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RESEARCH REPORT

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Developing outreach events that impact underrepresented students: Are we doing it right?

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Abstract

Many outreach programs share the common goals of serving underrepresented groups in STEM and improving public attitudes toward science. To meet these goals, scientists must find ways to both reach the appropriate audience and communicate the importance of science in meaningful and accessible ways. This requires careful consideration of the outreach method being used. Two common outreach methods include in-school visits (scientist in the classroom) and science fairs or open houses. Here, we compare the effectiveness of these two outreach methods in meeting the goals of reaching underrepresented students and/or students with less initial interest in science. We have found that in-school visits reached more underrepresented students and that initial attitudes toward science scores were lower for in-school visit participants than for open house event participants. Importantly, positive attitudes toward science increased significantly after in-school outreach events. Taken together, these data suggest that outreach events that are taken out into the community will reach a less enthusiastic but more diverse audience and can have a positive impact on attitudes toward science within these populations. These studies highlight the importance of knowing the goals of your outreach program and choosing the method that is best suited to meeting those goals.

KEYWORDS

attitudes toward science, diversity, neuroscience, outreach, science communication

1 | INTRODUCTION

Effective communication of science is critical for informing and sculpting the attitudes of the general public, and scientists are becoming more aware of the need to communicate with the general public about the importance of science (Davies, 2008; Dudo & Besley, 2016; Greenwood & Riordan, 2001; Leshner, 2003; Martin-Sempere, Garzon-Garcia, & Rey-Rocha, 2008). This is evident in the increasing number of outreach efforts by professional scientists, driven in part by government initiatives looking for "broader impacts" of funded research, which is one key merit review criterion that is required by the National Science Foundation (NSF) in grant proposals (Friedman, 2008; Kamenetzsky, 2012; Mathieu, Pfund, & Gillian-Daniel, 2009). Often, the goals cited by scientists for engaging in outreach are to improve public attitudes toward science and/or to reach underrepresented groups in STEM. Here, we use the standard definition of the term underrepresented to refer to students who are African American/Black, Asian, Hispanic, American Indian, and Multiracial, as well as those that are first-generation, or from low-income families. Data suggest that public engagement has the potential for significant positive effects

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on society, including increasing science literacy and education, stimulating critical thinking skills, improving attitudes toward science, and increasing diversity in STEM fields (Beck, Morgan, Strand, & Woolsey, 2006; Bruce, Bruce, Conrad, & Huang, 1997; Friedman, 2008; Krasny, 2005; Laursen, Liston, Thiry, & Graf, 2007; Rumala, Hidary, Ewool, Emdin, & Scovell, 2011). In addition, the benefits of these events are not unidirectional; scientists benefit from outreach with the community by considering the societal impacts of their work, improving communication skills, and understanding the issues facing their community (Clark et al., 2016; Laursen et al., 2007). These interactions can lead to discoveries that improve the health and general well-being of the entire community (Bjorkland & Pringle, 2001; Conway, 2006). Other outreach efforts can open lines of communication with individuals who may be skeptical of science or scientists (AAAS, 2005; Pew Research Center, 2015; Sterman, 2011; Tsipursky, 2018). It is important to remember that not all outreach techniques have the same impact. Thus, it is critical to determine the goals of an outreach event before determining the format of that event. With support from multiple sources including the DANA Foundation and the Society for Neuroscience, we have created Brain Awareness Week programing in our city and the surrounding area. Here, we examine the effectiveness of two different outreach methods, in-school visits and open houses, in meeting two common outreach goals: (a) improving attitudes toward science in middle schoolers and (b) reaching underrepresented groups in STEM. We hypothesized that in-school visits would reach a more diverse student population than open house events while also reaching more individuals who were not already "science enthusiasts." Our work suggests that taking outreach into the community is a more effective way to reach those less interested in science, as well as underrepresented populations that scientists hope to engage.

2 | MATERIALS AND METHODS

In order to examine the effectiveness of these two forms of outreach, we engaged 54 undergraduate students in outreach events during Brain Awareness Week at Hope College. Brain Awareness Week is a "global campaign to foster public enthusiasm and support for brain science. Every March, partners host imaginative activities in their communities that share the wonders of the brain and the impact brain science has on our everyday lives" (Brain Awareness Week, 2019). The students leading the sessions were representative of the Hope College student body, which consists of 37.9% males, 62.1% females, 82.1% White, 7.9% Hispanic, 2.8% Black or African American, 3.5% Asian, 3.2% Multiracial, and 0.5% Unknown (Hope College Enrollment Data, 2019). Specifically, the students leading the in-school sessions consisted of 71% females and 29% males, with 86.4% White, 6.8% Asian, 4.5% Hispanic, and 2.3% Multiracial. Students leading the open house event consisted of 75% females and 25% males, with 90% White, 5% Hispanic, and 5% Multiracial. One of the Brain Awareness Week activities is a series of single visits to local elementary and middle-school classrooms, during which undergraduate instructors deliver a lesson focused on sensory perception and integration (see Vollbrecht, Frenette, & Gall, 2019 for detailed lesson plans). The week culminates with a free on-campus open house style event that is open to the community and engages participants in a number of hands-on activities geared toward K-8 students. The use of multiple event formats through the course of the week allowed for the examination of differences in demographics at various events and comparison of attitudes toward science in different populations.

2.1 | Subjects

A total of one hundred and sixty-nine 10- to 14-year-old students in grades 6–8 participated in our in-school outreach activities and took a pre-event survey to assess baseline attitudes toward science (see Supporting Information and Section 2.3 below). A total of 105 students completed the post-test (62.1% retention) to assess science attitude changes following our lesson. Students in grades 6–8 were selected by emailing teachers in the Holland, Michigan region. Middle-school students were selected from a total of 7 classes with 2 different teachers in the Holland area. These 7 classes were selected from 2 school districts including the Holland Public School District and West Ottawa Public School District. The Holland Public School District is composed of ~47% Hispanic/Latino students, ~36% Caucasian students, ~8% African American students, and ~2.9% Asian students (Michigan's Center for Education & Performance Information, 2018–2019a). In addition, >64% of students from Holland Public Schools are considered economically disadvantaged (Michigan's Center for Education Performance & Information, 2018–2019b). West Ottawa Public School District is composed of ~42% Hispanic/Latino students, ~42% Caucasian students, ~7.2% Asian students, and ~3.1% African American students (Michigan's Center for Education & Performance Information, 2018–2019a). In addition, nearly 55% of students from West Ottawa Public Schools are considered economically disadvantaged (Michigan's Center for Education Performance & Information, 2018–2019b).

Out of 75 open house participants aged 2–13 years old, 34 students matching the age range of our in-school participants (10–13 years) completed the pre-event survey. Of the 34 open house middle-school aged participants, 9 (26.5% retention) completed the post-event survey.

All methods involving middle-school students were approved as an internal review board exemption from Hope

College under the following section of the Federal Common Rule: *45 CFR 46.104(d)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices* (*40*). This exemption allowed us to collect non-identifiable data in local middle schools.

2.2 | Outreach events

All in-school events followed a previously described lesson plan that was created to meet the criteria for the Next Generation Science Standard MS-LS1-8 (NGSS Lead States, 2013; Vollbrecht et al., 2019).

All of the activities used during in-school visits were also available at the open house event. The open house event was advertised via flyers distributed to local schools in both Spanish and English for students to take home. The event was also mentioned in a weekly institutional radio show highlighting upcoming local events. Social media (Twitter, Facebook, and Instagram) was also used through institutional accounts and with local Twitter/Facebook groups to inform the community about our open house event.

2.3 | Assessment

In order to assess attitude changes toward science, we adapted the *Student Attitudes Toward STEM Survey—Middle and High School Students* (Friday Institute for Educational Innovation, 2012). We only selected questions that pertained to attitudes toward science. The specific questions can be found in the Supporting Information.

In addition to assessing attitude changes toward science, demographic data were collected, which included age, gender, and race/ethnicity. Finally, students responded to one open-ended question in order to assess neuroscience knowledge gains relating to the lesson plan (see Vollbrecht et al., 2019).

Pre-event and post-event responses for in-school outreach visits were collected via Qualtrics (2019 Qualtrics LLC). Teachers were asked to have their students take the pre- and post-test on a computer. Pre-tests were completed between 1 and 3 days before the outreach visit, and post-tests were completed at least 7 days but less than 14 days after the outreach visit. Pre- and post-test assessments were matched to randomly assigned IDs, so that identifying information was not collected from the students.

Pre-event responses for open house visits were collected via pencil and paper. At check-in, students were asked if they would be willing to complete a pre-test. If the participants agreed, a random ID number were assigned. Email addresses were also collected at check-in, and participants were emailed and asked to complete a post-test 7 days after the open house via Qualtrics.

2.4 | Statistical analyses

Demographic data were collected and converted separately into percentages for in-school visit participants, and open house participants.

For the 9 questions that assessed attitudes toward science, a score was assigned as follows: 1 to "Strongly Disagree," 2 to "Disagree," 3 to "Neither Agree nor Disagree," 4 to "Agree," and 5 to "Strongly Agree." Question 8 was reverse-coded. Each student's score was summed with a maximum possible score of 45, a higher score indicating a more favorable attitude toward science.

To assess neuroscience knowledge gains relating to our lesson plan, we asked students to describe everything they knew about the following concept using complete sentences: "When a person touches a hot iron, describe what causes the person to move their hand away from the iron" (see Supporting Information). For this question, two independent evaluators (TT and AJG) blind to condition scored each response on a scale of 0–5. The average of the evaluators' scores was calculated for each response. A score of 0 was assigned if the student did not answer the question or if their answer was irrelevant. A score of 1 was assigned if the student was overly simplistic in their response by saying either "heat" or "pain." A score of 2 was assigned if they described that "heat" led to "pain," indicating a cause and effect response. A score of 3 was assigned if the student indicated that the cause and effect were due to the involvement of the nervous system. A score of 4 was assigned if the student also explained that nerves receive and send signals. A score of 5 was assigned if the student demonstrated complete understanding of the concept, including sensation, motor responses, nervous system integration, and reflexes. Each student's score was assessed in the pre-test and again in the post-test.

Independent-sample t tests were used to examine differences in initial attitudes scores for in-school visits (pre-event) versus open house (pre-event). Multiple t tests were used to examine initial attitudes scores by gender and race/ethnicity. Two-way repeated measures ANOVAs were used to examine pre- versus post-test attitudes toward science, along with effects of gender and ethnicity/race. Paired sample t tests were used to examine differences in attitude scores for in-school visits, and knowledge gains in the open-ended question (pre-event vs. post-event scores).

3 | RESULTS

3.1 | Demographics survey

Demographics data for both the open house outreach event (Figure 1a; $n = 34$) and the in-school outreach event (Figure 1b; $n = 169$) were collected. Over seventy percent of open house participants were Caucasian, with 20% of participants being

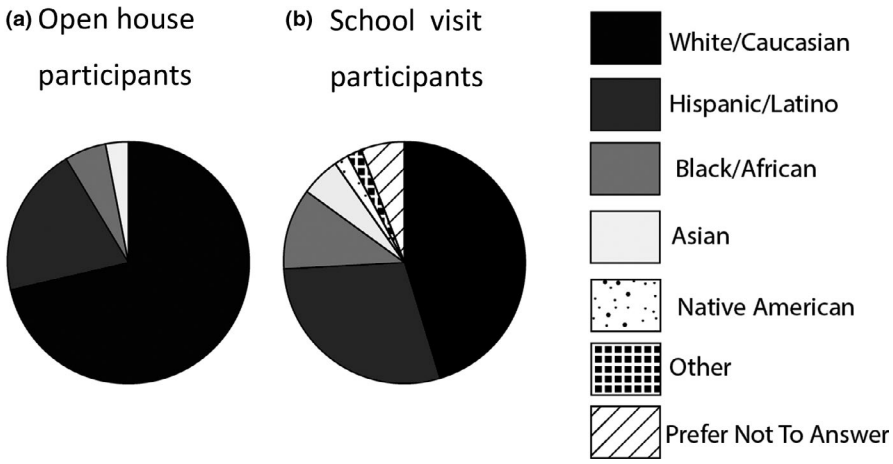

FIGURE 1 An in-school event reaches a more diverse population of students than an open house event. (a) Nearly three quarters of open house participants were white, (b) while over half of participants at in-school events were from other racial or ethnic groups

Hispanic/Latino, 6% being Black or African American, and 3% being Asian. In contrast, only 45% of in-school participants identified as Caucasian, 29% reported as Hispanic/Latino, 11% as Black or African, 5% as Asian, and an additional 10% reporting as other races or ethnicities.

3.2 | Attitudes toward science survey

Science attitude scores were calculated from responses to both pre- and post-event surveys from in-school and open house event participants. Individuals who participated in the open house event had significantly higher initial attitudes toward science scores than individuals participating in the in-school event (Figure 2a; $t_{201} = 3.863$; $p = .0002$). Similar effects were observed when data were separated by gender in both males (Figure 2b; $t_{68} = 2.266$; $p = .03$) and females (Figure 2b; $t_{65} = 2.939$; $p = .01$). While not represented graphically, we found no significant main effect of gender ($F_{1,101} = 1.306$, $p = .2558$) and no pre- versus post-test × gender interaction ($F_{1,101} = 0.0839$, $p = .7727$). When data were separated by race/ethnicity, a significant difference was observed between white students who participated in the in-school event and those who participated in the open house event (Figure 2c; $t_{71} = 3.569$; $p = .002$). While similar trends were apparent when examining other ethnicity/races, no statistically significant differences were observed. Specifically, a 2-way repeated measures ANOVA revealed a main effect of pre- versus post-test attitudes ($F_{1,92} = 4.533$, $p = .0359$), but no effect of ethnicity/race ($F_{4,92} = 0.1011$, $p = .1011$) and no interaction ($F_{4,92} = 0.2969$, $p = .8793$).

Attitudes toward science scores of individuals participating in the in-school event were significantly improved one week following the event when compared to pre-event scores (Figure 3a, left panel, paired sample t test, $t_{104} = 3.059$; $p = .0028$). The low number of subjects ($n = 9$) who took the post-test for the open house event precluded us from running statistical analyses on these data (Figure 3a, right panel).

3.3 | School visit effects on neuroscience content knowledge

Blinded evaluation of responses to an open-ended prompt regarding a neuroscience topic revealed a significant increase in scores of students who participated in the in-school outreach event (Figure 3b; paired t test: $t_{103} = 3.028$; $p = .0031$).

4 | DISCUSSION

Science communication and public outreach are important for promoting science literacy in the general public (Andrews, Weaver, Hanley, Shamatha, & Melton, 2005; Baron, 2010; Friedman, 2008; Illingworth, 2017). With more individuals and groups engaging in outreach activities, it is becoming increasingly important to evaluate outreach effectiveness (Illingworth, 2017; Spicer, 2017; Varner, 2014; Vollbrecht et al., 2019). In order to evaluate whether or not an outreach event is effective, one must have goals, and specifically, one must have goals that can be evaluated (Jensen, 2015; Spicer, 2017; Staton & Tomlinson, 2001). Two common goals of today's outreach efforts include improving public attitudes toward science, and increasing diversity in STEM fields (Clark et al., 2016; Payne, 2017). Here, we demonstrate that different types of outreach events reach different members of the community. Specifically, our data demonstrate that in-school outreach events reach a more diverse population, including individuals with less positive initial attitudes toward science than an open house style event.

Our in-school outreach event reached a more diverse student population when compared to the open house style event. Over seventy percent of middle-school open house participants were Caucasian (Figure 1a), which is significantly more than the 36%–42% of Caucasian students in our local school districts. However, our in-school outreach event reached a much more diverse population with 45% Caucasian, 29% Hispanic, and greater than 10% African American students

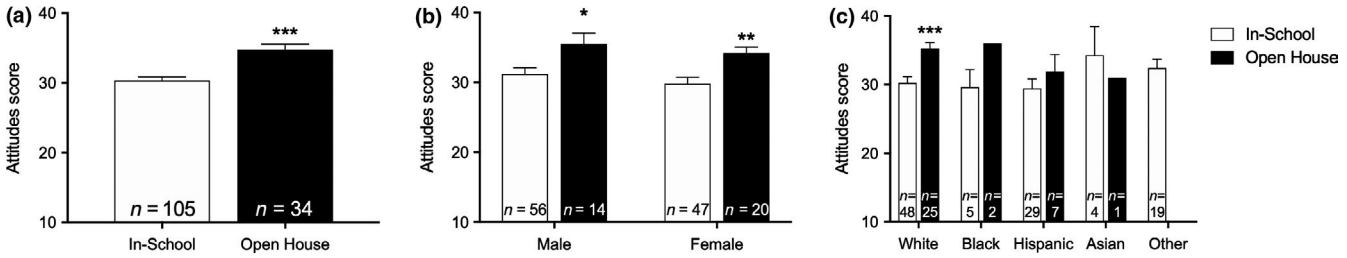

FIGURE 2 An in-school event reaches students with lower initial attitudes toward science scores than an open house event. (a) Comparison of pre-event attitudes toward science surveys demonstrates that open house participants had significantly higher initial science attitude scores than in-school outreach participants. (b) This observation remained when individuals were separated by gender with both males and females who attended the open house event having higher initial attitudes toward science scores. (c) Similar trends were observed when evaluating race/ethnicity with significantly higher initial attitudes toward science scores in white individuals attending the open house event. ***$p < .001$; **$p < .01$; *$p < .05$

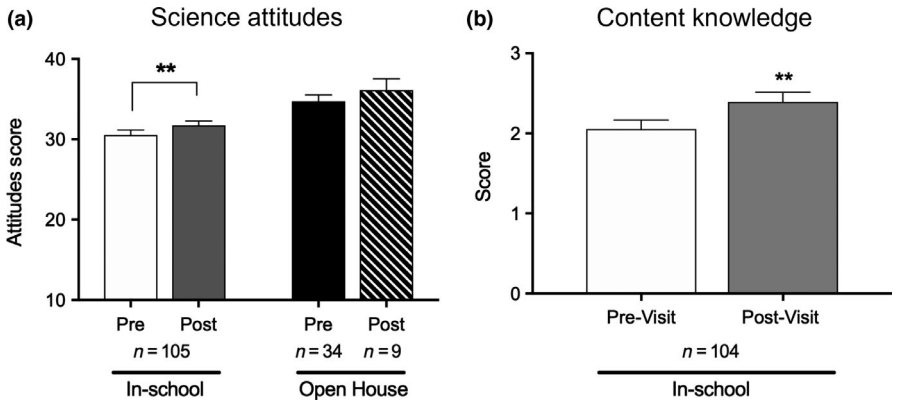

FIGURE 3 An in-school event improves neuroscience attitudes and content knowledge. (a) Our in-school event successfully improved science attitude scores, while no significant improvement was observed in open house participants. (b) In addition, an open-ended response assessment verified that our developed lesson plan is effective in increasing neuroscience knowledge a minimum of one week after the in-school outreach event. **$p < .01$

participating (Figure 1b). A number of variables could be responsible for these differences. A Pew Research Center survey has shown that among high school seniors, Hispanic and Black students "like" science less, and view careers in science less favorably than white or Asian/Pacific Islander students (Pew Research Center, 2017). Thus, it is possible that a lack of interest may result in fewer underrepresented students seeking out the open house event. This also suggests a need to reach these students at an earlier age and begs the question as to why these students have lower interest in science than their Asian or Caucasian counterparts. While this question is beyond the scope of our current work, some possibilities put forward by others will be laid out toward the end of this discussion. Interestingly, we reached fewer Hispanic/Latino students (29%) and more Caucasian students (45%) in our in-school sample than the representative number in the districts (42%–47% and 36%–42%, respectively). It is possible that this discrepancy occurred because teachers self-selected into the outreach event, possibly leading to differences in our sample. It is important to note that at least 55% of students in the local school district are considered economically disadvantaged (Michigan's Center for Education Performance & Information, 2018–2019b). This has the potential to create barriers such as transportation to the event, greater conflicts with weekend work schedules, and less time to devote to science opportunities (Barnett, 2008; Ngai, Cheung, To, Luan, & Zhao, 2014). Despite the difficulty in determining which factors underlie demographic differences, the fact remains that in-school visits successfully reached a more diverse population of students than an open house outreach event.

In addition to reaching a more diverse group of students, in-school visits are perfectly positioned to reach those students who feel science is less interesting or less important. Students who participated in the open house style event scored significantly higher on an initial science attitudes survey than students who participated in our in-school visits (Figure 2). This is not altogether surprising when one considers that a Saturday morning open house event requires that the student and/or their parents actively seek out the opportunity to participate. Indeed, data have shown that science festivals are preaching to the scientifically converted (Kennedy, Jensen, & Verbeke, 2017), resulting in outreach that is not accessible to a broad, diverse audience (Dance, 2016; Jensen, 2015). In-school visits do

not require initiative on the part of the student or parent and thus reach individuals with less enthusiasm for science. Our data suggest that in-school outreach events effectively reach those students with less positive attitudes toward science (Figure 2). These students are exactly the individuals that scientists should be engaging at a young age, if the aim is to improve public attitudes toward science. In addition to reaching individuals with lower attitude toward science scores, it is also important to determine whether these outreach events actually have a positive impact on student attitudes. While data were collected one week after a single in-school outreach event, significant improvements in student attitudes toward science scores were observed (Figure 3a, left panel). Thus, our in-school intervention raises science attitude scores bringing them closer to the attitude scores of the open house participants. Due to a low number of final survey responses in open house participants, no pre- versus post-event analysis was performed in this group (Figure 3a, right panel). Our data suggest that in-school outreach programs more effectively reach those with less positive initial attitudes toward science and are also effective in improving attitudes toward science of those who participate. It will be important to examine whether this gap in science attitudes scores between in-class and open house attendees can be further narrowed with repeated in-school outreach events or other interventions.

Finally, our data further demonstrate that our in-school outreach lesson is effective in promoting learning gains in students. Previous work used a multiple-choice assessment to demonstrate content learning gains were maintained in students one week after our in-school visit (Vollbrecht et al., 2019). Here, we utilized an open-ended question assessment to evaluate content gains. This open-ended question allowed students to more effectively describe what they learned from our lesson plan. Their answers were more complete and more descriptive, and students exhibited a higher level of understanding in responses after the event as compared to before the event. Two blinded reviewers coded each recorded response on a scale of 0–5, with 5 demonstrating complete understanding of the topic. Significant improvement was observed one week following the in-school event (Figure 3b), further demonstrating the effectiveness of our event in delivering neuroscience content.

In future outreach events, it will be important to collect data regarding socioeconomic status and parent education level for participants of both the open house and in-school events. These data could uncover underlying causes that drive differences in participation. Additionally, information regarding where open house participants attend school could help us to better understand the differences between in-school and open house populations as we did not determine whether or not we reached some of the same students at the open house event that we reached during in-school visits. These additional data points may help to explain why students that attended the open house event had higher initial attitude scores than those participating in the in-school visits.

Our data suggest that in-school outreach events are more effective than an open house style event at reaching underrepresented groups in STEM and individuals with lower initial attitudes toward science, two populations that many outreach events desire to reach. While beyond the scope of this article, it is important to understand the underlying reasons for lower initial attitudes toward science in both minority and low SES students. The work of others suggests that it is possible that lower initial attitudes toward science are a result of negative experiences with a science teacher (van Aalderen-Smeets, Walma van der Molen, & Asma, 2012), stigmas that exist especially for underrepresented students with respect to science (Chang, Eagan, Lin, & Hurtado, 2011; Settles, Cortina, Malley, & Stewart, 2006), or a lack of diversity in STEM teachers (Finkel, 2017). Research has shown that underrepresented students that have diverse teachers and mentors are more likely to succeed (Dee, 2004; Egalite & Kisida, 2018; Goldhaber, Theobald, & Tien, 2015; Syed, Goza, Chemers, & Zurbriggen, 2012; Villegas & Irvine, 2010). In order to improve attitudes toward science in underrepresented students, it is important that teachers are diverse and that the school environment supports diversity, including diversity training to acknowledge and overcome implicit and explicit biases. Furthermore, as efforts to improve diversity in STEM continue to progress we hope that increasing the diversity of mentors and role models will continue to lead to increased interest of underrepresented students in STEM fields.

It is important to note that with appropriate planning, some of the barriers that exist for an open house style event can be overcome, such as providing transportation, or having multi-day events to improve access. While this may help in reaching individuals with a lower socioeconomic status, it still does not necessarily solve the problem of reaching students with lower science interest levels. Bringing the discussion to them is still the best way to reach those individuals. We found that bringing our event to classrooms was the most effective way to reach more diverse students in terms of race/ethnicity as well as initial science interest. We do not wish to diminish the value of open house events as they serve as an important point of interaction between new and established scientists. In addition, these types of events often offer more hands-on activities and demonstrations that cannot always be brought to schools due to logistical reasons. One way to overcome the barriers for underrepresented students to attend open house events is to provide more collaborations between the schools and the open house event. It is important to consider the barriers to outreach and find ways to overcome those barriers so that all students are able to participate.

Therefore, scientists should consider making the effort to perform outreach in places that are convenient for *community members,* rather than performing outreach in places that are convenient for the scientist. One way to do this is to work with local schools to perform outreach in the classroom as described here. Additional possibilities include running booths at local fairs or other public events that allow for spontaneous interactions with the public. Doing so will reach a more diverse population and may reach those who are more skeptical about science. Creatively designing outreach events that reach these populations is critical to improving attitudes toward science in our society. What we want to emphasize is that scientists need to carefully evaluate the goals of their outreach event, and with those goals in mind, utilize the best outreach format to achieve those goals.

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CONFLICT OF INTEREST

The authors declare no competing interests.

AUTHOR CONTRIBUTIONS

AJG and PJV involved in study conceptualization. AJG, PJV, and TT involved in data collection, data analyses, and preparation of manuscript.

DATA AVAILABILITY STATEMENT

Data are publicly available.

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REFERENCES

American Academy of Arts and Sciences (AAAS) (2005). Perceptions of science in America. Cambridge, MA.

Andrews, E., Weaver, A., Hanley, D., Shamatha, J., & Melton, G. (2005). Scientists and public outreach: Participation, motivations, and impediments. *Journal of Geoscience Education*, *53*(3), 281–293.

Barnett, M. A. (2008). Economic disadvantage in complex family systems: Expansion of family stress models. *Clinical Child and Family Psychology Review*, *11*(3), 145–161.

Baron, N. (2010). Stand up for science. *Nature*, *468*, 1032–1033.

Beck, M. R., Morgan, E. A., Strand, S. S., & Woolsey, T. A. (2006). Volunteers bring passion to science outreach. *Science*, *314*(5803), 1246–1247.

Bjorkland, R., & Pringle, C. M. (2001). Educating our communities and ourselves about conservation of aquatic resources through educational outreach. *BioScience*, *51*(4), 279–282.

Brain Awareness Week (2019). What is Brain Awareness Week? Retrieved from https://www.brainawareness.org/about/

Bruce, B. C., Bruce, S. P., Conrad, R. L., & Huang, H. (1997). University science students as curriculum planners, teachers, and role models in elementary school classrooms. *Journal of Research in Science Teaching*, *34*(1), 69–88.

Chang, M. J., Eagan, M. K., Lin, M. H., & Hurtado, S. (2011). Considering the impact of racial stigmas and science identity: Persistence among biomedical and behavioral science aspirants. *Journal of Higher Education*, *82*(5), 564–596.

Clark, G., Russell, J., Enyeart, P., Gracia, B., Wessel, A., Jarmoskaite, I., … Roux, S. (2016). Science educational outreach programs that benefit students and scientists. *PLoS Biology*, *14*(2), e1002368.

Conway, F. D. L. (2006). Sharing knowledge, power, and respect: Keys in bringing communities together to improve science, practice, and relationships. *Journal of Higher Education Outreach and Engagement*, *11*(1), 133–143.

Dance, A. (2016). Avant-garde outreach, with science rigor. *Proceedings of the National Academy of Sciences of the United States of America*, *113*, 11982–11983.

Davies, S. R. (2008). Constructing communication: Talking to scientists about talking to the public. *Science Communication*, *29*, 413–434.

Dee, T. S. (2004). Teachers, race, and student achievement in a randomized experiment. *Review of Economics and Statistics*, *86*(1), 195–210.

Dudo, A., & Besley, J. C. (2016). Scientists' prioritization of communication objectives for public engagement. *PLoS ONE*, *11*(2), e0148867.

Egalite, A. J., & Kisida, B. (2018). The effects of teacher match on students' academic perceptions and attitudes. *Educational Evaluation and Policy Analysis*, *40*(1), 59–81.

Finkel, L. (2017). Walking the path together from high school to STEM majors and careers: Utilizing community engagement and a focus on teaching to increase opportunities for URM students. *Journal of Science Education and Technology*, *26*, 116–126.

Friday Institute for Educational Innovation (2012). *Student attitudes toward STEM survey—Middle and high school students*. Raleigh, NC: Author.

Friedman, D. P. (2008). Public outreach: A scientific imperative. *Journal of Neuroscience*, *28*(46), 11743–11745.

Goldhaber, D., Theobald, R., & Tien, C. (2015). *The theoretical and empirical arguments for diversifying the teacher workforce: A review of the evidence (CEDR Working Paper No. 2015-9)*. Seattle, WA: University of Washington Bothell, Center for Education Data & Research.

Greenwood, M. R. C., & Riordan, D. G. (2001). Civic scientist/civic duty. *Science Communication*, *23*(1), 28–40.

Hope College Enrollment Data (2019). Retrieved from https://hope.edu/offices/registrar/resources/enrollment-report-f2019.pdf

Illingworth, S. (2017). Delivering effective science communication: Advice from a professional science communicator. *Seminars in Cell & Developmental Biology*, *70*, 10–16.

Jensen, E. (2015). Highlighting the value of impact evaluation: Enhancing informal science learning and public engagement theory and practice. *Journal of Science Communication*, *14*(3), 1–15.

Kamenetzsky, J. R. (2012). Opportunities for impact: Statistical analysis of the National Science Foundation's broader impacts criterion. *Science and Public Policy*, *40*(1), 72–84.

Kennedy, E. B., Jensen, E. A., & Verbeke, M. (2017). Preaching to the scientifically converted: Evaluating inclusivity in science festival audiences. *International Journal of Science Education, Part B*, *8*(1), 14–21.

Krasny, M. (2005). University K-12 science outreach programs: How can we reach a broad audience? *BioScience*, *55*(4), 350–359.

Laursen, S., Liston, C., Thiry, H., & Graf, J. (2007). What good is a scientist in the classroom? Participant outcomes and program design features for a short-duration science outreach intervention in K-12 classrooms. *CBE—Life Sciences Education*, *6*(1), 49–64.

Leshner, A. I. (2003). Public engagement with science. *Science*, *299*, 977.

Martin-Sempere, M. J., Garzon-Garcia, B., & Rey-Rocha, J. (2008). Scientists' motivation to communicate science and technology to the public: Surveying participants at the Madrid Science Fair. *Public Understanding of Science*, *17*, 349–367.

Mathieu, R. D., Pfund, C., & Gillian-Daniel, D. (2009). Leveraging the NSF broader-impacts criterion for change in STEM education. *Change: The Magazine of Higher Learning*, *41*(3), 50–55.

Michigan's Center for Education Performance and Information. (2018–2019a). Student Count for Ottawa ISD, Holland City School District, All Schools, All Grades, Race/Ethnicity and All Students. Retrieved from http://bit.ly/2KfCbUG

Michigan's Center for Education Performance and Information. (2018–2019b). Student Count for Ottawa ISD, Holland City School District, All Schools, All Grades, Economically Disadvantaged and All Students. Retrieved from http://bit.ly/2KeveTx

Ngai, S. S. Y., Cheung, J. C., To, S., Luan, H., & Zhao, R. (2014). Economic disadvantage and transitional outcomes: A study of young people from low-income families in Hong Kong. *International Journal of Adolescence and Youth*, *19*(3), 318–335.

NGSS Lead States. (2013). MS-LS1-8 from molecules to organisms: Structures and processes. In: *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press. Retrieved from http://www.nextgenscience.org/

Payne, D. (2017). Science for all: Supporting diversity through science outreach. NatureJobs. Retrieved from http://blogs.nature.com/naturejobs/2017/04/27/science-for-all-supporting-diversity-through-science-outreach/

Pew Research Center (2015). Public and scientists' views on science and society. Retrieved from https://www.pewresearch.org/science/2015/01/29/public-and-scientists-views-on-science-and-society/

Pew Research Center (2017). Among high school seniors, interest in science varies by race, ethnicity. Retrieved from https://www.pewresearch.org/fact-tank/2017/01/04/among-high-school-seniors-interest-in-science-varies-by-race-ethnicity/

Rumala, B. B., Hidary, J., Ewool, L., Emdin, C., & Scovell, T. (2011). Tailoring science outreaching through e-matching using a community-based participatory approach. *PLoS Biology*, *9*(3), e1001026.

Settles, I. H., Cortina, L. M., Malley, J., & Stewart, A. J. (2006). The climate for women in academic science: The good, the bad, and the changeable. *Psychology of Women Quarterly*, *30*, 47–58.

Spicer, S. (2017). The nuts and bolts of evaluating science communication activities. *Seminars in Cell & Developmental Biology*, *70*, 17–25.

Staton, A. Q., & Tomlinson, S. D. (2001). Communication education outreach in elementary school classrooms. *Southern Communication Journal*, *66*(3), 211–225.

Sterman, J. D. (2011). Communicating climate change risks in a skeptical world. *Climatic Change*, *108*, 811.

Syed, M., Goza, B. K., Chemers, M. M., & Zurbriggen, E. L. (2012). Individual differences in preferences for matched-ethnic mentors among high-achieving ethnically diverse adolescents in STEM. *Child Development*, *83*(3), 896–910.

Tsipursky, G. (2018). (Dis)trust in science. Scientific American. Retrieved from https://blogs.scientificamerican.com/observations/dis-trust-in-science/

Van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. F. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Teacher Education*, *96*(1), 158–182.

Varner, J. (2014). Scientific outreach: Toward effective public engagement with biological science. *BioScience*, *64*, 333–340.

Villegas, A. M., & Irvine, J. J. (2010). Diversifying the teaching force: An examination of major arguments. *The Urban Review*, *42*(3), 175–192.

Vollbrecht, P. J., Frenette, R. S., & Gall, A. J. (2019). An effective model for engaging faculty and undergraduate students in neuroscience outreach with middle schoolers. *The Journal of Undergraduate Neuroscience Education*, *17*(2), A130–A144.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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