Collaborative Learning Tools To Foster Inclusive Participation and Sense of Belonging in a Microbiology Outreach Partnership†

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For secondary outreach programs to meet the goals of enhancing science education and attracting future scientists from underrepresented populations, we need an inclusive approach that integrates students’ knowledge and experiences in the process of doing science. I present three pedagogical tools designed by developing equitable, inclusive collaboration among microbiologist outreach mentors and high school biology students. These activities aim to foster a sense of belonging in a scientific community and serve as an entry point to the practice of inclusion. Over a one-semester course at an alternative high school, ten secondary students and their scientist mentors met weekly to design and conduct microbiology experiments together. This group of students and scientists participated in structured collaborative learning activities to: i) understand each other's ideas about science; ii) collectively analyze their research findings; and iii) offer peer feedback. I modified the following three learning tools for use in my secondary science classroom from protocols of the National School Reform Faculty: 1) the Quotes Introduction Activity set the stage for equitable discourse between high school students and scientist mentors, while initiating important conversations about the process of biological research; 2) the Data Analysis Protocol allowed both students and mentors to contribute to the scientific process; and 3) the Feedback Carousel Activity engaged students and scientists alike in reviewing and refining poster presentations. This inclusive engagement in the social aspects of learning science can help students feel a sense of belonging and imagine their futures in the scientific community, key steps towards inclusion. The supportive system of structured feedback in these collaborative learning activities created a safe, inclusive space for secondary students to try on the role of microbiology expert, and for scientist volunteers to practice inclusive mentorship. Drawing from inclusive pedagogical tools in secondary education will help expand our capacity for inclusive science outreach and bring us closer to the goals of improving biology education and attracting future biologists at the university level.

INTRODUCTION

Science outreach programs to secondary schools are a common strategy for community engagement by US universities to improve science education and recruit students to scientific careers (1–4). However, bringing scientist experts to schools does not necessarily include students in scientific inquiry nor support more students in feeling they belong to a scientific community, particularly those from nondominant groups (5). This paper offers easily adaptable tools for inclusive outreach that I created in working with scientist mentors and students in an alternative biology course at a US secondary school.

For outreach programs to meet our goals of enhancing science education and attracting future scientists from underrepresented groups, we need more inclusive pedagogical approaches. Fostering inclusion of marginalized groups in science requires outreach that integrates student knowledge and experiences in the process of doing science (6, 7), and that allows students to interact and identify with scientists through collaborative social learning (8, 9). Science outreach efforts need to purposefully recognize students as competent makers of scientific knowledge and position them as participatory members of a scientific community (10).
SPROWLS: COLLABORATIVE TOOLS TO FOSTER BELONGING

Pedagogical practices that create routines or tools for student collaboration and elicit student participation can help make secondary science education and outreach more inclusive for both students and outreach volunteers (11, 12). Inclusive, equitable interactions between scientist mentors and underrepresented minority (URM) students are significant for integrating students into the world of science research (13, 14). Learning activities that structure equitable participation of students and mentors as peers can foster a sense of belonging (15), defined as the feeling of being part of a scientific community (16). Inclusion in and belonging to such peer communities may sustain participation of URM students in science (17). To serve as an entry point to the practice of inclusion, I present three pedagogical tools that I co-developed with secondary students, scientists, and educators, drawing on evidence that structured, collaborative learning supports inclusive participation and a sense of belonging in a scientific community (18).

PROCEDURE

I incorporated the following collaborative learning activities into a secondary science course focused on hands-on microbiology research. I offered the course at an alternative Title I school serving low-income families (40% eligible for free and reduced meals) and at-risk students in rural Midwest USA. Graduate students, postdocs, and research scientists from the nearby state university’s biology department volunteered to mentor high school juniors and seniors who needed to earn additional science credits for graduation. Over the course of one semester, ten pairs of secondary students and scientist mentors independently designed and conducted basic microbiology experiments. The student-scientist research teams met weekly at the high school for collaborative sessions and visited lab facilities at the university as needed.

I structured collaborative learning activities at the beginning, middle, and end of the course in order for the group of students and scientists to: i) understand each other’s ideas about science; ii) collectively analyze their research findings; and iii) offer peer feedback. These pedagogical tools were modified from protocols designed by the National School Reform Faculty to facilitate equitable discourse and foster a sense of belonging in a group (19). While retaining structures that facilitate inclusive, collaborative learning among a diverse range of participants, I adapted the following three activities originally developed for professional learning communities of teachers, to my secondary science classroom.

Quotes introduction activity

To launch the student-scientist partnerships at the start of the course, secondary students and scientist mentors participated in the Quotes Introduction Activity. Participants introduced themselves by relating to ideas about the philosophy or process of science. I invited participants to select a quote from a deck of cards printed with quotes about science (Appendix 1). After taking a few minutes to select their cards, participants were instructed to quietly re-read and reflect on why they chose the quote they did. Next, students and scientists paired up around the room to introduce themselves and share their quotes and thinking about each quote, repeating this pair-share process for two more rounds of five minutes each. In 20 minutes, each student had engaged in multiple deep, contextualized conversations about the process and philosophy of science with scientists, as well as personally connected with various potential mentors in the group. More than just an ice-breaker, this activity set the stage for equitable back-and-forth dialogue between high school students and scientists, while initiating important conversations about research design and the learning opportunities of experimental “failures.”

Data analysis protocol

By the midpoint of the course, high school researchers had practiced basic microbiology techniques, designed their experiments, and begun experimental trials with the help of their mentors. Students then brought their preliminary data to the group for the Data Analysis Protocol. This activity provides structured guidelines for each student to present their research-in-progress, and then to listen to interpretations and suggestions from the group. This collaborative process required modeling constructive feedback, as well as scaffolding the skills of active listening and participation. As the facilitator, I emphasized the importance of hearing everyone’s ideas as the group collaborated to improve each other’s work, in order to foster equitable discourse among the students and scientists.

To help encourage inclusive participation, I began the Data Analysis Protocol by explaining the purpose and guidelines for each step in the structured discussion. The student presenter had one minute to show one image of their data (e.g., a graph, a photo collage of cultured plates, or a microscopy image). The presenter could not answer questions or explain further during the protocol, in order that the image speak for itself. Participants had a few minutes of silence to examine the data sample and prepare their contributions for the three rounds of analysis. In the first five-minute round, each participant shared an observation about the data, while the presenter listened and took notes quietly. In the second round, each participant shared an inference or an interpretation of the data. In the final round, they shared suggestions for either improving the image or for next steps in the experiment. Lastly, the presenter had one minute to verbally respond to the group’s analysis or share any insights they gained from it. In 20 minutes, each presenter gained valuable input from both their high school peers and the scientist mentors, which they were able to use as they continued their research and prepared for their final poster presentations. Likewise, each student contributed to the research process of their peers.
Feedback carousel activity

The final products of the course were mini-poster presentations by each high school researcher. Before final printing of their posters, the research teams participated in a Feedback Carousel Activity to review their work. Poster drafts were displayed on tables around the classroom with stacks of sticky notes color-coded for warm feedback, cool feedback, suggestions, and questions. Participants rotated around to write notes on the posters, with a three-minute timer to help keep the group circling to all the posters in the classroom. When participants had rotated back to their own poster, they had three minutes to read the sticky notes left by their peers. The final round asked each student to share with the group one sticky note they found most helpful as they looked toward finalizing their projects. As the notes were left anonymously, this final verbal step validated the person that had left that helpful note.

CONCLUSION

As students and scientists worked together throughout the course, the group developed shared ownership of and a vested interest in the work of the entire class. Rather than science outreach models in which “expert” scientists judge school science projects, these easily adaptable collaborative tools involved secondary students in research analysis and review alongside scientists. This equitable engagement in the social aspect of learning science can help many students overcome barriers they may face preventing them from feeling a sense of belonging or imagining their futures in the scientific community (5, 8, 20). The supportive system of structured feedback created a safe space for high school students to try on the role of microbiologist, and for scientists to practice inclusive mentorship (14). Building from evidence that a sense of belonging is connected to project ownership (9) and cultivated through social learning and community building (16, 21), these collaborative tools create important opportunities to contextualize science outreach through equitable discourse with marginalized students. Because these learning activities facilitate equitable participation, they provide entry points for science educators to cultivate a “culture of pedagogical inclusiveness” (22).

The three tools presented above are just a few examples of the many models that exist for collaborative, student-centered learning that we can incorporate into co-teaching microbiology more inclusively (23). These learning activities set the stage for the practice of inclusion in biology outreach programs by drawing from inclusive pedagogical models in secondary education. Continued collaborative learning among secondary students and scientists will help expand our capacity for inclusive science outreach, bringing us closer to the goals of improving biology education and attracting future biologists at the university level.

SUPPLEMENTAL MATERIALS

Appendix I: Science quotes for introduction activity

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