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Engaging youth of color in applied science education and public health promotion

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ABSTRACT

Participation in inquiry-based science education, which focuses on student-constructed learning, has been linked to academic success. Whereas the benefits of this type of science education are evident, access to such high-quality science curriculum and programming is not equitable. Black and Latino students in particular have less access to supplementary science programming, and fewer opportunities to engage in inquiry-based education. This paper describes outcomes associated with an inquiry-based out-of-school time science education program, *Nuestro Futuro: Applied Science Education to Engage Black and Latino Youth* (*NFASE*), which sought to build the capacity of middle school students of color to 'think' like health scientists from diverse disciplinary perspectives. The program was designed with the intent of (1) improving student attitudes toward and motivation for science and (2) increasing active and engaged citizenship (AEC). NFASE students explored health inequity and the social determinants of health locally and engaged in developing health promotion, outreach and education efforts targeted to their peers, parents/families, and community. Interest in the program was high overall, but implementation was not without challenges. Although evaluation outcomes indicate that there were no statistically significant changes in science-related attitudes or motivation, students reported significant increases in neighborhood social connection, as well as overall AEC.

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Science education; applied inquiry; youth-engagement

The National Science Teachers Association advocates for high-quality science education at all educational levels and envisions a society where all individuals are scientifically literate (National Science Teachers Association, 2015). For youth in particular, these goals are accomplished through active engagement in inquiry-based science curriculum, parental

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involvement in schooling, and supplementary science activities, which facilitate the meaningful integration of scientific concepts and processes into daily lives and bring about a deeper understanding and ability to think independently (National Science Teachers Association, 2015). Since youth are curious about the natural world, curriculum steeped in scientific inquiry can complement and bolster their understanding of and ability to navigate the world around them (Schweingruber, Duschl, & Shouse, 2007).

Racial and ethnic disparities in scientific literacy have been documented. A sample of eighth grade students completed the National Assessment of Educational Progress, a 2009 measure of student knowledge of physical science, life science, and Earth and space sciences. White students scored on average 36 points higher than Black students, and 30 points higher than Hispanic students on a scale of zero to 300 (National Center for Education Statistics, 2011, p. 26). In addition, among Black and Latino students that complete advanced placement science, technology, education, and math (STEM) coursework in high school, performance differences persist between white students and students of color (Riegle-Crumb & Grodsky, 2010). Research indicates that Latino students from low-income families and Blacks attending segregated schools fare worse in advanced math courses than their white counterparts in non-advanced math courses (Riegle-Crumb & Grodsky, 2010). An intentional focus on scientific literacy targeting youth of color is necessary to reduce the racial academic achievement gap.

This paper describes outcomes associated with an inquiry-based out-of-school time (OST) science education program, *Nuestro Futuro: Applied Science Education to Engage Black and Latino Youth* (*NFASE*). NFASE was intended to build the capacity of middle school students of color to engage in applied inquiry, learning how health scientists from diverse disciplinary perspectives think about disease. The program was designed with the intent of (1) improving student attitudes toward and motivation for science and (2) increasing active and engaged citizenship (AEC). NFASE students explored health inequity and the social determinants of health locally and engaged in developing health promotion, outreach, and education efforts targeted to their peers, parents/families, and community. We aimed to address several questions in evaluating the NFASE program including: Is participation in the NFASE program related to changes in science-related attitudes toward and youth motivation for science? And, Is participation in NFASE related to increases in youth AEC? In addition, as we were interested in how youth engaged their contexts in relation to program participation, we also explored the extent to which youth perceptions of peer, family, and teacher support for youth's science interest and education changed over the course of the intervention.

Inquiry-based education and OST programs

Inquiry-based education involves engagement in the learning process, and challenges learners to question and explore as they seek knowledge (Brewer & Daane, 2002). Different from traditional learning settings, inquiry-based education recognizes that students come to their experiences with preconceptions about the world and how things work. Inquiry-based education allows learners to seek evidence and construct solutions to support their reasoning (Gibson & Chase, 2002). Finally, inquiry-based education provides students the opportunity to develop their meta-cognition skills and develop the capacities to monitor and direct how they think and learn. The benefits of the application of this method have been well documented in the context of science education (Kanter & Konstantopoulos, 2010; White & Frederiksen, 1998; Wolf & Fraser, 2008). However, inquiry-based education and conceptual understanding in the sciences is not always emphasized in urban public school settings where science education is not connected to the broader context in which youth learn (Basu & Barton, 2007).

OST programs offer an important opportunity to increase interest in science and science careers among youth. Participation in OST activities is associated with STEM career interest in universities (Dabney et al., 2012). OST offers a host of benefits beyond academics; youth who participate are more likely than non-participating peers to do well in school, get sufficient physical exercise, and avoid risky behaviors (Moore, Murphey, Bandy, Mae, & Cooper, 2014). Students who participate in science-focused OST have demonstrated statistically significant gains in subject matter knowledge (Miller, Ward, Sienkiewicz, & Antonucci, 2011). OST participation has also been linked to civic engagement (Sherrod & Lauckhardt, 2009; Stoneman, 2002; Zaff, Moore, Papillo, & Williams, 2003). For young men of color, after-school programs can offer promising strategies to promote both health and academic outcomes (Woodland, 2008). However, accessibility of these programs and their sustainability may be inequitable, with cost and location presenting barriers, particularly for some low-income students (Moore et al., 2014)

NFASE program overview

OST science enrichment provides an opportunity to tap into children's natural curiosity, encouraging them to explore, experiment, and ask questions. NFASE is an OST enrichment program that sought to (1) cultivate a deeper, contextualized understanding of scientific concepts among students related to health disparities and the social determinants of health in their community; (2) foster the ability of students to 'think' like scientists from various disciplines (e.g. epidemiology, sociology, biomedicine) as they study conditions and diseases that present inequities in their community (e.g. stress, obesity, asthma, diabetes); and (3) provide an opportunity for students to use what they have learned about health, science, and inequity to develop and carry out local advocacy and outreach efforts. Inquiry-based education was a key tenet of the NFASE program. Unlike traditional science education programs, NFASE was built on the premise that existing knowledge and lived experience can be leveraged to increase students' motivation to study science and improve their science-related attitudes while serving as a basis to increase students understanding of complex social and environmental issues that give rise to health inequity endemic to urban communities of color. To that end, NFASE was grounded in popular education (Freire, 1970).

Popular education relies on critical pedagogy, a method of education focused on learner empowerment that exists in response to the inequities of our society. Freire argued the education system is oppressive in that it is based on *Educação Bancária*, a hierarchy in which students are empty vessels dependent on teachers to fill them with information (Freire, 1970). Students in this system only absorb information, they do net digest it. As such, they do not question or inquire; disempowered, they are left void of creativity and the ability to think critically about the information in the context of the world around them (Freire, 1970). On the contrary, critical pedagogy emphasizes empowering learners to reflect, challenge, and take action to ameliorate injustice by encouraging them to become agents for change in their community (Luque et al., 2011).

We hypothesized that providing applied science learning opportunities related to health and health equity, outreach activities, research career awareness opportunities, mentoring, and space to reflect on program content in the context of their own lived experience would (1) improve attitudes and motivation for science and (2) increase AEC among the youth. In addition to examining youth attitudes, motivation, and AEC, we were interested in how youth participation in the program might have influenced the people in the youths' lives. In particular, we hypothesized that youth engagement in the program would be linked to positive change in the level of support youth received for pursuing their interests in science. Therefore, we explored whether family, peer, and teacher support of the youth's interest in science and science education changed over the course of program participation.

NFASE was set in a K-8 school in Boston. The K-5 population in the school was demographically quite different from the grade 6–8 population. Students who attend grades K-5 often leave after grade 5 to attend more academically rigorous public schools that require entrance exams. Students who are not able to transfer to these higher performing schools remain for grades (6–8). The majority of the middle school (6–8) population identifies as Black or Latino. At the time of the intervention, there were 311 students enrolled in grade 6–8, 74% of whom qualified for free (66.7%) or reduced (7.3%) lunch. Therefore, the NFASE program served a sample of primarily low-income students of color.

Students met in the context of after-school Monday–Friday from 2:30 to 6:00 pm. A sample schedule can be seen in Figure 1: *Daily schedule*. They transitioned from the regular school day into open STEM activities. Students selected one of three short 30-minute science activities that began immediately at the end of the school day. Open

<table>
<tr><th></th><th>Monday</th><th>Tuesday through Thursday</th><th>Friday</th></tr>
<tr><td>2:30-3:15</td><td colspan="3"><u>Check-in and Open STEM centers</u>
The goal of Open STEM is to allow students structured opportunities to engage in non-curriculum related STEM activities. Students will choose among several options of activities to participate in. Activities are characterized by movement, engagement, and fun.</td></tr>
<tr><td>3:15-3:30</td><td colspan="3"><u>Snack and STEM center debrief</u>
Students will eat their snacks and will debrief the STEM center activities with their team leader.</td></tr>
<tr><td>3:30-5:00</td><td><u>Flex STEM / Field Trip / Guest Speaker:</u>
Students will have the opportunity on these days to participate in longer, non-curriculum focused STEM activities.</td><td><u>Inquiry based science education</u>
Students will learn to think like scientists and public health practitioners about health disparities present in their communities. There will be four modules spread across the year each focusing on a health disparity area.</td><td><u>Flex STEM / Field Trip / Guest Speaker</u>
Students will have the opportunity on these days to participate in longer, non-curriculum focused STEM activities.</td></tr>
<tr><td>5:00-6:00</td><td colspan="3"><u>Home work and dismissal</u></td></tr>
</table>

Figure 1. Daily schedule.

STEM focused on simple take-away messages delivered through mini-lessons with structured activities. These were used to engage the youth with basic STEM concepts. Open STEM activities were developed with positive youth development principles in mind. For example, multiple Open STEM activities were available each day allowing students to choose activities that most suited their interests. Examples of Open STEM activities include mini-catapult construction, egg drops, movie filming and editing, and creating lava lamps using different liquids. Students also developed functional models of anatomical systems such as the lungs, stomach, and mucous. In addition, there were active Open STEM sessions, such as the aerodynamics of Frisbee throwing and paper airplanes.

Given the number of Monday holidays and inconsistency of attendance on Fridays, the core curriculum was conducted on Tuesday–Thursday. On Mondays and Fridays, we had field trips, guest speakers, and Flex STEM. Flex STEM sessions were designed to provide students with exposure to more traditional STEM content. Students rotated through four-lesson electives each semester over the course of the year. A key goal of Flex STEM was to demonstrate how STEM permeates all aspects of life. Examples of electives include a module on nutrition, computer engineering, the anatomy of dance, stop motion animation, geometric art, sports medicine, and kinesiology.

The core inquiry-based science education curriculum began with a pre-curriculum and team-building unit to create a sense of community among the youth. The students then began an exploration of health disparities and disease-specific conditions through the lens of the disciplines at the core of the program: sociology, biomedicine, epidemiology, and public health practice. Through each disciplinary lens, students studied diseases that present disparities in their community. This design presented an opportunity for youth to explore factors associated with the social and racial hierarchy present in the USA as it relates to health as a sociologist would do. They then were able to explore from the lens of a biomedical researcher the physiological effects of the hierarchy on the body and, from the lens of an epidemiologist, its impact on population health. Finally, using a public health practitioner lens, students developed strategies, such as education and outreach campaigns, to tackle disparities locally by directing attention to them. Using what they learned about health, science, and disparities, students developed local advocacy and outreach efforts. Efforts included the development of health messages presented in the form of posters, public service announcements, and stop motion animation videos that were shared with peers and broader school community. In Year 1, we covered asthma and diabetes and in Year 2, we added stress, obesity, and cardiovascular disease.

Upon school district approval of the protocol, student recruitment began. Recruitment efforts targeted all sixth graders as well as seventh and eighth graders who participated in the Nuestro Futuro Saludable (NFS), an after-school intervention we implemented in the previous year (Sprague Martinez, Ndulue, & Peréa, 2011). Program recruitment materials were handed out during science classes. The guidance counselor and K-5 after-school program coordinator promoted the program extensively. Additionally, project staff spoke during science classes and presented the goals, activities, and purposes of the program. In Year 1, 62 students handed in completed program application materials (including parental signature), and 58 were enrolled (four were unable to enroll due to transportation barriers).

Evaluation methodology

The Tufts University Social Science and Behavior Institutional Review Board and the Boston Public Schools Office of Research and Evaluation approved the program evaluation protocol. All program participants were invited to take part in the evaluation, but participation was not required.

Program participants

In Year 1 of the evaluation, 54 of the 58 students participated; only 39 provided data at both the pre-test and post-test data collection points. Over 50% (55.6%) of the sample were male, 37.0% were female, and 7.4% did not provide their sex. The sample identified as 53.7% Hispanic/Latino, 18.5% African American/Black, 7.4% Multiracial/ethnic, 3.7% White, 1.9% Asian American, and 3.8% Other. About 11% of students (11.1%) did not report their race or ethnicity.

Measures

AEC. Using data from the 4-H Study of Positive Youth Development (Bowers et al., 2014; Lerner, von Eye, Lerner, & Lewin-Bizan, 2009; Lerner, von Eye, Lerner, Lewin-Bizan, & Bowers, 2010; Lerner, Lerner, von Eye, Bowers, & Lewin-Bizan, 2011), researchers identified a model to measure civic engagement that contained the following four factors: civic duty, civic efficacy, neighborhood social connection, and civic participation (Zaff, Hart, Flanagan, Youniss, & Levine, 2010). The factors combined to form an integrated, second-order latent variable measure of civic engagement, termed AEC. This civic engagement measure not only considered a behavioral (i.e. civic participation) component, but also civic-related factors pertinent to cognition (i.e. perceived civic efficacy) and socio-emotional functioning (i.e. a sense of civic duty and neighborhood social connection).

The *civic duty* factor was composed of 12 items drawn from the Social Responsibility Scale of the Teen Assessment Project (TAP) Survey Question Bank (Small & Rodgers, 1995, based on the Social Commitment subscale of the Psychosocial Maturity Inventory (Greenberger & Bond, 1984), the Political Efficacy and Participatory Citizen constructs of the Student Voices measure (Flanagan, Syversten, & Stout, 2007), and the Search Institute's Profiles of Student Life-Attitudes and Beliefs (PSL-AB) questionnaire (Leffert et al., 1998). A sample item states, 'How much do you agree or disagree with the following? I often think about doing things so that people in the future can have things better', with response options ranging on a 5-point Likert-type scale (*strongly disagree* to *strongly agree*). A second sample item had respondents indicate the extent to which they agreed or disagreed with the following statement, 'I believe I can make a difference in my community' with response options ranging from *strongly disagree* to *strongly agree* on a 5-point Likert-type scale. Across Waves 1 to 4, the Cronbach's alpha were 0.87, 0.81, 0.91, and 0.88, respectively.

The *civic efficacy* factor was composed of 6 items adapted from the Political Voice and Competence for Civic Action constructs of the Student Voices measure (Flanagan et al., 2007). Sample items had respondents indicate the extent to which they can 'write an opinion letter to a local newspaper' and 'sign an e-mail or written petition' with response options ranging from *I definitely can't* to *I definitely can* on a 5-point Likert-type scale. Across Waves 1–4, the Cronbach's alphas were 0.83, 0.88, 0.83, and 0.87, respectively.

The *neighborhood social connection* factor was composed of 6 items taken from the Search Institute's PSL-AB questionnaire (Leffert et al., 1998). For example, respondents indicated the extent to which they agreed or disagreed with the following statements, 'In my town or city, I feel like I matter to people' and 'Adults in my town or city listen to what I have to say'. Response options ranged from *strongly disagree* to *strongly agree* on a 5-point Likert-type scale. Across Waves 1 to 4, the Cronbach's alphas were 0.84, 0.70, 0.83, and 0.76, respectively.

The *civic participation* factor was composed of 8 items created specifically for the 4-H Study and drawn from the Search Institute's PSL-AB questionnaire (Leffert et al., 1998). For example, one item indexed how often youth 'help make your city or town a better place for people to live'. Response options ranged from *never* to *very often* on a 5-point Likert-type scale. For other items, participants indicated how often they participated in specific service activities, such as volunteering and mentoring/peer advising, with responses ranging from *never* to *every day* on a 6-point Likert-type scale. An additional item stated, 'During the last 12 months, how many times have you been a leader in a group or organization', with response options ranging from *never* to *5 or more times*. Across Waves 4 to 8, the Cronbach's alphas were 0.65, 0.61, 0.56, and 0.73, respectively.

The response options for the AEC items were measured on a variety of scales. Thus, for consistency, items were reverse coded, if necessary, and rescaled so that their values ranged from 0 to 25, with higher scores indicating higher levels of civic duty, civic efficacy, neighborhood social connection, and civic participation, respectively. The four factor scores were averaged to compute the overall AEC measure. For the overall AEC measure, across Waves 4 to 8, the Cronbach's alphas range from 0.69 to 0.73. Additional information about this civic engagement measurement model can be found in the literature (Bobek, 2007; Bobek, Zaff, Li, & Lerner, 2009; Zaff et al., 2010).

Science attitudes, motivation, and support. We measured students' science attitudes, motivation, and support using a set of items derived from several previously validated measures. These included measures developed or adapted in earlier works (Marsh, 1990; Simpson & Troost, 1982; Stake & Mares, 2001), and Science Outlook Survey developed by the Partnership in Innovative Preparation for Educators and Students (Pugh, Endres, Grassman, Marle, & Decker, 2011). The initial item pool of the survey was a 49-item scale, which included items pertaining to one's own motivation, interest, and, confidence in science; self-perception of science ability relative to peers; family support for science, peer support for science; and teacher support for science. In order to reduce the length of the measure, we first selectively removed items that severely violated the normality assumption. We examined skew and kurtosis values for all items in Wave 1 omitting items that displayed absolute skew > 2 and/or absolute kurtosis > 10. This process resulted in the removal of seven items. We also examined item histograms to ensure the unimodality of all items, although this review did not result in any items being dropped.

We then assessed the factor structure of each of the subscales by deleting items that lowered the internal consistency of the measure (through having low item-total correlations). That is, if keeping an item in the measure resulted in a lower Cronbach's alpha for the measure, the item was deleted. In total, 14 items were deleted through this

Table 1. NFASE student mean scores and standard deviations for AEC and science attitudes, motivation, and support.

Outcome	Pre-test	Post-test	Effect size
Civic duty	17.89 (4.50)	18.24 (3.41)	.09
Civic efficacy	12.20 (6.08)	15.09 (5.83)**	.48
Neighborhood social connection	14.48 (5.59)	17.68 (4.30)***	.65
Civic participation	12.84 (5.43)	14.38 (4.96)*	.30
AEC	14.36 (3.90)	16.37 (3.39)***	.55
Science motivation, interest, and confidence	2.08 (1.23)	2.29 (1.05)	.18
Science ability compared to others	2.19(1.13)	2.30 (0.98)	.10
Family science support	1.76 (1.33)	1.91 (1.23)	.12
Friend science support	1.82 (1.22)	1.92 (1.03)	.09
Teacher science support	2.50 (1.14)	2.42 (1.15)	−.07

*$p < .05$.
**$p < .01$.
***$p<.005$.

process. Therefore, we arrived at a 28-item scale, with 9 items for self-motivation, interest, and confidence in science (Example item: 'Science is easy for me.'); 6 items for self-perceptions of science ability relative to peers (Example item: 'Compared to others my age, I am good at science.'); 4 items for family science support (Example item: 'My family is interested in the science courses I take.'); 5 items for friend science support (Example item: 'My friends encourage me to do well in science.'); and 4 items for teacher science support (Example item: 'My science teachers encourage me to learn more science.').

All item responses were on a Likert scale from 0 (*Not true at all*) to 4 (*Very True*). Composites for each subscale were created by averaging the relevant items. Cronbach's alphas for the final set of items at Wave 1 were $\alpha = 0.94$ for the self-motivation, interest, and confidence in science scale; $\alpha = 0.91$ Alphas for these scales in Waves 2–4 ranged from 0.92 to 0.94 for self-attitudes; and 0.86 to 0.93 for self-perceptions of science ability in comparison to others. Please see Table 1 descriptive data for all measures of interest for participants in the NFASE program.

Procedure

All program participants were invited but not required to participate in the evaluation. Those who elected to take part in the evaluation completed surveys during the NFASE after-school programs. In all classrooms, facilitators or program staff gave youth an envelope to take home to their parents. The envelope contained a letter explaining the study and consent forms. Data collection was conducted by trained study staff or assistants, who began all testing sessions by reading the instructions to the participants.

Results

The aims of the present study were to determine whether participants in the NFASE program changed in several indices of AEC and science attitudes, motivation, and support. We compared mean differences in the indices. In order to account for the multiple comparisons conducted in Year 1, we applied a Bonferroni correction to control for a family-wise error rate of $\alpha = .05$; therefore, the corrected $\alpha = .005$. Table 1 shows the results of these analyses.

The results indicated that over the course of the first year of the NFASE program, students reported significant increases in neighborhood social connection and overall AEC, $t(36) = 3.20$ and $t(36) = 4.71$, respectively, both p's $< .005$. Students also reported increases in civic efficacy, $t(36) = 2.89$, $p < .01$, and civic participation $t(37) = 2.39$, $p < .05$; however, these increases were not significant after applying the Bonferroni correction. Participants did not report any significant changes in the indices of science attitudes, motivation, or support (all p's $> .05$). At the beginning and conclusion of the NFASE program, students on average reported that their interest in and support for science was 'somewhat true'. As sample sizes were relatively small, we also included effect sizes as calculated using a d statistic formula for single group pre-test–post-test design (Dunlop, Cortina, Vaslow, & Burke, 1996) in Table 1. Based on Cohen's standard (1988), effect sizes for measures of active and engage citizenship ranged from very small for civic duty to medium/large for neighborhood social connection. There was also a small effect size for changes in our measure of science motivation, interest, and confidence.

Discussion

Students in the NFASE program did not report statistically significant changes in attitudes toward or motivation for the sciences; however, there was a small effect size for changes in attitudes and motivation ($d = .18$), which is inline with the overall effect of many mentoring as well as social and emotional learning programs (Durlak, Weissberg, & Pachan, 2010; DuBois, Portillo, Rhodes, Silverthorn, & Valentine, 2011). There were significant and medium-to-large changes in several of the indices of AEC, in particular, neighborhood social connection and civic efficacy. It may be that youth who enrolled in the program were more interested in civic engagement than in science and honed in on aspects of the program associated with civic action. It may also be the case that the program's two-fold focus was more effective at promoting connections to the community and civic skills than in promoting science interests and motivation.

Youth were largely drawn from the NFS intervention that took place at the school the previous year. NFS was focused on applied inquiry and action; it may be that changes observed were associated with AEC and not science motivation due to their participation in the previous program. Conversely, it may also be that because activities and topics were connected to the lived experience, program participants did not connect them to science. Basu and Barton (2007) found that incorporating and building on student's 'fund of knowledge' or lived experiences can increase their engagement in science. Here, for example, it may be that framing science in the context of health inequities associated with the United States social hierarchy allowed students to employ scientific concepts in the context of social action and health equity work.

Moreover, the results may have been influenced by program staff, who was largely youth workers and not public health professionals or scientists. During the NFS intervention, we found that youth workers were adept with respect to engaging youth, assessment and action, but needed training and educational support around health topics in the curriculum. It may be that their personal interest in local action and community change influenced how those elements in the curriculum were delivered and made them more appealing to students.

Nevertheless, studies examining the association between neighborhood context and adolescents' civic engagement have focused primarily on social processes of the local community, in particular, analyzing levels of neighborhood social connectedness. This line of inquiry has demonstrated that when adolescents perceive themselves to be living in a neighborhood where people look after each other and are willing to collaborate to solve common issues, they also report a higher commitment to civic participation (Flanagan, Cumsille, Gill, & Gallay, 2007; Kahne & Sporte, 2008). Changes in AEC among NFASE youth may be associated with working together with a group of adults committed to tackling inequity in their communities. Similarly, as community connection is associated with civic engagement, youth may have become more socially connected as a result of participating in applied inquiry and local action through the NFASE program (Albanesi, Cicognani, & Zani, 2007; da Silva, Sanson, Smart, & Toumbourou, 2004; Duke, Skay, Pettingell, & Borowsky, 2009; Flanagan et al., 2007; Kahne & Sporte, 2008).

Conclusions

While overall student interest in the NFASE program was high, participants did not demonstrate significantly improved attitudes toward or motivation for the sciences, as measured by pre-/post-test surveys. Youth did report significant increases in neighborhood social connection, civic efficacy, and overall AEC. This may be largely due to the fact that they were studying inequities in their own communities, which allowed them to employ scientific concepts in the context of social action and health equity work. Future research should explore alternative evaluation strategies to assess interest and motivation in science.

Disclosure statement

No potential conflict of interest was reported by the authors.

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