Promoting Authentic Research Experiences in the High School Classroom: Opportunities and Challenges

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Abstract: This study examines the nature of student experiences conducting open-ended scientific investigations as part of a new high school neuroscience curriculum. Semi-structured interviews with program participants (37 students and 25 teachers) revealed both challenges, mainly reading primary research articles and making sense of data, as well as opportunities for increasing students’ self-efficacy and college readiness. These findings can inform future efforts to promote authentic research experiences in K-12 classrooms.

Background
Despite efforts to promote inquiry-based learning, many K-12 science classrooms, especially in underserved schools, still heavily rely on direct transmission of pre-packaged knowledge, and practical work that does take place is often overly orchestrated, not allowing students to experience the open-ended investigative nature of science (Burgin, Sadler, & Koroly, 2012). By engaging students in authentic scientific inquiry, they can gain an understanding of the dynamic nature of science as a process that involves developing theories, testing them empirically, and then revising the theories based on data (Schwartz & Crawford, 2006).

To address this need, our team has developed a semester-long neuroscience curriculum for high school students (“BrainWaves”) that emphasizes student-led investigations. In this program, students first learn about neurons, brain anatomy, and brain plasticity, and then, with support from science mentors (Ph.D. students and postdocs), develop a research question of personal interest to them (e.g., how does listening to music affect learning), read background literature, design an experiment, collect data from their peers, analyze data, and share their findings at a culminating program symposium (Azeka, Carter, & Davidesco, 2020).

In the current study, we asked how students and teachers experienced the process of conducting open-ended science investigations, what kind of scaffolding students needed, and what kind of challenges and opportunities were encountered in this process. This work is grounded in participatory inquiry learning, a sociocultural perspective on learning that emphasizes rich, authentic problems and co-construction of knowledge and ideas with community members (Barab & Hay, 2001).

Methods
To address our research questions, a phenomenographic methodology was deployed (Larsson & Holmström, 2007). Phenomenography is a research approach used to describe the different perspectives of people (in this case, students and teachers) and to understand a phenomenon (here, open-ended scientific investigations in the classroom). To that aim, semi-structured interviews were conducted with all 25 teachers who implemented the neuroscience program between 2018-2021 as well as with 1-2 students from each classroom (37 students total). All teachers and students were from public high schools in a large northeastern city in the United States. The interview questions were designed to help researchers understand students’ past experiences in science classes, their experience in the program, and their outlook on science and college preparedness. Interviews lasted approximately one hour and were audio-recorded with the participants’ consent.

Transcribed interviews were coded through a thematic analysis process outlined by Braun and Clark (2006), which suggests a six-step framework of, (1) familiarizing oneself with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. Two trained researchers conducted the analysis and met frequently to discuss and refine the codes and how they were operationalized. Following preliminary data analysis, the research team grouped codes into broader overarching themes by analyzing the statements associated with each code.

Findings
Four overarching themes emerged from both students’ and teachers’ perspectives. First, there were reported challenges in conducting background research. Some students struggled with finding relevant literature, while others felt overwhelmed by the amount of literature that emerged from their search. There were also reported challenges in understanding scientific jargon and the basic structure of research articles. For example, one of the students reported: "I have never read that type of scientific literature, it was a new experience… For one it was a
lot harder to read. Some of the ones we read were like stuff you can get from google scholar, but other stuff was like well there is this really obscure thing with words that we do not even know. So we had to search what things meant, like what is the amygdala and the drugs they use to turn it off and other things.” This sentiment was shared widely with another student remarking, “It was like I want to say confusing but like brand new it has the abstracts and it is different from other articles that we read in my prior science classes.”

Second, interpreting data, especially when it contradicted students’ hypotheses, was a challenge. This often resulted in students focusing on aspects of the data that supported their hypotheses. For example, one teacher reported: “I think the idea of being open to whatever your data shows you is important because a lot of times students are looking to prove their hypothesis and so it is difficult for them to first of all understand that they are just supporting their hypothesis and but also the fact that their data might disprove their hypothesis.”

Third, findings indicated that support and scaffolding was a key element in shaping students’ experiences of conducting research. For example, one of the teachers pointed out that “the science mentors came in and they really helped me when it came to checking the proposals before they started it and checking their research questions and methods, which was all part of their proposal. That was really like the big chunk of like making sure that they were going in the right direction before they actually got started.” Similarly, a student commented, “Oh yes the mentor showed us how to identify if a site is credible or not and she helped us to um factor in more variables and factor in things that could help us or affect the experiment that we were doing.”

Lastly, despite the challenges, the overall experience of conducting research was highly positive. In particular, it seems that this experience helped increase students’ self-efficacy and college readiness. One student told us: “I think it (the program) prepares us for college because if we have that experience and exposure now we won’t receive that as a shock in college and say like oh my god what is this it is like no we need to know now so that we are not overwhelmed at college and end up failing the course.” Relatedly, one of the teachers reported, “that was fun to see them sort of like kind of be able to become more independent learners and when they were proud of themselves when they came up with something unique.”

Significance
These findings suggest that student-led research investigations can provide a rich context for students to develop their science self-efficacy. However, sufficient scaffolding and structure are needed to help students overcome challenges related to reviewing background literature and designing an investigation that can yield interpretable data. This work could help shape questions for further research, such as how to prepare teachers to support students’ data practices. This work could also impact how teachers facilitate students’ investigations while balancing student autonomy and curriculum requirements. At the conference, we seek to explore how these findings can provide direction for others seeking to bring authentic science research literacy into K-12 classrooms.

References

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