM fields [31, 35]. Engaging students in undergraduate research experiences has been shown to boost students' academic engagement and skill mastery, sense of belonging, and confidence to persist in academic degree programs [21, 25, 31]. Finally, experiential education can enhance the knowledge of, and engagement in, science among underrepresented minority youth [13].

While much is known about experiential education activities as they relate to formal research experiences and summer programs, less is known about the impact on conference engagement for undergraduate students in STEM fields; however, there is some evidence of the benefits of conference participation. For example, a 2009 study found that conference participation can improve communication skills and foster positive attitudes towards science careers [29]. Further, an exploratory analysis showed that computing majors who attended diversity focused conferences were more confident in their ability to complete their undergraduate degree in computing than those who had no experience attending these conferences [39]. Finally, a qualitative study examining the results of 90 in-depth interviews conducted over three years showed that engagement in conferences dedicated to undergraduate researchers helped develop skills like scientific communication and critical thinking, boost confidence, and give value to the importance of research engagement [42].

Recently, participation in academic conferences, especially for first and second year students, has been recommended as a mechanism for student engagement and retention. In 2006, faculty at Harvey Mudd College (HMC) began taking first-year women to the Grace Hopper Celebration of Women in Computing conference (GHC), which is an annual conference celebrating the achievements of women in computing. In combination with other efforts to recruit and retain women in computing, such as transforming the introductory computing course and expanding research opportunities to rising sophomores, HMC saw an increase in the percentage of women entering the major, as well as higher graduation rates among women in computing [1]. In addition, HMC learned from survey data that students who attended GHC were more likely to take computing courses and major in computing, which held true for both students who intended to major in computing, and those who did not, prior to entering college [2]. Finally, an ACM Inroads article published in 2017 was dedicated to supporting undergraduate students at conferences and how to encourage them to make the most of their experience [11].

Although recommendations around conference participation and student retention has encouraged faculty to enable first and second year students to attend conferences, an exploratory analysis showed that only a small portion of these students seem to be actually attending conferences; students in their third and fourth years of undergraduate study were more likely to have participated in technical conferences than first and second year students [44]. Even so, encouraging students early in their undergraduate education toward active learning activities may be an important step towards student retention [41].

2.1 Engaging First and Second Year Students

Engaging first and second year students may be particularly advantageous due to higher attrition rates among freshman undergraduate students. Data from the National Student Clearinghouse showed that for students who entered college in 2015, 26.6% of first year students dropped out of college completely; when analyzing those data by race and ethnicity, Black students had the lowest persistence rate (66.9%) followed by Hispanic students (72.5%) [9].

Researchers have posited psychological factors may be at play; studies investigating psychological outcome measures have examined the role that belonging takes in relation to students' academic persistence. Belonging, known as feeling welcomed and socially interconnected with others, has been argued as an inherit human need that can impact physical and emotional well-being, sense of identity and security, judgment, self-esteem, and academic engagement [6, 7, 10, 12, 26, 27, 34, 45].

In a longitudinal study examining sense of belonging among African American and White first year college students [20], researchers found that both groups of students equally reported a weaker sense of belonging over time; however, students who reported more academic integration showed stronger levels of belonging over time. They also found that both sense of belonging and institutional commitment were positively correlated with students' intentions to persist in their degree regardless of background.

Even so, studies have shown that URMs and women are particularly sensitive to the effects of belonging when it comes to their academic achievement and persistence [43]. Among Latino/a undergraduate students, researchers have found these students are more likely to think about leaving their degree when confronted with adversity and identity threat [23] and perceive a lack of social fit and support from peers and mentors [19].

When both belonging and self-efficacy (e.g., the belief and/or confidence in one's ability to perform tasks and achieve goals [3]) are low, researchers have found women are particularly likely to consider leaving their academic degree program across a range of STEM disciplines [28]. Just like belonging, self-efficacy has been theorized to play a major role in students' academic engagement, persistence, and future career choices [3–5, 36]. For example, a six-year longitudinal study of women in science and engineering (S&E) at the University of Washington [8] found that over time, women lose confidence (i.e., self-efficacy) in their academic abilities. While women intending to pursue an S&E major reported a strong initial level of confidence in their math and science abilities, their confidence levels dropped dramatically over the course of their first year of college; however, they also found that women who held high levels of confidence in their math and science abilities

consistently over time were the ones more engaged in extracurricular and experiential learning activities, such as student societies, conferences, and internships.

Given that literature supports the idea that the first and second years of college are critical time periods, we theorize that incorporating experiential learning into the curriculum may act as a buffer from negative environmental and social factors that reduce belonging to the field and confidence to persist in computing. As a case in point, a study of Latino/a students showed that when students were socially and resourcefully supported in their first year of college, they showed positive academic and personal adjustment in the second year of college [22].

2.2 Research Questions and Hypotheses

To examine the relationship between conference participation and psychological predictors of students persistence in the field , we conducted two research studies. In our first study of a cross-sectional dataset, we asked how does conference participation *relate* to first and second year undergraduate students' persistence in computing pathways, and does that relationship differ for students who are considered underrepresented in computing?

In our second study, which uses a repeated measures design with two-time points, we asked how does conference participation *influence* first and second year undergraduate students' persistence in computing pathways, and does that relationship differ for students who are considered underrepresented in computing?

We hypothesized that students who participated in technical computing conferences would report a stronger sense of belonging and confidence to persist in computing (e.g., self-confidence) compared to those without conference participation. We also hypothesized that for underrepresented students, conference participation would have a greater impact on belonging and self-confidence than for well-represented students.

3 RESEARCH DESIGN

Each year, the Computing Research Association's Center for Evaluating the Research Pipeline (CERP) collects national survey data in an initiative called Data Buddies Survey (DBS). To do so, CERP researchers ask academic departments across the United States to distribute an anonymous survey link to students in their department. The online survey asks students who are affiliated with computing in some way (e.g., computing majors, minors, and those taking courses) about their degree program, psychosocial measures, and future career plans. At the end of the survey, students are given the option to complete future surveys, and students who agree to be tracked over time are contacted directly for the purpose of longitudinal data collection.

In Study 1, we examined DBS data collected from undergraduate students during the fall of 2016 [17]. In Study 2, we analyzed data collected at two points (2014 and 2015) from a panel of undergraduate students [16].

3.1 Participants

In our studies, survey respondents were drawn from DBS between 2014 and 2016. Undergraduate students in both studies were considered computing majors if they were in the following degree programs: computer science, computer information systems and/or informatics, bioinformatics, computing and business, information technology, computer engineering/software engineering, and any other degree related to computing (marked as "other computing-related degree"). Below, we describe participants specific to each study.

3.1.1 Study 1. In 2016, 11,753 undergraduate students responded to DBS. Among those, 2,662 first year and 2,366 second year students completed the survey. Students who were not computing majors and did not complete survey questions about their gender, racial/ethnic identity, or conference participation were excluded from the analysis. The final sample of first and second year students who were computing majors equaled 3,652. Of those, 18% had participated in a technical conference in computing and 42% were identified and coded as URMW [1].

3.1.2 Study 2. In 2014, 2,909 undergraduate students agreed to be contacted by CERP in the future, and 1,118 responded to the follow-up survey in 2015. Of these, 283 (26%) were first year and 328 (30%) were second year students. In order to examine the impact of conference participation early on in their career, we selected these first and second year students for our study. We further restricted our sample to only those students who had (a) not attended a conference during either of the data collection waves and (b) those who had attended a conference only during the 2014-2015 academic year. After dropping students who were not computing majors and those who had missing data in any of our independent and dependent variables, there were 347 students in the resulting dataset; 16% of these students attended a technical conference during the 2014-2015 academic year and 43% of the sample were coded as URMW.

3.2 Measures

This research focuses on the following subset of quantitative measures collected from DBS between 2014 and 2016.

3.2.1 Dependent Variables.

Belonging. Survey respondents were asked on a Likert scale from *(1) Strongly disagree* to *(5) Strongly agree* to rate the degree to which they felt a sense of belonging in computing with the following three statements: "I feel like I belong in the computing community," "I feel like an outsider in the computing community," and "I feel welcomed in the computing community." Item "I feel like an outsider in the computing community" was reverse coded for analysis.

Self-confidence. Survey respondents were asked on a Likert scale from *(1) Not at all* to *(5) Very* to rate the degree to which they felt confident to do the following: complete their undergraduate degree in computing, get admitted to a graduate computing program, find employment in their area of interest, and become a leader in the field of computing.

3.2.2 Independent Variables.

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[1] Underrepresented minorities and women (URMW) included students who identified as a woman or as Black/African American, of Hispanic or Latino descent, Native Hawaiians/Pacific Islanders, or multiracial in which one of their multiracial identities included at least one of the earlier listed racial/ethnic groups.

Conference participation. Using a single binary item (Yes = 1 or No = 0), survey respondents were asked if they had participated in a technical conference related to computing over the past year.

URMW. To identify URMs and women, survey respondents were asked to provide their racial/ethnic identity and gender. Students who identified as a woman or as Black/African American, of Hispanic or Latino descent, Native Hawaiians/Pacific Islanders, or multiracial in which one of their multiracial identities included at least one of the earlier listed racial/ethnic groups were included as URMW (coded as 1). Students who identified as men and were also White/Caucasian or of Asian descent were categorized as majority men (e.g., not URMW; MM) and coded as 0.

3.3 Analysis

3.3.1 Study 1. Each item discussed above measuring sense of belonging and self-confidence were aggregated together to form two constructs. Each construct was tested for internal reliability. The reliability coefficient (Cronbach's alpha) for belonging was .75 and .74 for self-confidence. These values are considered to indicate satisfactory reliability.

To test our hypotheses, data were analyzed using separate two-way Analysis of Variance (ANOVA) models. Conference participation and URMW status were treated as two independent variables in each model. Belonging and self-confidence were treated as dependent variables separately. Statistical significance was determined using $p \leq .05$.

3.3.2 Study 2. The constructs used for sense of belonging and self-confidence were tested for reliability at both time 1 and time 2 by calculating Cronbach's alpha values. Sense of belonging measure had Cronbach's alpha values of .76 at time 1 and .84 at time 2. Self-confidence construct had Cronbach's alpha values of .74 at time 1 and .76 at time 2. Based on these alpha coefficients, these constructs have satisfactory reliability.

In order to test the changes in students' belonging and self-confidence, we used two-way repeated measures ANOVA models. In our models, belonging and self-confidence measures were the dependent variables while URMW and conference participation were independent variables. Note that belonging and self-confidence were modeled separately. Statistical significance was determined using $p \leq .05$.

4 RESULTS

In this section, we present our findings for each study by outcome measure.

4.1 Study 1

Belonging. In our analysis, we first looked at all first and second year students' sense of belonging as a function of their conference participation. Results indicated an effect of conference participation, $F(1, 3643) = 8.42, p \leq .01$; such that students who participated in a conference in the past year reported a stronger sense of belonging in computing than students who had no conference participation.

Next, we examined whether the effect of conference participation on first and second year students differed by their represented status (URMW vs MM). First, results revealed that MM students
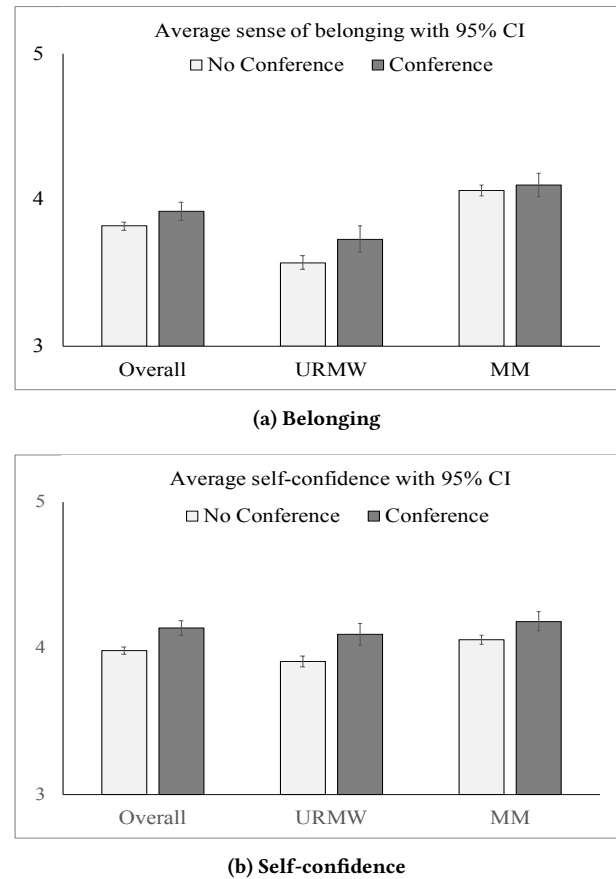

(a) Belonging

(b) Self-confidence

Figure 1: Study 1 Results-Sense of belonging and self-confidence by conference participation and group

reported stronger confidence to persist in computing overall than URMW students ($F(1, 3643) = 155.14, p \leq .01$), regardless of conference participation. Second, we found that URMW first and second year students who participated in a conference reported a stronger sense of belonging than URWM students without conference participation, $F(1, 3643) = 9.31, p \leq .01$. Finally, results indicated no difference in belonging for MM as a function of their conference participation, $F(1, 3643) = .88, p = .35$. See Figure 1a for a visualization of these results, including 95% confidence intervals, based on mean values.

Self-confidence. Next, we tested all first and second year students' confidence to persist in computing as a function of their conference participation. Results revealed that students with prior conference experience reported stronger confidence to persist in computing than non-participants, $F(1, 3645) = 31.24, p \leq .01$. When testing for differences in conference participation as a function of students representation status, results indicated both URMW ($F(1, 3643) = 20.01, p \leq .01$) and MM ($F(1, 3643) = 11.44, p \leq .01$) students reported stronger confidence if they had participated in a conference compared to URMW and MM students who had not participated in a conference.

Finally, while MM reported stronger self-confidence to persist in computing overall than URMW students ($F(1, 3645) = 18.16, p \le .01$), the difference in confidence between MM and URMW students disappeared among conference participants, $F(1, 3645) = 3.09, p = .08$. See Figure 1b for a visualization of these results, including 95% confidence intervals, based on mean values.

4.2 Study 2

Belonging. We began by looking at time 2 pairwise comparisons in order to see if they aligned with our findings in Study 1. We found that conference participants at time 2 had a stronger sense of belonging than non-participants overall ($F(1, 343) = 4.96, p \le .05$). When we look at this comparison for URMW and MM separately, we found that this difference was statistically significant only for the URMW students ($F(1, 343) = 6.98, p \le .05$) and not for MM ($F(1, 343) = .04, p = .83$). These comparisons on data from 2015 replicated the results of Study 1.

Next, we examined the changes in students' sense of belonging over time. For the full sample, students who did not participate in a conference showed a statistically significant decrease in their sense of belonging over time ($F(1, 343) = 4.59, p \le .05$). On the other hand, conference participants did not have a statistically significant change in their levels of belonging ($F(1, 343) = .22, p = .64$). When we looked at the change over time for URMW and MM separately, we found that while URMW students who did not participate in a conference showed a statistically significant decrease in their sense of belonging ($F(1, 343) = 4.73, p \le .05$), URMW conference participants did not show a statistically significant change ($F(1, 343) = .22, p = .64$). MM did not have a statistically significant change in their belonging regardless of their conference participation (non-participants: $F(1, 343) = .52, p = .46$, participants: $F(1, 343) = .07, p = .79$). Figure 2a shows the results for the analysis of change in belonging over time, including 95% confidence intervals.

Self-confidence. We examined the pairwise comparisons at time 2 to understand if results aligned with our findings in Study 1. The overall comparison of conference participants and non-participants showed that students who participated in a conference had higher levels of confidence to persist in computing ($F(1, 343) = 6.51, p \le .05$). Both URMW and MM conference participants had higher confidence to persist in computing; however, this comparison was not statistically significant for MM (URMW: $F(1, 343) = 4.07, p \le .05$, MM: $F(1, 343) = 2.60, p = .11$) . While the overall difference of conference participants and non-participants aligned with that of Study 1, analyses in Study 2 did not show a statistically significant difference for MM.

When we looked at the effects of conference participation over time, we found that without conference participation, students' self-confidence decreased over time ($F(1, 343) = 7.95, p \le .05$). On the other hand, conference participants did not experience a statistically significant change in their confidence to persist ($F(1, 343) = 2.68, p = .10$).

When we looked at this change for URMW and MM separately, our results showed that URMW non-participants showed a statistically significant decrease in their sense of belonging ($F(1, 343) =$
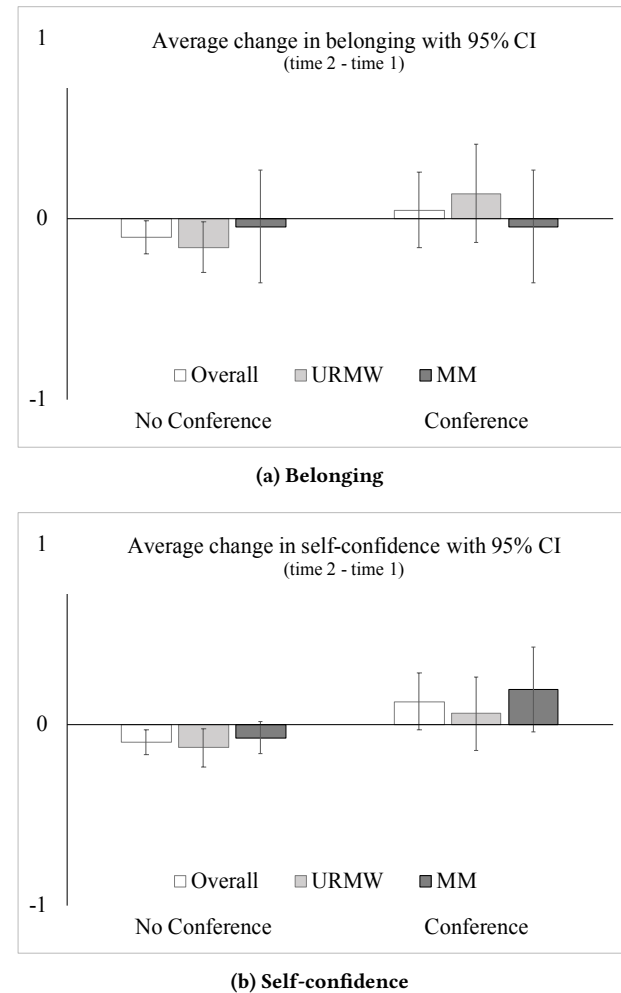

(a) Belonging

(b) Self-confidence

Figure 2: Study 2 Results- Sense of belonging and self-confidence by conference participation and group

$5.49, p \le .05$); MM non-participants did not have a statistically significant change in their self-confidence ($F(1, 343) = 2.53, p = .11$). For students who participated in a conference, neither URMW nor MM showed a statistically significant change in their confidence to persist in computing (URMW: $F(1, 343) = .36, p = .55$, MM: $F(1, 343) = 2.71, p = .10$). Figure 2b shows the results for the analysis of change in confidence to persist in computing over time, including 95% confidence intervals.

5 DISCUSSION

We aimed to examine any relationship between conference participation and non-cognitive psychological factors related to students' persistence in computing. Specifically, we focused on first and second year undergraduate students, as intervening early on in these critical years may help retain students in the long term [20]. Studies have found that, especially in the case of women and racial/ethnic minorities, students experience a decline in their belonging and self-confidence after they enter into their degree programs [8, 20, 22].

We argue that, based on the evidence supporting the positive impact of experiential learning activities on students' sense of belonging and self-confidence [21, 29–31, 35, 39, 42], participating in conferences may help attenuate the conditions that result in attrition.

Our goal in the current research was to test our hypothesis that conference participation, an experiential learning opportunity, would have a positive impact on student retention in computing as measured in students' self-reported sense of belonging and confidence to persist in their field. We further hypothesized that this impact would be especially significant for URMW students, who tend to not only have comparatively lower levels of belonging and confidence to persist [28, 43], but also leave their degree programs at higher rates [14, 19, 23, 28, 37, 38, 40].

Taken together, results from our studies indicate that conference participants report higher levels of belonging and confidence in their ability to persist in computing. These findings were replicated in cross-sectional data from two separate years: 2015 in Study 2 and 2016 in Study 1. Our analysis also indicated that not only does conference participation benefit all students, URMW students seem to reap the most benefits from conference participation.

In Study 1, URMW students who participated in a conference had a stronger sense of belonging than non-participant URMW students, while MM's sense of belonging did not differ based on their conference participation. Overall, both URMW and MM conference participants were more confident in their ability to persist in computing compared to their non-participant counterparts. Even though URMW students as a whole had lower confidence levels than MM, this gap in confidence levels between URMW and MM students held only for those who did not participate in a conference and was not present for conference participants.

Study 2 showed that conference participation helped eliminate the decrease that is observed in non-participant URMW students' sense of belonging and confidence to persist over time. Overall, URMW students showed a decrease in their belonging and confidence levels over time while MM did not experience a significant change in either of these measures. However, URMW students who participated in a conference did not experience this decrease. MM's levels of belonging and confidence over time did not change regardless of their conference participation.

It is also important to note that while we observed statistically significant benefits of conference participation on students' sense of belonging and confidence to persist in computing, we also observed that URMW students reported both weaker belonging and confidence on average than MM students. This finding is consistent with existing research and theory that posits that students in underrepresented groups are more likely than their majority peers to feel like they do not belong and think about leaving their field, as discussed above; however, given that results from our study indicate conference participation may eliminate these differences, our research findings support recommendations to provide experiential learning opportunities to help retain students in the field.

5.1 Limitations and Future Work

More work is necessary to understand the extent to which conferences make an impact on student retention in the long-term. For example, while Study 2 examines two time points of data from a panel of students, additional time points can examine whether participation in conferences has a sustained impact on the students' belonging and confidence to persist. Additional time points of data would also allow for the examination of actual persistence; the current work only examines students' *confidence* to persist.

Furthermore, additional work is needed to examine causal mechanisms linking conference participation to higher belonging and confidence levels, which can help illuminate the way in which conferences (and other experiential learning interventions) influence students' persistence in the field. This would provide practitioners with more insight on what aspects of these activities are especially important for students and help inform decision-making related to broadening participation in computing. Additional work should also help identify other interventions that have similar positive impacts on students' belonging, self-confidence, and ultimately, their persistence. Because this study only examines one form of intervention, conference participation, additional research examining other forms of interventions will be an important consideration for future work.

Finally, as discussed earlier, a larger portion of undergraduates who attended conferences are more likely to be students who are further along in their degree programs [44], understandably, as these students have already engaged more deeply in their computing major. However, this research does not explore any impacts of conference participation on third and fourth year students. This research also does not explore impacts of conference participation on students in individual computing majors, nor does it examine group differences by students' individual racial/ethnic and gender identities. Future work should compare the differential impact of conference attendance on third and fourth year undergraduates versus first and second year students' psychological and environmental factors that are related to persistence, in addition to exploring differences in the impact of conference attendance on differing computing majors and group identities. Even so, this work is a first-step in understanding, empirically, whether it is worth the time and financial resources to send undergraduate students early in their education to conferences in computing; at present, research results suggest that it might be a worthwhile investment.

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