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Project Reports

Air Toxics Under The Big Sky – A High School Science Teaching Tool

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Abstract
A project has been developed between Big Sky High School and The University of Montana (UM) which has brought together high school students and teachers, university scientists, and county environmental health officials in a multilayered research experience focusing on the collection and analysis of specific air toxics, and investigating their relationship to respiratory diseases. The Air Toxics Under the Big Sky project allows students to benefit from an independent experience linking science, research, and local environmental issues. We see this as a long term project which will be built upon and expanded by future students during each new school year and as new schools are added. This project will foster a long-term scientific collaboration between UM and Montana high schools, and establishes high school students as valuable contributors to the scientific community while educating them about environmental issues.

Introduction
Over the past decade there has been a growing trend to change the way sciences (including chemistry) are taught at the K-12 level.[1-2] An increasing focus seen in the educational community is the shift to more inquiry-based lectures and laboratory experiences, including discussions on inquiry-based instruction in reference to teachers' knowledge and practices[3] providing insight into students' responses and opinions.[4-5] Laboratory exercises are being changed from 'cookbook' style preparatory experiments to 'guided inquiry' experiences.[6] Insight and evaluation of inquiry-type laboratory experiments have shown improvement in student's ability to ask more in-depth questions and to critically read scientific literature.[7] There has also been a successful implementation of research and socially relevant scientific topics into high school chemistry and science curricula.[8] In this fashion, we at Big Sky High School along with University of Montana (UM) scientists have implemented a project designed to involve high school students in a locally relevant environmental research problem relating to air quality. In 2003, a collaborative project was developed between scientists from UM's Center for Environmental Health Sciences (CEHS), UM's Department of Chemistry, and Big Sky High School in Missoula, Montana with the goal of incorporating a community based participatory research project into the curriculum of a high school chemistry class. The fundamental idea is that students will achieve a far greater interest and understanding of science principles through vested involvement within the research project, as opposed to just learning concepts from a book within the classroom.

Known as "Air Toxics Under the Big Sky," high school students collect indoor and outdoor air pollution samples from multiple households in various locations throughout western Montana in an effort to understand the environmental factors that potentially contribute to the exacerbation of respiratory conditions such as asthma. The pilot project with Big Sky High School in Missoula was conducted during the 2003/2004 school year, where a junior high school chemistry student organized a sampling program at the homes of 14 other students. During the 2004/2005 school year, two more high schools (Hellgate and Corvallis) and Salish Kootenai College joined the program bringing the total to 69 participating students throughout western Montana.

Research Methods

The program focuses on the collection of Volatile Organic Compounds (VOCs) inside and outside of the homes of the students. Several of the VOCs measured are emitted from gasoline-powered automobile exhaust, and are listed on the Environmental Protection Agency's (EPA's) list of 189 Hazardous Air Pollutants. The program begins early in the school year when a UM researcher goes to each of the participating schools and provides a presentation on air pollution, and why it is important to them as inhabitants of western Montana. Following the presentation the UM researcher provides training to the teacher and students on how to correctly operate the sample pumps and sample collection media. Sampling equipment was initially donated by UM, and later supplemented by equipment purchased through smaller grants received by Big Sky High School.

Before students begin the sampling in their homes, they must first take home a description of the study which includes a questionnaire. This questionnaire is used to elicit information on potential sources of air pollution in their households, as well as identify incidences of asthma and other respiratory diseases. After the questionnaire has been signed by the student's parent or guardian, the students can begin the sampling program. The students simultaneously collect both indoor and outdoor air samples at their individual residences. The air sampling equipment utilized in this program are personal sampling pumps (SKC Model Number 222-3) with reusable Supelco Carbotrap 300 sorbent tubes. Each site is sampled for twelve-hour periods with samples collected in fall and winter for a seasonal comparison. The students turn the pumps on at 7 AM, in which they operate for a 12-hour period until 7 PM, capturing the morning and evening rush hours. The samples are then analyzed in a UM laboratory by Thermal Desorption/Gas Chromatography/Mass Spectrometry (TD/GC/MS). After the samples have been analyzed, the UM researcher provides the results back to the high school students to allow them to interpret the raw data.

Students calculate the concentration of the target VOCs by using the TD/GC/MS results and the pump flow data to arrive at concentrations in ng/m^3. In the second semester, after students have had the opportunity to inspect their individual VOC results, the class breaks up into three or four groups. In these groups, students generate research questions using their VOC data. Using a consensus process, the student groups narrow down their questions and select one on which to propose a hypothesis for their group research projects.

At the end of the school year, a symposium is held at UM where the students present their findings to members from UM, State of Montana Health Department, and the Missoula City / County Health Department. As a public event to showcase student research, the symposium is an excellent platform for civic engagement and gives students experience in communicating scientific findings to the general public, their peers, and researchers. Following the symposium, all of the PowerPoint presentations and pictures from the event are posted on the Air Toxics Under the Big Sky websi te (www.umt .edu/cehs/k12_outreach.html).

Results

The Air Toxics Under the Big Sky project has several unique outcomes. From the standpoint of meeting high school science curriculum standards, participating students learn how air pollution episodes are measured and begin to understand the human health risks involved with acute and chronic exposures to air pollution. Students are also exposed to modern instrumentation and

sampling equipment. Having learned basic GC/MS theory within their high school chemistry class, students apply the instrument theory in order to investigate a relevant problem which alleviates the disconnect that students so often experience. Finally students have contact with active professional researchers at UM while studying a "real world" issue. These mentoring interactions can stimulate students to choose a science-oriented career path. From the perspective of an institution of higher learning, UM is promoting young students' involvement in primary investigative research: measuring the levels of VOCs inside the homes of Missoula school children. This project also fits in with the larger goals of UM-CEHS of studying the role of ambient and indoor air pollution in contributing to respiratory disease.

Given the multi-disciplinary nature of the project, teachers have flexibility in choosing a direction to complement their curriculum goals. For instance, a chemistry class might emphasize the instrumentation and analytical component, where as a biology or physiology class might emphasize the health component. For either scenario, the overriding goal of incorporating communitybased participatory research into the high school science experience is realized.

Discussion

One of the most rewarding parts of the project has been the long-term involvement of students and the development of meaningful peer-led learning opportunities among different grade levels.

During the 2004/2005 school year, three students at Big Sky, who had been involved as samplers during their junior year, took on the role of coordinating and running the day-to-day details of the sampling program as individual senior projects. Due to the workload, these more independent and intensive efforts are appropriate for use as seniors. Two of the three students are now freshmen at UM and are employed by CEHS to work on the laboratory component of the project. During the 2005/2006 school year, four students who participated as samplers during their junior year took on various aspects of the project as seniors. Two students managed the VOC sampling, one worked on a GPS/GIS component, and the fourth incorporated particulate matter sampling into the program under the supervision of a former Big Sky High School student, now an undergraduate intern at CEHS.

A multi-level assessment paradigm was used to assess student learning outcomes. The first level of classroom assessment for this program consists of standard exams and quizzes to check student knowledge and understanding of the basic principles of the science and techniques used for the research. A second level of evaluation consists of monitoring how well students work in groups to accomplish research tasks such as collecting, evaluating, and analyzing data. A rubric was used to evaluate student reports and classroom discussions about data collection and their ability to think critically and analyze their data. In a third level, students generated posters and gave oral presentations of their research and conclusions. This latter exercise prepares students for the rigors of a professional presentation, and provides students a forum to learn from their peers.

The Air Toxics Under the Big Sky project is multidisciplinary, multi-dimensional and multi-linear in its strategies and partnerships for enhancing science learning. Young students learn to apply science to their everyday lives. They experience what it feels like to be an active citizen and a useful resource within their community. In this way students are exposed to the ways and benefits of community-based participatory research during a formative part of their lives. Whether or not they eventually choose careers in environmental or biomedical sciences is beside the point. What they gain through the Air Toxics Under the Big Sky project is the growing sense of civic engagement and responsibility as they face the challenges of the future.

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