The Science Symposium

A Substantive Alternative Assessment

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Student collecting data with Wynd HALO

Will this be on the test?" is a common question posed by students when approaching new content and the answer often guides their level of investment in learning. In today's science classes, where standards are shifting toward engaging in scientific practices, a shift in science assessments to better reflect the skills and knowledge achieved in modern science classrooms is needed. If science is a discipline to be practiced rather than memorized, then science assessments should be designed to gauge a student's progress toward employing better science practices. A substantive alternative assessment in science—one that provides authentic and meaningful feedback to students as they *do science*—is the science symposium.

The University of Montana's Research Education on Air and Cardiovascular Health (REACH) program provides opportunities for high school students to conduct student-designed science research projects (Delaloye et al. 2016; Delaloye et al. 2018; Ward et al. 2016). The culminating event of this yearlong REACH program is the Environmental Health Science Symposium. This year's 18th annual symposium will bring together high school students from Montana, Idaho, and Alaska to present their research findings and engage with their peers, University faculty and staff, and a panel of judges—just as research scientists would do. The science symposium provides students with experience in science communication and an alternative assessment providing meaningful, timely, and relevant feedback to students and their teachers. Here we present findings from student survey data and teacher interviews regarding their experiences with the REACH symposia.

What is REACH?

REACH is an education outreach program designed to support classroom teachers as they facilitate health science research projects related to indoor air quality conducted by their students. Offered by the University of Montana's School of Public and Community Health Sciences, REACH provides science content resources, materials, infrastructure, and support for participating students to conduct authentic scientific inquiry in their community. REACH participation begins with a summer teacher workshop where interested teachers receive low-cost air quality monitors, background knowledge on air quality concerns in their region (specifically the Environmental Protection Agency criteria pollutant $PM_{2.5}$, particulate matter 2.5 microns and smaller), REACH curriculum modules, and training on implementing science research projects with students. Following the workshop, teachers incorporate REACH in their science classes throughout the school year. While the degree of implementation is up to the teacher's discretion based on the context within a specific high school course, a typical participating class will begin the school year with an introductory presentation from REACH staff about the significance of $PM_{2.5}$ and its impact on cardiovascular and respiratory health. Teachers choose when to incorporate the REACH curriculum modules throughout the fall semester and, when ready, begin embarking on the student-designed air quality research projects. For a full list of the *Next Generation Science Standards (NGSS)* addressed in the curriculum modules and overall REACH program, please see *Connecting to the NGSS* document.

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These research projects are the heart of the REACH program. Students receive guidance and support from their teachers, the REACH team, and University of Montana faculty engaged in ongoing air quality science research. Low-cost air quality sensors and training on their use is provided by the program at no cost. Following the introductory presentation and an emerging understanding of the sources and the health impacts of $PM_{2.5}$, students form small research groups. Driven by a research question of their choosing, they spend the early part of the spring semester designing their research project and gathering and analyzing data. During the remainder of the spring semester, with their teachers periodically checking in on their progress, the students finalize their projects by producing analytic graphs, formulating their conclusions, and preparing to present their work. The culminating event takes place at the conclusion of the school year with the annual Environmental Health Science Symposium, where over two hundred students gather to present their research projects, answer questions, and receive feedback from their peers, the REACH team, and a panel of expert judges.

The Environmental Health Science Symposium

The annual Environmental Health Science Symposium provides a venue for students to present their research findings to their peers for feedback, just as research scientists would do. Two options for presenting are available to students: the traditional presentation and the poster presentation. Traditional student presentations using PowerPoint slides are approximately five minutes long and are presented to the audience of fellow students and teachers, the REACH team, and a panel of judges. Following the presentation, students answer questions posed by the au-

dience. Each student project is scored by a five-person panel of judges using a structured scoring guide (rubric) that is provided to teachers and students early in the year. The top three projects are recognized with awards at the end of the symposium.

As an alternative to the traditional presentations, participating students may present a poster highlighting their research. Approximately 40 posters are submitted to the poster session at the REACH Symposium each year, with three judges evaluating each poster using a similar structured scoring guide. After an initial review, the top six poster presenters are interviewed by the judges about their methods and results, with the top three poster presenters receiving awards.

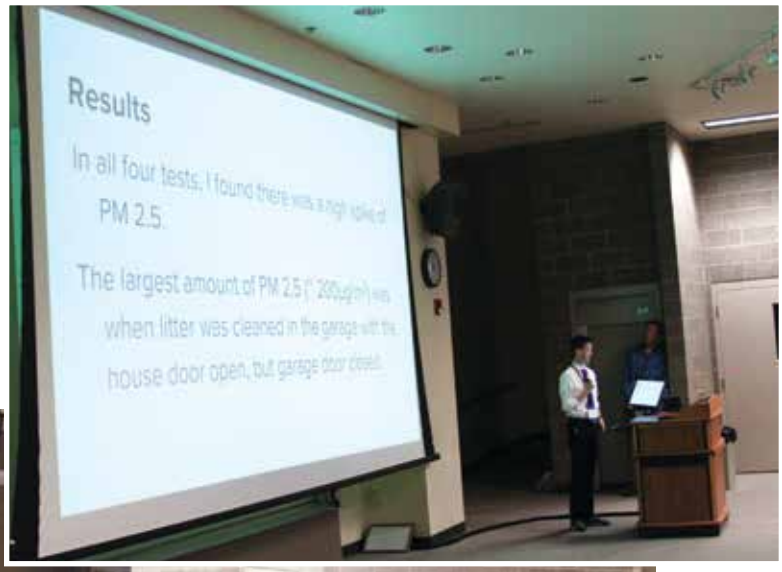
For schools unable to travel to the in-person symposium (such as participating Alaska schools), a virtual symposium is held using the same framework. During the COVID-19 pandemic, the virtual symposium became a very valuable tool so that students could still experience the opportunity to present their projects to an audience including judges.

How can a science symposium serve as an alternative assessment?

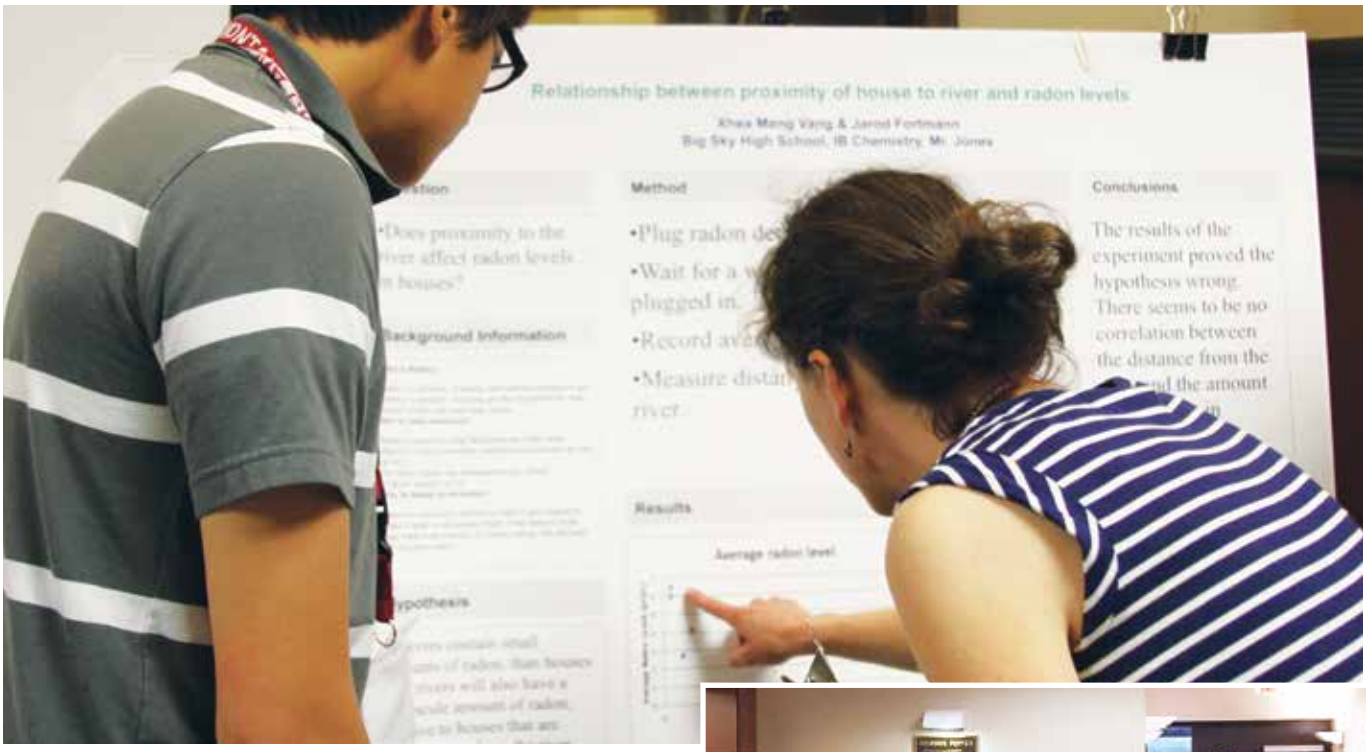
REACH teachers use the symposium as an alternative assessment in various ways, depending on the needs of their own classes. A common approach is to average the judges' scores following presentations and assign the average as an assessment grade. Other teachers will average the judges' scores with their own score that they assign, using the same rubric. One longtime REACH teacher replaces the final exam in his classroom with the symposium experience, assigning a final grade that incorporates judges' scores, his own score, and a reflection paper the students complete following the symposium. Another teacher uses a two-tier approach to assessment, with the first tier compiling marks earned throughout the semester as students prepared and executed their research projects, and the second tier comprising the symposium presentation scores assigned by the judges. A high school chemistry teacher who incorporates REACH into his class assigns a content test on air quality in addition to the scores obtained from the symposium. Just as the REACH program is adaptable and flexible to teacher needs, so too is the symposium's ability to serve as an alternative assessment.

What additional benefits does the symposium provide to teachers and students?

At the end of the school year, students are asked to complete an evaluation survey. Designed by the REACH program's external evaluator, surveys include approximately 35 fixed-response or free-response questions to elicit responses regarding the program's impact on students' interest in science and science careers. Two survey questions—*What were the most important things you learned as a result of preparing for your presentation or poster this past school year?* and *What were the most important things you learned as a result of giving your presentation or poster today?*—provide valuable insight into the intended and unintended consequences of participation in the Symposium. To quantify the benefits of the symposia on student impact,



Student presentation.



Poster judge and student (above). Poster Session (right).

thematic analysis (Braun and Clarke 2006; Braun et al. 2019) was used by a panel of three REACH personnel and the program's external evaluator to identify patterns in students' free responses from survey data collected at the Symposia in 2014, 2015, 2016, and 2018 (Jones et al. 2022).

Four hundred and thirty student comments about preparing their poster or presentation and 425 comments from presenting their poster or presentation were analyzed. Eight themes emerged from the data, which are detailed in Table 1. Of the identified themes, the students reported most frequently that participation in a Symposium taught them skills regarding preparation and time management (27.6% from preparing their poster or presentation and 12.8% from presenting their poster or presentation) and taught them how to effectively speak and communicate science information (17.5% from preparing their poster or presentation and 52.2% from presenting their poster or presentation). In addition to new skills, students also reported new air quality knowledge gained from the experience, with 21.7% of responses indicating the knowledge gained from preparing their poster or presentation and 5.2% from presenting. Identifying the experience as challenging and positive were found in about a third of student responses (8.3% from preparing and 22.8% from presenting) (Jones et al. 2022).

What do teachers report about the value of the symposium?

To better understand the perceived impacts of REACH participation from the perspective of the teacher, the REACH team conducted interviews with 11 participating teachers in spring 2021. A full discussion of the teacher interviews was detailed in a recent manuscript (Taylor et al. 2021). The annual REACH Symposium was highlighted in responses by every interviewee. When asked what the most important aspect of the REACH program was, a teacher responded: "Number one is the air quality symposium—I think that's a stand out activity or aspect of the program that really isn't available in any other kind of situation." Another responded to the same question with "I think the accountability and presenting to a group of people who know what's going on; that's pretty huge—or being heard, having a valuable enough research project that's meaningful, valuable, and are able to produce and present that at the symposium is

TABLE 1

Themes in Student Comments About What They Learned from Preparing and Presenting Summaries of Their Air Quality Research Projects.

Theme	Description	Examples	Percent (%) of student comments
1) Design and conducting an experiment.	Students stated that they learned how to design, conduct, and explain an experiment or science research project.	How to clearly describe an experiment and its importance on the real world. It is important to have good data and to be able to accurately interpret this data.	11.0 % Preparing 3.0 % Presenting
2) Preparation and time management.	Students stated they learned that preparation and time management were instrumental in the success of their project.	Time management and communication is extremely important over long periods of time. A project that spans over a year goes by faster than you think.	27.6 % Preparing 12.8 % Presenting
3) Working with a group.	Students stated that working with and coordinating with a group of fellow students was important to the success of their project.	What it's like to work with a group when it's a challenge to get together. Working with your group collaboratively will help you succeed.	7.9 % Preparing 2.6 % Presenting
4) Air Quality knowledge and related information.	Students stated they gained new knowledge and appreciation of air quality and related environmental health science issues.	Air quality is important and I did not realize how relevant it was. Particulate matter is and can be a problem for health.	21.7 % Preparing 5.2 % Presenting
5) Nature of science.	Students stated they learned something about the nature of science as an evolving process.	You can't assume science. Experimenting is key. I learned that in all sciences conclusions lead to more questions.	3.2 % Preparing 0.9 % Presenting
6) Challenging, positive experience.	Students stated that the project was a challenging yet positive and rewarding experience.	Data gathering and sharing isn't as easy as it seems. To be proud of the time and effort I put into my project. If you don't try, you won't learn.	8.3 % Preparing 22.8 % Presenting
7) New Skill: Effective speaking and construction of poster or presentation (science communication).	Students stated they learned a new skill that involved effective speaking about or presenting their project including how to relax/not stress.	I learned that I could stand and be able to speak about something I had no knowledge on previously. How to portray my ideas to other people in a clean and organized way.	17.5 % Preparing 52.2 % Presenting
8) New Skill: Data management and/or analysis.	Students stated they learned a new skill that involved efficient and effective data management and analysis with the use of spreadsheets and graphing software. (Excel, Sheets)	How to manage data/change data to graphs. We learned how to statistically analyze data.	2.8 % Preparing 0.4 % Presenting

Note. N = 425 student comment classifications about preparing their presentation and 430 comment classifications about giving their presentation.

huge." Another teacher stated, "One of the things that I always found gratifying doing this program was after we would get back to class after the symposium, very few kids didn't think it was valuable to them. Doing something you are proud of—getting up in front of 200 people—you've got to have your ducks in a row. I think they were proud of what they did."

When asked if the REACH program has helped them as a teacher, several interviewees mentioned the symposium as an element of the program that has helped them be a better teacher. One teacher discussed the value of the symposium by stating, "You get to see a larger community. You better understand how other people are approaching challenges and overcoming them." Another teacher discussed the value for her students to present to the larger community, adding the importance of "getting feedback from other people besides me." Responding to a question regarding whether the REACH program has helped increase their students' interest, confidence, and aspirations for further learning in health science or environmental science, a teacher stated, "One of the unique aspects of the REACH program, maybe the most unique aspect, is this opportunity it gives kids to stand up in front of their peers and say 'this is what I did, this is why I did it, this is what I learned' and they have to defend what they did when their peers ask them questions. That doesn't happen very much in a high school setting. When kids realize they have to do that, they really invest." Another teacher speaking on the symposium said, "I have a lot of students who, before didn't want to talk or didn't want to speak and they have to talk into the microphone and have their presentation up on the big screen, I think it gave them confidence that they realized they really could do it. And that they had something to share—that they could do science themselves."

Conclusion

Students and teachers value the experience of the science symposia. Leveraging this value with the symposia's ability to serve as an alternative science assessment can provide students and teachers with a rich experience true to science in the real world. By presenting their own work and fielding questions from their peers as well as scientists, students gain far more than a letter grade and can showcase their knowledge of the content as well as the science practice skills they have refined. "Authentic assessment requires students to engage in discipline-based inquiry, to produce or apply knowledge, to value the experience beyond the classroom, and to produce a product or engage in a means of communicating their understandings" (Emery 2001). The science symposia celebrate the journey of scientific progress by valuing every step of learning along the way, not simply the recall of memorized and rehearsed content knowledge. As science teachers aim to fully integrate the *NGSS* in their practice, embracing opportunities for students to marry the necessary science content with the scientific process becomes critical. The science symposium, following a project-based research opportunity, provides this important culminating event. "Coupling practice with content gives the learning context, whereas practices alone are activities and content alone is memorization" (NGSS Lead States 2013).

Programs such as REACH can facilitate student research projects and ease the burden on the classroom teacher to incorporate scientific research in their classrooms. But participation in such a program is not necessary for a teacher to move toward a more engaging, relevant, and true-to-science experience for students. Incorporating small-scale research projects and requiring students to present their findings to their classmates in a mini symposium can provide an authentic experience for all. We are confident that the science symposium can serve as a substantive alternative assessment, providing opportunities for students to master content as well as build 21st-century skills. And, for teachers, the symposium can be equally rewarding: "Seeing my kids up there presenting their results in front of a lot of people and getting it done and feeling good about themselves afterwards was truly one of the highlights of my teaching career. I wish more teachers could experience it."

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