Retrospective analysis of a STEM outreach event reveals positive influences on student attitudes toward STEM careers but not scientific methodology

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Abstract

Substantial, involved, and expensive efforts to promote the dissemination of scientific knowledge and career interest in Science, Technology, Engineering, and Mathematics (STEM) are enthusiastically supported by many scientific, federal, and local organizations. The articulated underlying goals for these efforts include an enhanced public understanding of science and science-related policy, an increased diversity in STEM careers, and an increase in the future STEM workforce. This effort is primarily driven by an underperformance of the United States that includes poor test performance and limited number of students pursuing STEM degrees. Despite this investment, attitudes toward STEM have not notably changed. The goal of this project was to determine students’ attitudes toward STEM in response to a previously established scientific outreach event. This event was used to address three common goals in STEM outreach: STEM literacy, diversity and inclusion, and career preparedness. We found there was a notable difference in the attitudes toward scientific activities and interest in pursuing a “Science Career” after participation in this event. Strikingly, interest in hypothesis development, the keystone of all STEM disciplines, was the least liked of all the activities offered during the event. Our data suggest that events designed to enhance interest in pursuing a STEM career may benefit from different elements compared with events designed to increase understanding of STEM literacy concepts, such as hypothesis development.

career preparedness; outreach; physiology; science literacy

INTRODUCTION

The United States is experiencing a long-standing labor shortage of prepared Science, Technology, Engineering, and Mathematics (STEM) workforce employees and regularly reports some of the lowest STEM program retention rates and percentage of citizens pursuing STEM graduate education compared with other industrialized countries (1, 2). The President’s Council of Advisors on Science and Technology projects a labor market short-fall of nearly 1 million STEM professionals than are predicted to matriculate in the coming years (3). Projections indicate that, in order to fulfill this shortage, an increase of 34% of STEM bachelor’s degree holders will be required (4). Given the nature of the industries that rely on STEM graduates, a shortage in the labor market compromises not only the United States’ innovation and global economic position but our health and security as a nation (5). Additionally, components of STEM education, including math and critical thinking, are of universal importance in all career fields and contribute to society’s ability to reason key issues of policy (6).

To address this labor shortage problem, significant monetary and temporal resources have been devoted to increasing the pool of STEM graduates by shaping positive attitudes toward STEM subjects. Despite the US government’s significant annual financial investment of nearly 3 billion dollars for the last decade to support STEM education programming, self-reported student data collected as part of the college entrance process by the American College Testing (ACT) indicate there has been no increase in interest in STEM education over the last decade (7, 8). While many agencies continue to demand improvement to STEM recruitment strategies, little initiative has been
taken to evaluate the effectiveness of current spending strategies (1, 6).

STEM outreach programs can be structured in a variety of ways, including week-long camps, 1-day events, and monthly programs with scientists, commonly with the goal to increase discipline-specific knowledge and encourage students to pursue careers in STEM (1, 3, 7, 9, 10). Typically, inquiry-based activities are designed to provide hands-on experiences and develop critical thinking skills; however, the effectiveness of this approach in achieving the desired goals is rarely assessed or critiqued, despite being necessary to improve future events. Our physiology-based single-day outreach event for middle school students utilized inquiry-based activities to both highlight the scientific method in practice and deepen knowledge of the cardiovascular and visual systems.

**STEM Event Goals**

We first identified the common goals across typical outreach programs from federal, state, and privately sponsored groups to establish evaluation criteria necessary for quality improvement of our STEM outreach event. Typical program goals fell into three categories, or buckets (see Supplemental Fig. S1; see https://doi.org/10.6084/m9.figshare.14308769), which we identified as STEM literacy, diversity and inclusion, and career preparedness (9–11).

**Increased literacy.**

The first category of program goals consists of building a strong foundation for scientific and STEM literacy. This includes not only an understanding of basic math and science but also experience with critical thinking and problem solving. These skills are valuable for nearly all citizens, not just those actively working in STEM fields. The emphasis on STEM literacy comes from the transferable skills of problem solving into many decision-making processes including personal health, financial decisions, civic matters, and parenting (12). Higher productivity in any of these key areas is assumed to produce greater economic opportunities for society (13).

**Increased diversity.**

The second common educational goal encompasses increasing diversity and inclusion in STEM. Continued efforts to promote STEM literacy to historically underrepresented groups in science (including racial and ethnic groups such as African Americans, Latinos, and American Indians, as well as low-income individuals) is emphasized throughout many federal programs (14). To diversify the future scientific workforce, efforts should be made to ensure minority representation in outreach programs. Inclusion of historically underrepresented groups is expected to increase total levels of innovation (15).

**Increased career preparedness.**

Lastly, federal STEM goals tend to include aims for improving students’ readiness to fulfill the demand for STEM careers (5). Because STEM professionals encompass fields as diverse as agriculture, energy, healthcare, and defense, their economic impact is far-reaching (16).

We set out to evaluate our annual, established event in the context of the three main goals of STEM outreach and determine if these were being addressed by our event. The evaluated program consisted of a variety of activities as outlined in Fig. 1 with the direct goals outlined in Fig. 2. We hypothesized that, with the incorporation of a 5-min postevent student survey, we would be able to identify key strengths and weaknesses of our event, thus enabling us to deliver a more effective event in the future. As a recurrent event that had not been previously validated, we believed this was an ideal event to evaluate against the STEM outreach goals we consistently observed in the literature.

**METHODS**

To evaluate our hypothesis, we assembled a volunteer outreach team composed of faculty and students from the University of Nebraska Medical Center (UNMC) to execute an educational, scientific, and physiology-themed outreach event at an urban, Nebraska public middle school. UNMC has sponsored this event for over 5 yr. The established event was created based on input from the participating school’s teachers and focused on physiology-based concepts from the school’s curriculum. We placed special emphasis on the steps of the scientific method. Two faculty members from the College of Medicine co-organized the event using a previously established event outline (17). Our survey data was collected postoutreach event, which was not necessarily part of the student’s normal curriculum but was instead viewed more as an enrichment activity, lacking structured program objectives. The event has taken place in a similar form, regularly, for several years. We therefore decided to evaluate the impact of the event on student’s attitudes, one of the objectives designated by the STEM outreach literature as a starting point to evaluate the event (see Supplemental Fig. S1 for more on published goals of STEM outreach). Three volunteer teams, consisting of three graduate students each, had 48 min with a classroom of 25–28 seventh grade students, totaling 265 students that participated on the event day.

**Event Activities**

On the day of the event, each volunteer team was assigned to a classroom. An outline of the 48-min classroom session is included in Fig. 1. Before splitting the class into two groups for the hands-on activities, a classroom lead volunteer introduced the group as “scientists.” The volunteers then lead the students in a discussion asking, “What is science?” and “Who wants to be a scientist when they grow up?”. Classroom lead then explained how scientific discovery is the reason for much of humanity’s knowledge of the world, as well as development of new technologies and medical advances; furthermore, we then described how this information is often shared with others through what is written in textbooks, such as the ones they use in school. We also talked about the process of how scientists design experiments to answer questions and solve problems. Next, we introduced the class to a famous experiment by Dr. John Snow, who hypothesized that a certain water pump was the source of London’s cholera outbreak in 1854. He tested his hypothesis by removing the handle of the specific pump and found the number of
local cholera infections and deaths slowed remarkably. We chose this example for its clear representation of the steps of the scientific method to ensure easy comprehension for the seventh-grade students. We then divided students into two groups of 12–14 individuals to partake in hands-on activities on the visual system and cardiovascular physiology as detailed in Supplemental Material: Instructor’s Guide (see https://doi.org/10.6084/m9.figshare.13260314.v1). At the end of each session, we allotted 10 min for students to ask the volunteers any questions they had about physiology, accomplishments in the laboratory, and daily activities of scientists.
Visual System Activity

The visual system activity started with the volunteer demonstrating the anatomy of the eye using a predissected, fixed sheep eye (Nebraska Scientific, Omaha, NE), and focused on specific structures such as the cornea, iris, pupil, lens, retina, and optic nerve. We let the students feel the firmness of the sclera and lens and drew special attention to the opalescent tapetum lucidum with its notable appearance.

The latter portion of the visual system activity reviewed the scientific method. We asked the students questions related to each part of the scientific method as detailed in Supplemental Material: Instructor’s Guide. For example, during the hypothesis step of the scientific method, we asked, “Based on your own experiences in life, do you think both eyes would be required for depth perception?”. We performed a simple experiment in which students attempted to drop pennies into a cup to test their hypotheses. For step-by-step instructions for this experiment, please see Supplemental Fig. S2.

We continued to review and carry out the scientific method with students by asking them to draw conclusions about their data and by engaging them in a discussion of their results. Our discussion with the students briefly explained how depth perception works and highlighted the importance of a robust sample size by showing individuals’ depth perceptions occasionally deviated from the group as a whole. We also highlighted confounding variables and how the students might address them in future experiments. Finally, to demonstrate the assumptions we often make for a well-designed study, we asked the students in the first activity rotation if they expected similar results from the second half of their class. As an extension of the scientific method, some classrooms performed the X-ray Vision Activity, if time allowed. Individual talking points of the discussion and the X-ray Vision Activity can be found in Supplemental Material: Instructor’s Guide.

Cardiovascular Activity

The other hands-on activity reviewed cardiovascular physiology, beginning with a dissection of a fixed sheep heart. The brief anatomy lesson focused on the atria, ventricles, valves, aorta, chordae tendineae, and coronary arteries (see Supplemental Material: Instructor’s Guide for the labeled heart anatomy). In brief, we explained to the students that the heart is able to beat on its own, but the rate of this beating changes in response to stimuli. We asked the students what activities might cause their heart rate to change.

The latter portion of the cardiovascular activity focused on the scientific method as detailed in Supplemental Material: Instructor’s Guide. Similar to the visual system activity detailed previously, we asked students questions related to each part of the scientific method. To test their hypotheses, we guided students through a hands-on heart activity.

Figure 2. Overview of scientific method instruction. The outreach activity began with an introduction to the whole class. Students were divided into two groups to complete one hands-on activity followed by the other. The class came back together for open forum questions about the didactic material, science as a career, and the scientific method.
Table 1. Survey questions regarding conserved STEM outreach goals

| STEM Literacy                                                                 |   |
|-------------------------------------------------------------------------------|---|
| “Which one was your favorite [eye] station or activity?”*                    |   |
| “Which one was your favorite [heart] station or activity?”*                  |   |
| “This event increased my appreciation of science.”#                          |   |
| “This event increased my knowledge of science.”#                             |   |
| Career Preparedness                                                          |   |
| “This outreach event helped me to understand what a career in science is like.”# |   |
| “After attending the event how has your interest in careers involving science changed?”* |   |

STEM, Science, Technology, Engineering, and Mathematics.
*Options: developing hypothesis; dissection; testing hypothesis; X-ray vision (visual system station only).
#Likert ratings (1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree).
†Likert ratings (1 = decreased; 2 = no change; 3 = increased).

The population of instructors included multiple minority groups that a diverse classroom of students might identify with. Of these scientists, 75% identified as female, 50% identified as underrepresented in STEM fields, and 37.5% were first generation college students. It is of note that our original survey sought to include demographic data about the students partaking in the outreach event. However, the survey was modified due to concerns about student anonymity, and we were unable to collect such data. Therefore, future events are needed to comprehensively

RESULTS

Event Goals: Improving STEM Literacy

Results from the postsurvey support the observations made by the volunteer instructors during an informal debriefing session (Fig. 3A); students reported their preferred activity to be the dissections, followed by hypothesis testing. The lowest preferred activity was hypothesis development. When student responses were stratified by station (cardiovascular system vs. visual system), the activity preference remained the same (Fig. 3, B and C, respectively).

At the conclusion of the event, most students responded to the survey question “This event increased my appreciation of science” with “strongly agree” or “agree” (Fig. 4A). Additionally, over 80% of students responded to the survey question “This event increased my knowledge of science” with “strongly agree” or “agree” (Fig. 4B).

Event Goals: Improving STEM Inclusion and Diversity

The participating school’s Research Review Committee approved the event. The committee required a letter of intent, a copy of our evaluation survey, and an opt-out parental consent form. The letter of intent detailed the content of the outreach event, introduced the outreach team, and explained the purpose of the evaluation survey. Students’ parents received the opt-out parental consent form via email. This document informed parents of the event, the purpose of the evaluation and gave the option to refuse their child’s participation in completing the survey. The approved final survey included modifications to maintain student anonymity. We were not permitted to ask the students’ sex, gender, or ethnicity. UNMC’s Institutional Review Board approved this as an exempt study.

Survey

We evaluated our event using student self-reported answers on general knowledge, appreciation, career awareness, and career interest from the survey, which students completed postevent. The survey sought to assess the event’s effect on STEM literacy and career preparedness. This was accomplished using specific questions that correspond to the conserved STEM outreach goals, which are listed in Table 1. The survey results were analyzed by the Methodology & Evaluation Research Core from the University of Nebraska-Lincoln. Figures 4 and 5 have different n numbers as not every student answered every question on the survey; some surveys were incomplete with a few questions left unanswered.

Figure 3. Students preferred dissection activities. As a measure of Science, Technology, Engineering, and Mathematics (STEM) literacy, students reported their preferred activity (A) and were asked “Which one was your favorite [eye] station or activity?” (B) and “What was your favorite [heart] station or activity?” (C) (n = 247).
address quality improvement for determining inclusion and diversity of this particular established outreach event.

Although the lack of data left us unable to stratify impact on individual participants of different backgrounds (thus leaving us unable to identify impact on our diversity and inclusion goal in our survey), our diverse set of instructors were still able to engage students in activities that engage trust in the scientific community: a common goal for inclusion and diversity activities (18). Unfortunately, our survey lacked questions regarding student attitudes surrounding trust of science and scientists.

Event Goals: Improving STEM Career Preparedness

As shown in Fig. 5A, ~70% of students self-reported that “This outreach event helped me to understand what a career in science is like.” While most students indicated no change in their interest in careers involving science, a greater percentage of the total students reported they were more interested, compared with less interested, in a career involving science after the event (Fig. 5B).

Observational Notes

Instructors noted that student engagement and questions were highly responsive to familiar disease pathologies that affect them and their families. Thus numerous focal points and discussions from this outreach event centered around exploring and improving students’ readiness for STEM careers. As a result, over 70% of students reported that their understanding of science careers was improved, and more than 21% of students said their interest in a science career had increased (Fig. 5A and B).

Overall, the instructors anecdotally reported very high student engagement throughout the demonstrations and activities. Observationally, the volunteer instructors also observed higher levels of engagement during the dissection activities, with more hesitant participation during the hypothesis development and experimental design discussions. Students appeared especially engaged with questions about each instructor’s disease model and the progress they were making as scientists.

DISCUSSION

Event Design and Execution

We conducted an observational study to evaluate the effectiveness of an established outreach event, which has been conducted numerous times over the past 5 yr. Our evaluation examined three well-conserved STEM outreach goals among federal, state, and privately funded outreach efforts. The goals included enhancing STEM literacy, increasing inclusion and diversity, and improving career preparedness (9, 10, 19). The ability of the event to meet these goals was assessed via indicators of student attitudes toward science including knowledge of science, appreciation of science, career awareness, and career interest. Although
Our event has been well received by both the teachers, as indicated by their continued request to perform the yearly event, and the students, as indicated by feedback to their teachers, we had not previously evaluated the program in terms of meeting the commonly defined goals of STEM outreach.

Event Goals: Improving STEM Literacy

The first goal of our outreach event was to promote scientific literacy by generating understanding of the scientific method. Thus we divided both activities (visual system and cardiovascular system) into equal time allotments to focus on both goals. One-time allotment discussed anatomical terminology through dissection, while the other led students through an experiment using the scientific method. Our dissection activities consisted primarily of anatomical terms that the students had previously been exposed to in their anatomy curriculum in the classroom. Examples included the cornea, lens, and tapetum lucidum for the visual activity and the ventricles and atria for the cardiovascular activity. This allowed us to introduce new physiological concepts and transition the students into critical thinking activities such as hypothesis development and testing.

The instructors engaged students throughout the discussion and instruction of the scientific method (Fig. 2) using guided prompts from a previously produced handout (see Supplemental Material: Instructor’s Guide). During this portion of the activities, students made observations such as “I notice every one of us has two eyes. I wonder if having two eyes instead of one is important.” Instructors used these observations to prompt students to generate guesses and speculations. Their guesses and speculation were then identified as hypotheses. While their hypotheses varied, the students had a nearly universal interpretation of the plotted data and were able to identify if their original predictions were supported as correct or incorrect. Discussions following the data interpretation encouraged students to further engage with the outreach instructor. This discussion and application of material has been previously shown to maximize learning and enhance critical thinking abilities (21, 22).

Of the select students who did not prefer the dissection activities, their questionnaire responses indicate this was largely due to them being off put by the specimens and their odors (formaldehyde from preserved specimens) and/or disinterested in the subject material. It is of note that, given the time limitations of only interacting with the students one time and for less than an hour (48 min scheduled), we were satisfied with the impact our scientist instructors had on students, as evidenced by the increase of self-reported student appreciation for science (Fig. 4A). Considering eighth-grade students who express interest in STEM are three times more likely to ultimately pursue STEM careers later in life (23), our event will likely positively affect the chances of these students pursue careers in STEM. Additionally, previous studies indicate that short-term inquiry-based approaches to outreach, such as the outreach approach we took, result in improved attitudes toward science compared with traditional lecture-type instruction (9). However, it is still unclear whether this change in appreciation is long-lasting.

Student Activity Preferences and Preference Factors

The scientific method requires significant critical thinking, especially in the development of a hypothesis and analysis of results. Thus critical thinking and the scientific method are highly emphasized needs in outreach programs. In fact, disseminating the scientific method and critical thinking skills are a conserved focus among many funding agencies, particularly federal funding agencies (2). However, limited resources exist detailing delivery of scientific method to students. It is ironic that many of the instructors of outreach events, such as graduate faculty and students, are often individuals who work heavily with the scientific method every day, but few research events are critically evaluated to understand if the goals were met via a means for collecting data on the results of their outreach event and/or how to reformat event for quality improvement based on their results (20). Therefore, we utilized an established outreach event to consciously engage students throughout the process of the scientific method, particularly forming and testing a hypothesis (Figs. 1 and 2). However, students reported an overwhelming lowest preference for the hypothesis generating activities and highest preference for dissection activities (Fig. 3). These preferences held true for both the cardiovascular and visual system activities (Fig. 3, B and C, respectively), indicating that the responses were not biased by a particular instructor or station.

In our postanalysis of the event, we considered a few factors that may provide insight toward improving the quality of future outreach events. Students’ majority preference for the dissection may be a result of the hands-on nature of the dissection activity. This is supported by the fact that other hands-on activities, such as hypothesis testing, were preferred over activities that were not as hands-on, such as developing hypotheses. The hands-on approach of the dissection and hypothesis testing activities provides an opportunity for critical thinking and intellectual engagement for kinesthetic and visual learners. Students may have preferred the hands-on activities because they required easier, lower order thinking, such as general recall and recitation of information. Thus future plans include requiring students to properly identify an anatomical feature before being allowed to touch the tissues. Having students apply what they have previously learned in the didactic lecture from their schoolteachers to the inquiry-based dissection provides an opportunity to incorporate critical thinking and intellectual engagement with the outreach instructor. This discussion and application of material has been previously shown to maximize learning and enhance critical thinking abilities (21, 22).

Impact on Student Attitudes toward Science

Given the time limitations of only interacting with the students one time and for less than an hour (48 min scheduled), we were satisfied with the impact our scientist instructors had on students, as evidenced by the increase of self-reported student appreciation for science (Fig. 4A). Considering eighth-grade students who express interest in STEM are three times more likely to ultimately pursue STEM careers later in life (23), our event will likely positively affect the chances of these students pursue careers in STEM. Additionally, previous studies indicate that short-term inquiry-based approaches to outreach, such as the outreach approach we took, result in improved attitudes toward science compared with traditional lecture-type instruction (9). However, it is still unclear whether this change in appreciation is long-lasting.

RETROSPECTIVE ANALYSIS OF A STEM OUTREACH EVENT

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Of the select students who did not prefer the dissection activities, their questionnaire responses indicate this was largely due to them being off put by the specimens and their odors (formaldehyde from preserved specimens) and/or disinterested in the subject material. It is of note that, given the time limitations of the outreach event, we were only able to engage with students in the context of biological and physiological sciences. We may have been able to capture more student interest if we have been able to present on a broader array of topics.
Impact on Scientific Knowledge

Most agencies sponsoring STEM outreach events recognize that all citizens should have science knowledge even if they are not interested in STEM or STEM careers (5, 24). With nearly 80% of our students self-reporting an increase in science knowledge following our event, we have evidence indicating our outreach program is establishing and enhancing scientific knowledge for the students. Furthermore, the self-reported increase in science knowledge supports the idea that this established outreach event is meeting some components of the STEM literacy goal regarding students’ understanding STEM career jargon (see Fig. 5A).

Event Goals: STEM Inclusion and Diversity

The second goal of the evaluated outreach event was to differentiate the impact on multiple underrepresented student populations including minority, female, and first-generation college students. We had nine instructor scientists present for the activities that represented multiple minority groups that a diverse classroom of students might identify with.

While IRB limitations prohibited us from collecting response data from students regarding these demographics, other components of inclusion were still included. Our outreach event provided an opportunity to build trust among the students with the scientists through interactive “Question and Answers” at the conclusion of the activities. For students who do not pursue careers in science, trust in scientists, including one-on-one interactions with advanced level scientists, contributes to an increased willingness to engage with and be responsive to social issues relating to STEM fields (18). To build this trust, instructors led the conversation by telling students about the grade school experiences that led them to college, experiences during college, and how they leveraged these experiences to attend graduate school. This discussion included examples of resources available to first generation college students, college readiness programs, and alternative career paths in STEM. Instructors also designated time for briefly explaining their current research and career goals.

Event Goals: Improving Career Preparedness

The third goal of our evaluation was to determine the impacts of our event on students’ understanding and interest in science careers. To this end, our efforts began with real-world examples of major scientific discoveries and a discussion on the logical rationale leading to these discoveries, such as the aforementioned telling of Dr. John Snow’s cholera experiment (see Supplemental Material S2: Instructor’s Guide). Instructors revealed how the rationale that led to those discoveries was part of the scientific method that they use every day as scientists. This discussion was expanded on as instructors detailed how the scientific method applies to their current research in cancer, hypertension, immunology, microbiology, and regenerative medicine. Importantly, students also inquired about alternative careers in STEM not represented by the instructor group.

Impact on Student’s Understanding of Science Careers

We directed the volunteers to introduce themselves using the broad term of “scientist,” as opposed to a narrow identifier of their specific career interest such as physiologist, biochemist, or cancer biologist, to place emphasis on STEM fields as opposed to a specific niche. This appeared to synergize well with the rest of our approach; we were satisfied with our impact on student’s understanding of STEM careers (Fig. 5), as students showed a >70% agreement that the event increased their understanding of careers in science (combined agree and strongly agree responses). The National Career Development Association (2011) recommends middle school guidance counselors emphasize helping students develop increased self-understanding of how career interest, aptitudes, and work values apply to themselves. We were able to increase students’ self-understanding of science careers, so the career is seen as an approachable opportunity to pursue (Fig. 5).

Impact on Student’s Interest in Pursuing a STEM Career

One of the main goals of agencies sponsoring STEM outreach events is to fulfill the demand for STEM careers by increasing students’ interest in pursuing a STEM career (1). Not unexpectedly, as our program was a one-time event, most students reported no change (68.2%) in their interest in careers involving science. These results enhance the importance that our event influenced 21.2% of students to be more interested in science careers. This is not surprising, as informal learning environments, like the ones used in our event, are successful in motivating and increasing students’ interest in science careers and disciplines (10, 11, 25).

Study Limitations

We identified limitations to this study. First, as an observational study with limited time and interactions with the students, we were unable to make long-term conclusions about how our event affected students. Next, the approved questionnaire did not include any questions regarding demographic information, one of the major STEM outreach goals (diversity and inclusion). This information can help inform the analysis of our questionnaire results, as individuals from different backgrounds, such as socioeconomic factors, may be predisposed to have more positive or negative experiences with rudimentary science (26). This data set would also aid us in analyzing our impact on underrepresented populations, a major theme throughout STEM outreach program goals.

Conclusions

Effective STEM education has immense impacts on the social and economic status of a nation, which is a large part of why the US spends nearly 3 billion dollars every year with the goal of improving student attitudes toward STEM. Educators and scientists need the best available tools to accomplish this feat. Establishing mechanisms for continual event improvement should be an essential component to any regularly scheduled program. In this study, we
demonstrated that, while our event was intentionally focused on activities that would engage students in the scientific method and critical thinking skills, students reported being least interested in these activities. Additionally, we found that, while only a secondary emphasis of our event, student increase in awareness and interest in STEM careers were increased greater than we anticipated.

By placing the common goals of STEM outreach, we found in the literature and funding agency websites in several “buckets,” we were able to differentiate what criteria we most wanted to focus on when evaluating their impacts (Supplemental Fig. S1). From there, we evaluated what activities from our event might contribute most to student attitude changes. By asking students to rank their activity preferences and provide feedback on their attitudes toward STEM as a result of the event, we were able to identify clear strengths and weaknesses of our event.

All these valuable data will guide changes in our event design and evaluation methods, which we will continue to expand on and use with future events. We plan to adapt design and evaluation methods, which we will continue to survey students and reassess the criteria we most wanted to focus on when evaluating their interest from all the additional volunteers who participated in this project. Safwan Elkhatab, Cassandra Mosfiegh, and Sarah Hortman. Additional thanks to the Methodology & Evaluation Research Core at the University of Nebraska-Lincoln for analyzing the survey results.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

A.J.C., C.L.H., M.A.C., and A.M.S. conceived and designed research; A.J.C., C.L.H., S.L.S., S.E.G., H.J.M., R.M.S., M.A.C., and A.M.S. performed experiments; A.J.C., C.L.H., S.L.S., S.E.G., H.J.M., R.M.S., M.A.C., and A.M.S. analyzed data; A.J.C., C.L.H., S.L.S., S.E.G., H.J.M., R.M.S., M.A.C., and A.M.S. interpreted results of experiments; A.J.C., C.L.H., S.L.S., S.E.G., H.J.M., R.M.S., M.A.C., and A.M.S. prepared figures; A.J.C., C.L.H., S.L.S., S.E.G., H.J.M., R.M.S., M.A.C., and A.M.S. drafted manuscript; A.J.C., C.L.H., S.L.S., S.E.G., H.J.M., R.M.S., M.A.C., and A.M.S. edited and revised manuscript; A.J.C., C.L.H., and A.M.S. approved final version of manuscript.

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