PRISM: A Journal of Regional Engagement

Volume 3 | Issue 2 Article 3

December 2014

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The Students & Technology in Academia, Research, and Service (STARS) Computing Corps is a nationally-connected system of regional partnerships among higher education, K-12 schools, industry and the community, with a mission to broaden the participation of women, under-represented minorities and persons with disabilities in computing (BPC). With support from National Science Foundation funding, the University of North Carolina at Charlotte founded the STARS Alliance (now the STARS Computing Corps) which includes 44 universities, each with its own "constellation" of local and regional partnerships. McClintock Partners in Education (McPIE) is a partnership between a middle school, a church, and their surrounding community. This paper describes how a STARS-McPIE "partnership between partnerships" has impacted both the middle school students and their college student mentors.

Keywords: STEM education, Regional partnerships, Broadening participation in Computing (BPC), Diversity

Recent reports by the Commerce Department indicate that under-representation of minorities and women in the fields of science, technology, engineering, and math (STEM) has persisted into the new decade (Strauss, 2011). Although women make up about half of the U.S. workforce, they hold less than 25% of STEM jobs. African Americans, American Indians, and Hispanics between the ages of 18 and 24 account for 34% of the American population in this age category, yet earn only 12% of undergraduate engineering degrees. Almost three-quarters of American scientists and engineers are white, and only 1 in 10 STEM professionals is a minority woman (Feller, 2012, June 19).

The Obama administration has made improving STEM education and increasing the participation of all groups a national priority, arguing that the country's economic future depends on a strong and diverse STEM work force (Strauss, 2011). "The emphasis on *all* students is important because we cannot afford to leave behind those groups that have traditionally been underrepresented in STEM: women, persons with disabilities, African Americans, Hispanics, Native Americans, and indigenous peoples. Together these groups make up nearly 70% of our population. Without their participation, talents, and creativity, our Nation cannot meet its imperative for a globally competitive, computationally savvy workforce and we cannot hope to achieve the appropriate scientific, technological and economic innovations that will serve our highly diverse society" (National Science Foundation (NSF), 2013, p.1).

Many efforts are currently underway to address the diversity-gap in STEM education and employment. The purpose of this paper is to describe one such effort that utilizes STEM

college student outreach to underrepresented middle school students with the overarching goal of creating and sustaining pathways into STEM disciplines and careers for both groups of students. Specifically, the paper addresses the following research questions:

1. How does participation in a structured, semester long outreach program that teaches computing skills to underrepresented middle school students impact their interest in computing, their perceived efficacy of succeeding in computing, and their perceived fit in computing disciplines and careers?
2. How does participation in the same outreach program impact the college students' computing efficacy, computing identity, and computing commitment?

These questions were examined using a pre-post field-study design that was set in a high-poverty middle school that was the focus of an innovative regional partnership called McPIE (McClintock Partners in Education). The college student outreach volunteers were part of a national partnership focused on building STEM pathways and supported by the National Science Foundation (NSF) called the STARS (Students & Technology in Academia, Research, and Service) Computing Corps,[1] a nationally-connected system of regional partnerships among higher education, K-12 schools, industry and the community, with a mission to broaden the participation of women, under-represented minorities and persons with disabilities in computing (BPC). With support from NSF funding,[2] the University of North Carolina at Charlotte founded the STARS Alliance (now the STARS Computing Corps) which includes 44 universities, each with its own "constellation" of local and regional partnerships. STARS goals include recruiting, bridging (increasing student readiness to enter computing programs and increasing the number of undergraduates that enter computing graduate school or the workforce) and retaining underrepresented groups in computing, and the primary vehicle for achieving these goals is the STARS Leadership Corps. Corps students are called to action to advance their own skills and success in computing, while taking leadership in service projects to advance peers or younger students, particularly from the underrepresented groups. Corps leadership projects attempt to catalyze regional partnerships by providing college student volunteers for K-12 and nonprofit organizations in a systematic way. The Corps seeks to strengthen programs that already exist and leverage program impact through partnerships such as McPIE.

The McPIE Regional Partnership

McPIE began in 2007 in response to the Charlotte Mecklenburg School District (CMS) challenge to the faith-based community to support high-poverty schools (Cagley, 2011). Christ Lutheran Church of Charlotte, North Carolina responded by "adopting" McClintock, a neighboring middle school with a large at-risk population (800 students, 82% economically disadvantaged and 87% minority). About 100 students transfer in and out of McClintock each year due to family instability, and 10% of students were homeless at some point during the last academic year. The mission of the partnership is to "ensure that students have access to support, opportunities, and resources which will provide them with the best education available and to ensure their future, life-long success in the 20th century world" (Cagley, 2011, p. 3). While the McPIE partnership pursues this mission through a broad array of programs and activities, many are designed to support McClintock's status as a "STEM-focused Middle School," a designation formally conferred by the County Board of Education in 2010. This designation implies a concerted and committed effort

[1] For more information, see http://www.starscomputingcorps.org/

[2] NSF awards that have supported STARS are 1042468, 0739216, and 0540523.

to stop the well-documented leak in the middle-school STEM pipeline, especially among minority and female students.

McPIE was the first and has become the flagship model for partnerships between faith-based organizations and CMS high-poverty schools. With involvement of over 200 volunteers, McPIE has become a regional and national model for comprehensive school-community partnerships. During the past year, McPIE has hosted over 60 external visitors from across North America who are benchmarking the success and sustainability McPIE has achieved. Finally, McPIE was awarded the 2013 North Carolina Science, Math, and Technology Center Partnership Award recognizing "organizations whose innovative partnership supports the advancement of STEM Education" (http://ncsmt.org/awards/partnership/2013). Perhaps the power of McPIE is best captured by the McClintock Principal who stated that McPIE is "a model for our nation in so many ways….our students have begun to envision a future story for themselves and to develop a plan to achieve that future…I know the children are worthy of the time, energy, and talent our volunteers have put into this partnership" (*An Open Letter to the Community*, 2011).

McPIE's success is centered on the provision of authentic, personal, supportive relationships between volunteers, students, and their families (Cagley, 2011). Much of this relationship-building occurs through Family Night, a program for McClintock students and their families sponsored by McPIE. Family Nights are held every Tuesday evening for 14 weeks during each academic semester. Families are treated to dinner followed by McPIE-supported development opportunities for both parents and students. Parents receive training and are exposed to resources to help them support their students' success. Students can choose from a variety of clubs provided by volunteers, including STARS Corps students from the University of North Carolina at Charlotte, who joined forces with McPIE in 2011 to form the partnership between partnerships referred to in the article's title.

STARS-McPIE Partnership

The STARS Corps volunteers at McClintock include college students who are enrolled in a credit-bearing Computing Leaders Seminar class and who choose McClintock as their Corps project for that semester (some continue at the site for a second semester). Because of its diversity, Corps students provide McClintock students with diverse role models. Over the last three semesters, student leaders of the McClintock Clubs have included one Hispanic male, two Hispanic females, one African-American female, and one Caucasian female.

After experimenting with several technology themes and formats for clubs at McClintock (e.g., computing concepts for boys, robotics for girls), it has evolved into its current format—the Cyber Club. This club includes both boys and girls and focuses on a variety of computing concepts and is part of the McPIE-sponsored Family Night program for McClintock students and their families. During Cyber Club meetings, Corps students introduce computing concepts such as game design, programming with Scratch, security, web design, and mobile application development. Several weeks are devoted to each concept. Corps students are responsible for the development and delivery of the club's "computing curriculum." They began with lesson plans from the SPARCS (Students in Programming, Robotics, and Computer Science) program developed by the STARS Leadership Corps at North Carolina State University. The SPARCS goal is for knowledgeable students studying computer science to lead hands-on learning activities

that introduce adolescents to computing concepts in order to "spark" an early interest in the field. Originally designed for a four-hour span taught monthly, these lesson plans had to be adapted to McClintock's schedule of shorter but more frequent sessions. A typical club session includes a presentation of the concept by a Corps student and then hands-on activities for the middle school students. In addition to the weekly club sessions at McClintock Middle School, each semester the Cyber Club leaders host participants at UNC Charlotte for tours of the computing labs and escort them to dinner at the Student Union.

Expected Outcomes of the STARS-McPIE Partnership

The literature on enhancing diversity in STEM focuses on two areas: recruiting young students to enter STEM fields of study, and retaining them once they become STEM students. The STARS-McPIE partnership addresses both recruitment of middle school students (through Cyber Club) and retention of college students (through the Corps). Therefore, the partnership is expected to have positive effects for both groups of under-represented students. First, Corps students who engage in service-based leadership projects that utilize and develop their computing and leadership skills should experience enhanced perceptions and attitudes related to their retention in STEM. This is supported by a decade of research—e.g., Astin, Vogelsang, Ikeda, and Yee, 2000; Coyle, Jamieson, & Oakes, 2006; Cohoon, 2005; Marra & Bogue, 2006; Rittmayer & Beier, 2006. Specifically, we expect Corps participation to positively impact three such attitudes—computing efficacy, identity and commitment. Second, Cyber Club students who benefit from the outreach provided by the Corps students should develop attitudes that the literature has linked to STEM recruitment: interest, efficacy, and fit (e.g., Murzyn, 2013; Rivoli & Ralston, 2009; Tachibana, 2012). While the STEM intervention itself is the same for both sets of students and the anticipated outcomes are similar, it should be noted that the two groups have very different roles in the intervention which has important implications for framing our method and results. Specifically, what we are assessing for the college students is the impact of the community engagement program and what we are assessing for the middle school students is the impact of the outreach program.

Method

Participants

Middle school students included were those who participated in Cyber Club during three academic semesters: 29 students completed pre-surveys (at the beginning of each semester) and 28 students completed post-surveys (at the end of each semester). Not all of the students completing pre-surveys completed post-surveys, as club participation varied across each semester and surveys were anonymous. The vast majority of participants were from groups under-represented in computing: 45% of participants were female and 96% were students of color (53% Black; 30% Hispanic; 7% Other). The average age of the students was 11 years. Because UNC Charlotte Corps students participate in several different leadership projects each year, only five were involved at McClintock Middle School. Because the data analysis for the college students was provided by the STARS evaluation team, it, unfortunately, was not possible to separate the five who worked at McClintock from the larger group of students enrolled in the Corps at UNC Charlotte. Therefore, data from all 59 students enrolled in the Corps during the three academic semesters of the Cyber Club were included in the analysis. Participants included 32 females and 26 from an under-

represented minority group.

Measures and Procedures

College students

The STARS Alliance evaluation team developed a survey to measure the attitudes identified by research as associated leading indicators of computing success: computing identity, computing efficacy, and computing commitment. Computing efficacy items were adapted from the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) Survey[3] which assesses task-specific efficacy for success in engineering. These items were changed so that all references to "engineering" were replaced with "computing". A subscale consisting of three computing-specific self-efficacy items was created from these items, which yielded a Cronbach's alpha reliability coefficient of .69. This subscale is referred to as "computing efficacy." Computing identity items were adapted from the LAESE "feeling of inclusion" subscale and consisted of three items which yielded a Cronbach's alpha reliability coefficient of .70. Psychological research has shown that behavioral intentions are predictive of actual behaviors (Muchinsky, 2006), and we developed three items to measure behavioral intentions to remain in computing, which yielded a Cronbach's alpha reliability coefficient of .65. See Table 1 for specific items.

Table 1
Changes in Computing Attitudes for Corps Students

Item	Pre	Post
Computing Efficacy Subscale	4.94	5.56*
I believe I can complete the programming requirements for my Computing degree.	5.12	5.66*
I believe I can complete my Computing degree.	5.23	5.78*
I can succeed in Computing without having to give up my other interests/ activities.	4.78	5.25
Computing Identity Subscale	4.14	4.65*
I have a lot in common with the other students in my Computing classes.	4.30	4.52
I feel a part of the Computing Department.	4.12	4.66*
I feel a sense of belonging to the Computing/IT Community.	4.01	4.75*
Computing Commitment Subscale	5.04	5.44*
I plan to obtain a graduate degree in Computing	4.65	5.22*
I plan to stay in the field of Computing long-term	5.01	5.50*
At the present time, I am confident that I will keep Computing as my major	5.45	5.60

* denotes means significantly different at $p < .05$

All items on all subscales were measured with 6-point Likert-style scales, ranging from 1 (strongly disagree) to 6 (strongly agree). The survey also contained demographic items about gender, race, and the number of semesters students participated in the SLC. The survey and all STARS assessment instrumentation are available on the STARS website

[3] The LAESE is a validated instrument developed by the Assessing Women in Engineering Program, funded by the National Science Foundation, https://www.engr.psu.edu/AWE/default.aspx.

(www.starscomputingcorps.org). The surveys were administered electronically to Corps students by the alliance evaluation team at the beginning of their first academic semester in the Corps, and repeated at the end of each academic semester thereafter.

Middle school students

Selected items from The STARS Outreach Computer Attitude Survey for Secondary Students (OCASSS)[4] were used to measure computing interest, efficacy and fit. The OCASSS was developed by the STARS Alliance Evaluation Team for use with middle and high school students who were recipients of Corps students' outreach. Some items were adapted from the Longitudinal Assessment of Engineering Self-Efficacy (LAESE Survey); items were adapted to change "engineering" to "computing" and to make age-appropriate for use with secondary students. The OCASSS included 20 items rated on a 5-point scale where 1= strongly disagree and 5= strongly agree. The OCASSS measures several subscales of Computing Attitudes, three of which were used in this study: Efficacy (confidence in computing success); Fit (computing is a good fit for me); and Interest (in computing).

The "efficacy" subscale is similar to the computing efficacy measure described above, adapted for secondary students. Likewise, the "fit" subscale is similar to the computing identity subscale described above, but adapted for this age group. The "interest" subscale was developed by the STARS Alliance evaluation team. Each subscale consisted of 3-4 items, as shown in Table 2. Each subscale was shown to be reliable for the current sample, with alpha coefficients ranging from .67 to .81. Corps students distributed the OCASSS in paper-pencil format at the beginning and end of each Cyber Club semester-long session, in compliance with IRB guidelines for participants under the age of 18. The IRB agreement required that all responses were anonymous so pre and post responses could not be matched.

Table 2

Changes in Computing Attitudes for Middle School Students

Subscale	Pre	Post
Interest in Computing Subscale	3.41	3.57
I might be interested in a career in computing	3.24	3.56
I am interested in learning more about computing	3.40	3.52
Someday I might be interested in majoring in computing in college	3.58	3.62
Efficacy in Computing Subscale	3.37	3.86*
I know a lot about computers	3.21	3.82*
I am good at using computers	3.90	4.44*
I am not smart enough to be good at computing as a major or career (reverse scored)	3.01	3.32
Fit in Computing Subscale	4.03	4.55*
People like me are interested in computers	3.35	3.89*
It is fun to use computers	4.46	4.96*
I like using computers	4.29	4.76*

* denotes means significantly different at $p < .05$

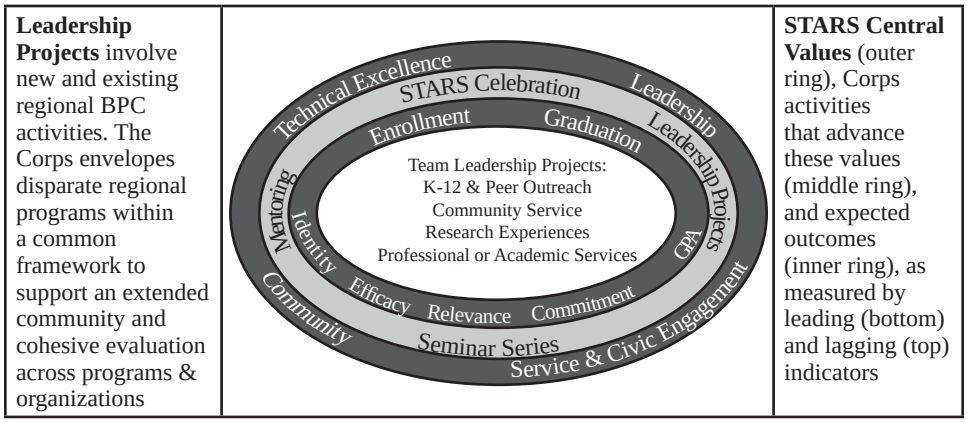
[4] OCASSS is available on the STARS Computing Corps Program Evaluation Toolkit, www.starscomputingcorps.org/resources

Results and Discussion

College students

As described above, Cronbach's alpha reliability coefficients were computed for each sub-scale and all yielded acceptable levels (above or near .70). Next, independent samples *t* tests were used to test for pre- and post-differences on all variables. As shown in Table 1, there was a significant pre-post increase (p= .05) on all three sub-scales, indicating that college students who participated in community outreach through the STARS Corps showed increased levels of computing identity, commitment, and efficacy. A shortcoming of this study is that the surveys of the Corps students who led the Cyber Club could not be analyzed separately from the larger Corps results, however, the results from the entire Corps are consistent with the literature which provided the theoretical basis for the Corps model (shown in Figure 1) and are also consistent with previous STARS findings.

Fig. 1.The STARS Leadership Corps Model



Previous studies by the STARS evaluation team reported results showing that Corps students had significantly higher commitment to computing, computing efficacy and computing identity than similar college computing students who were not involved in the Corps (Barnes, Dahlberg, Buch & Bean 2009; Dahlberg, Barnes, Buch, & Bean, 2010). A third study used a repeated-measures design to show positive change in the same attitudes—as well as GPA—over the course of students' participation in the Corps (Dahlberg, Barnes, Buch, & Rorrer, 2011). All of these are leading indicators of undergraduates' persistence and success in computing that are anticipated to impact lagging indicators of actual retention and graduation, also shown in Figure 1.

Middle school students

Similar but less marked changes in computing attitudes were observed for the middle school students participating in Cyber Club. As shown in Table 2, middle school scores on computing efficacy and fit increased significantly, suggesting that students began to change how they viewed themselves in relation to computing. Over the course of the semester, students began to see themselves as capable of success in computing and they also found the field increasingly attractive in terms of fit. The significant changes in students' efficacy—or the belief that they have the knowledge, skills, and aptitude to be successful in the field of

Published by Encompass, 2014

computing—is very important because efficacy has been shown to predict many outcomes. According to Bandura's theory, efficacy exerts a strong influence on behavior through goal choice, effort, and persistence and can predict both the level of motivation for a task and ultimately task performance (Bandura, 1997). Research has shown the importance of efficacy as a predictor of academic performance and retention in STEM disciplines, and found that programs which help to strengthen STEM efficacy are especially valuable for under-represented students (e.g., Marra & Bogue, 2006).

Similarly, perceived "fit" in an academic discipline or community has been shown to be predictive of student recruitment and retention in STEM disciplines, particularly for under-represented students (e.g., Cohoon, 2005). Research suggests that fit can be fostered through the presence of role models that students perceive as being "like me." Our interpretation of the findings is that the presence of diverse Corps students who are also successful in STEM may help to foster both computing efficacy and perceived fit in computing among the middle school students in Cyber Club.

Our results also showed increased interest in computing as a potential major or career among middle school students following participation in Cyber Club, but the increase was not statistically significant. There are several possible explanations for this result. Note in Table 2 that average responses on this subscale tended to be in the midpoint (neutral) range of the scale, suggesting perhaps that students are neither positive nor negative but instead have simply not given much serious thought to what they will be doing in college or career. This is perhaps to be expected given the average age of students in the study was only 11 years. Another possible explanation is that the content of Cyber Club did not explicitly address college and career decision making. When Corps students engage in outreach to older students this content is typically covered and positive change in computing interest has been observed. This suggests that in the future this content might be added to the Cyber Club in order to get students thinking of computing as more than a fun activity—perhaps something they can even turn into a future career. Another possibility is that interest will follow as a result of the observed increases in computing efficacy and fit. It seems unlikely that students would develop an interest in a computing major or career unless they first feel they can succeed (efficacy) and that they will like it (fit).

Overall, these results suggest that participation in Cyber Club is helping to foster positive attitudes toward self and computing for both the college and middle school students, which in turn offers support for the efficacy of the STARS-McPIE partnership.

Challenges, Future Directions, and Closing Observations on the Value of Partnerships

Challenges

Mentoring adolescents presents unique challenges for college students and at McClintock the challenges may be even greater due to the high incidence of poverty and instability in students' home environments. Corps students who had worked with both middle-class and high-poverty middle-schoolers commented on the differences in the attention-span and engagement of these two groups. To address this challenge, McPIE personnel facilitate workshops for Corps students based on *Bridges Out of Poverty* curriculum (Payne, DeVol, & Smith, 2001), a program used by McPIE to foster understanding and trust across socio-economic boundaries. The workshop gives the Corps students a framework for understanding poverty and the crucial need to build relationships with the students in order

to engage them in learning.

According to a McPIE volunteer, the *Bridges Out of Poverty* program helps people in poverty create a "future story" as a pathway out of poverty: "Think about it. For most of us, that future story is always there. Finish high school. Likely go to college. Find a career. Support ourselves and our family. And we're always planning for it. These children and their families don't have that future story" (L.Cagley, personal communication, April 1, 2014). Interacting with diverse college student role models, gaining confidence and building skills in Cyber Club, and visiting campus and touring computing labs help middle school students envision their own "future story." And, according to Corps volunteers, the opportunity to be a part of creating "future stories" for at-risk students is a rewarding part of the partnership.

An initial challenge for the STARS and McPIE partners was conveying to the McClintock students what the Cyber Club was about and why they should participate. Given that computing and information technology are not always familiar to young students, labeling and presenting the clubs in an engaging way was critical to their success. Initially, there were two clubs, Techno Club and Girls Get IT. The Techno club focused on computing concepts and Girls Get IT was a girls-only club intended to interest girls in robotics. The Techno club was successful from the start with a core group of students that attended regularly and were engaged in the activities. For the Girls Get IT club, the path was not as smooth. The McClintock girls had varied expectations of the club and the STARS club leaders became fairly adept at altering their lesson plans in order to better align the younger girls' interests with robotics. The following semester, several structural changes were made. The two clubs were combined into the Cyber Club with content for both girls and boys and this has worked well. The field trip to the UNC Charlotte computer research labs was moved to earlier in the semester to set the context that computing is used for exciting and useful purposes. Hands-on activities and demos in the research labs provided real-life examples and created enthusiasm in the students to learn and create with the computing concepts in the weekly club meetings. In the future, McPIE plans to target students that participate in the program's summer science camps for enrollment in the weekly clubs. This will both extend the camp experience of these students and enhance the club enrollment.

Overcoming these challenges has strengthened the STARS-McPIE partnership and this study has confirmed the benefits of the partnership for both McClintock and Corps students. However, there are many additional benefits of partnerships that have emerged from this study. First is the power of the McPIE partnership to leverage community, family, and school resources to transform a high-poverty middle school. There is no doubt that McPIE is making a difference and, as mentioned above, that it is a role model for others who wish to effect change through creative leveraging of new and existing partnerships. However, this study revealed additional benefits of the McPIE partnership for its university partner. First, McPIE had already set up a data collection agreement with the school that facilitated the data collection for this study. The current study is the first of many STARS studies to explore attitudinal outcomes of both middle school and college students. Second, and a benefit that is unique among STARS partners, McPIE volunteers provided valuable training for all Corps students (not just those volunteering at McClintock) on how to work with at-risk students and how to build relationships across cultural and socioeconomic boundaries. This extended their service-learning experience beyond the computing

aspects to a broadened awareness of relevant social issues and how they can contribute to an equitable society. A third benefit of this unique partnership was the tiered mentoring opportunities it provided: as college students served as mentors to middle school students, they were also the recipients of mentoring from McPIE volunteers, many of whom were community STEM and business leaders. A final benefit of the partnership for STARS is how the continuity of the relationship has allowed more long-term and sustained leadership projects for Corps students. Unlike those with McPIE, many leadership projects are one-time events and most of them have not been sustained over several years. This continuity of relationship improves the volunteer experience for the college students and reduces the administrative burdens of managing the Corps. McPIE has also benefitted from the partnership. They are excited to have tapped into such a large and continuous pool of qualified and diverse volunteers that a large research university can provide, and they are hoping to attract larger numbers of volunteers in the future.

Future Directions

The current study and the dialogue it generated among members of the McPIE-STARS partnership have identified several directions for future investigation. First, we need to better understand how different types of volunteer experiences and sites may affect the college student volunteers. For instance, it seems that placing students in partnership sites like McPIE may enrich their experience in a way that we could not measure in this study because of the small number of college students placed there and because of our inability to separate their data from students placed at other volunteer sites. Over time, as the number of McClintock volunteers grows, we hope to explore this question with additional research, perhaps using a more qualitative research design which would allow us to distinguish between the McClintock volunteers and other Corps students. Another useful avenue of inquiry would be a study to examine more directly the ways that the *Bridges Out of Poverty* workshops influence college students' understanding of poverty and the implications of socio-economic class on students' STEM interest, readiness, and success.

Summary

The study results reported in this paper suggest that the investments made in McPIE are reaping many benefits for multiple stakeholders in the partnership. The paper also identifies benefits of "partnerships between partnerships (STARS and McClintock/McPIE)" which share similar goals and leverage resources to enhance outcomes for each partnership. Certainly, STARS could not achieve its mission of broadening participation in computing without sites like McClintock where college students can engage in real-life community service projects that help them strengthen their computing skills and commitment. And McPIE could not achieve its mission as a Science, Math, and Technology school without the expertise provided by volunteers like the Corps students. Besides helping achieve individual partnership goals, the partnership between partners is contributing to the broader societal goal of building diverse STEM pathways.

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Authors' Note

This work was partially supported by NSF-CNS 1042468: The STARS Alliance: A Southeastern Partnership for Diverse Participation in Computing (2006-2009); NSF-CNS 0739216 BPC-AE: The STARS Alliance: A Southeastern Partnership for Broadening Participation in Computing (2008-2011); and NSF-CNS 0540523 BPC-AE: Scaling the STARS Alliance: A National Community for Broadening Participation through Regional Partnerships (2011, 2012, 2013).

About the Authors

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•**Linda Cagley** serves as Vice President of McClintock Partners In Education - McPIE. For the past seven years, she has volunteered as their director of development, securing funding and developing partnerships, and as their STEM advocate, developing summer and out-of-school time hands-on learning opportunities to engage low income middle school students and help them find a future pathway. Linda worked for 17 years with Exxon Company USA. She graduated from Vanderbilt University with bachelor degrees in chemical engineering and mathematics.