High Altitude Ballooning at an International Baccalaureate High School

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Curie Metropolitan High School's International Baccalaureate Middle Years Program (IB MYP) aims to provide students with the opportunity to show their understanding of physical and life science concepts, the nature of science and scientific inquiry processes, by applying these to solve real world problems. High altitude ballooning provides students with an exciting opportunity to design experiments and carry out scientific investigations in collaborative groups. Ballooning is well aligned with the aims and objectives of the IB MYP, such as the development of scientific inquiry, collaboration and communication skills and the appreciation of the relationship between science and technology. Five Curie students and their teacher participated in a five-week summer research program at DePaul University in 2011. Here we report on a follow-up mission we carried out in spring 2013, which involved 82 Curie students enrolled in three different IB MYP chemistry classes.

I. Introduction

The partnership between Curie Metropolitan High School and DePaul University began in the summer of 2011, when we collaborated on a 5-week summer research program for high school students in high altitude ballooning[1] (HAB). Five students from Curie participated in the program, along with seven students from two other high schools. Each student completed his or her own research project, and many of these were presented at the science fair. The speed of sound and ozone concentration projects of two of the Curie students (Wendy Vergara and Brenda Hernandez) even advanced to the Chicago Public School City Science Fair in 2012, were they both earned high marks. Participating in HAB helped Brenda, Wendy and the other students in the program gain problem solving, scientific writing and speaking skills that will be invaluable when they enter college in fall 2013.

The summer program provided the teachers with exciting new and technology-intensive ways to engage students in science. Students were able to develop their own experimental designs and collaborate with a university professor. In addition, HAB provides an ideal context for teaching the concepts and practices emphasized in the International Baccalaureate Middle Years Program[2] (IB MYP) chemistry curriculum. Thus, we decided to continue our partnership and plan a ballooning mission at Curie for spring 2013.

II. The IB MYP Chemistry Curriculum and High Altitude Ballooning

Curie High School's IB MYP chemistry curriculum is based on the American Chemical Society's *Chemistry in the Community* textbook[3]. It presents chemical concepts in the context of societal issues. At the end of each unit students apply their new knowledge in "Putting It All Together" projects (PIAT). In Unit 2 *Air: Designing Scientific Investigations* students learn about gas laws, kinetic molecular theory, atmospheric properties, air pollution and scientific inquiry. The IB MYP objectives provide learning outcomes and specify how students will be able to demonstrate proficiency. HAB projects naturally addresses many of these objectives, including *Communication in Science*, *Scientific Inquiry*, *Processing Data* and *Attitudes towards Science*.

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Communication in Science Objective
The IB MYP stresses that students need to be able to use scientific language correctly, use verbal, graphical and written modes to communicate their findings, and acknowledge the work of others. Similarly, the Next Generation Science Standards[4] emphasize that being able to communicate scientific ideas and information in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers, is crucial for developing scientific habits of mind. Students need to be able to recognize the major features of scientific writing and speaking, and implement them in their own work. In addition, students need to be able to critically evaluate and integrate information from books, papers, the Internet, and other sources. Without good communications skills, scientists cannot advance new discoveries and theories. Even for students who do not become scientists or engineers, the ability to communicate effectively and obtain and evaluate scientific information is an important component of scientific literacy, which helps them become more competent users of scientific information. In our ballooning project, students engaged in scientific communication in a variety of ways. They completed a laboratory report with a background section that was based, for example, on information they found in Paul Verhage's *Near Space* book and *Nuts and Volts* articles[5,6,7,8], the *Chemistry in the Community* textbook, and in scientific journals and periodicals. The students also viewed and discussed talks by master science communicators such as Neil deGrasse Tyson to prepare for their oral presentations to the class.

Scientific Inquiry Objective
The *Scientific Inquiry* objective requires students to state a research question, formulate a hypothesis, identify variables and controls, list materials, develop a method to collect and process data, and address the limitations of the experimental design. The NGSS also emphasize inquiry skills such as asking questions, planning and carrying out investigations, and constructing explanations. Providing students with opportunities to not just learn facts but also engage in inquiry helps them appreciate the processes by which scientific knowledge is generated. The students constructed research questions and experimental hypotheses that are supported by references based on their background research and the information in their laboratory report. They also identified variables and controls, listed materials, developed a method for collecting and processing data, and for addressing the limitations of their experimental design. In the following section we present an example of how the Scientific Inquiry objective was met in our project.

<u>Cosmic Radiation Experiment</u>
Research Question: *Which variables in Earth's atmosphere affect cosmic ray intensity, and how does it vary with altitude?*
Hypothesis: Cosmic ray intensity on earth's surface depends on the altitude where we live. Cosmic rays are absorbed by the atmosphere, so the higher the altitude the greater the cosmic ray intensity. We expect that this increase observed on Earth will continue to the burst altitude of the balloon. Therefore, we predict that the balloon will be exposed to very high amounts of cosmic rays at high altitude.

Variables & Control Table

Variables		**Units**	**Range**
Independent Variable	*Altitude of Balloon*	*m*	*200-21,000*
Dependent Variable	*Radiation Intensity*	*counts*	*10 counts per minute from ground level*
Controlled Variables (Constants)	*Size and position of hole in pod, type of sensor and data logger*	Possible effect(s) on measurements: *Size of hole could affect the number of cosmic rays that hit the sensor. Type of sensor/data logger could affect the number of cosmic rays that hit the sensor and what percentage of them is counted.*	Method for Control: *Use Vernier Technology for control and flight data collection. Make sure sensor is secure in the pod.*
Control	*Radiation Counts at ground level*		

Processing Data Objective

The IB MYP *Processing Data* objective indicates that students need to collect, process, and interpret sufficient qualitative and/or quantitative data to form valid conclusions. Students in our project met this objective by collecting large amounts of data with Vernier and HOBO data loggers. For example, students measured the speed and intensity of sound, sky brightness at different wavelengths, sun rays and cosmic ray intensity using a motion detector, sound level meter, light sensors, UVB and radiation detector connected to two Vernier LabQuest II sensor interfaces. The effect of color and different types of liquids on temperature was measured using eight temperature sensors connected to two HOBOs. After the flight students exported their data from the LabQuests and HOBOs into Excel for processing and analysis.

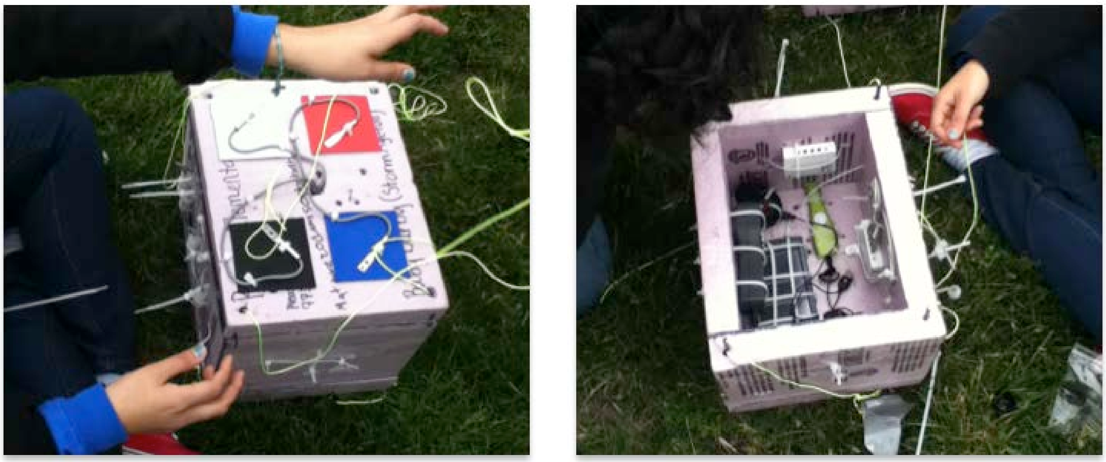

Figure 1: This pod (shown with and without the lid) contains three experiments based on a sound level meter connected to a LabQuest II, an MP3 player with internal speaker, eight temperature sensors connected to two HOBOs, four different colored vinyl pads, and four small plastic bottles with different liquids. The experiments are designed to test the effect of color and liquids on temperature change, and the effect of atmospheric pressure on sound intensity.

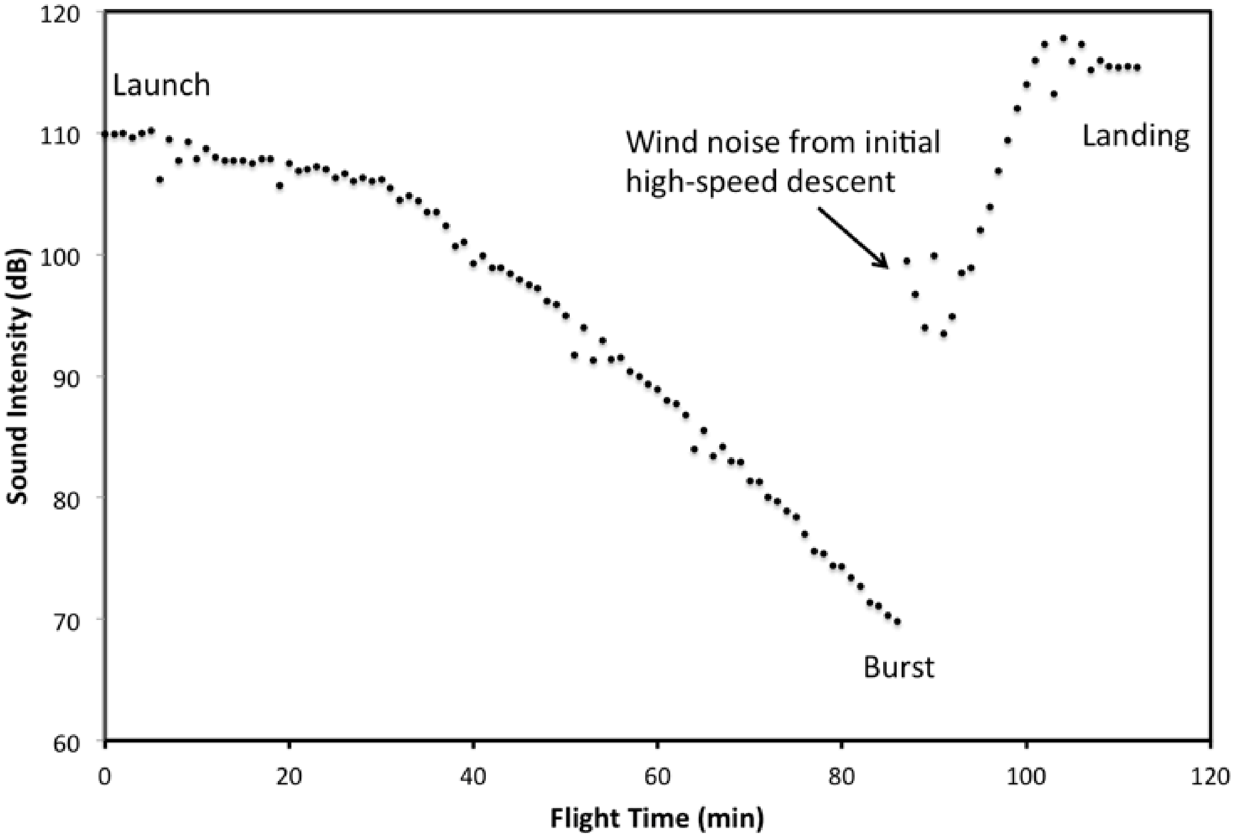

Figure 2: Sound intensity recorded by the Vernier sound level meter during the flight.

Attitudes towards Science Objective

The *Attitudes toward Science* objective stresses the importance of developing safe, responsible, and collaborative working practices and of working safely and responsibly with living things. When constructing their payloads students had to work safely and responsibly to minimize the risks of property damage and personal injury by following FAA regulations, and by constructing robust payloads that can survive the harsh conditions during the flight. They also had to consider this objective in their investigations of the effect of the conditions in near space on the behavior of living organisms (bacteria, crickets, Daphnia Magna, Soybean & Radish seeds, sea urchin eggs). The students worked in collaborative groups on background research, experimental design, pre- and post-launch experimental procedures, and on launch, chase and recovery.

Fig 3: The Curie team just before launch

III. Lessons Learned

Executing a high school HAB mission presented us with a number of unique challenges. First, there were many more students who wanted to build experiments than we could accommodate within the weight limit. We worked with three different chemistry classes at Curie, which resulted in 19 groups working on 15 potential flight experiments. In the future we will either limit the number of experiments to three per class by forming larger groups, or only include one class in the launch. Second, the logistics of launch day also proved to be difficult to manage. To ensure that students would be able to participate in the launch we scheduled our primary and secondary launch dates on school days. Unfortunately, weather and jet steam did not cooperate on either day. After asking other teachers to change their lesson schedules twice in order to accommodate students who would miss class because of the launch, we couldn't ask them to do it a third time, so we had to move the launch to a Saturday. This meant that a significant number of students were not able to attend. Purchasing helium turned out to be a third unexpected obstacle. Public schools in Chicago are only allowed to purchased products from vendors that are registered with the Chicago Public Schools. None of the helium vendors in Chicago are registered, so we had to purchase the helium using a personal credit card. As a result, the vendor was unwilling to allow us to rent the helium cylinders and return them after the flight. Instead, we were required to buy the cylinders. In addition, we were not allowed to store the helium at the school because of safety concerns. To avoid these complications in the future we will consider applying for grant funding through the university instead of using school funds to cover the cost of helium.

Conclusion

The High Altitude Ballooning Project provided teachers with a new and exciting way to teach science that met the IB MYP Chemistry curriculum goals and the Next Generation Science Standards. The HAB Project worked well to engage even the most challenging students. Students that initially had a low interest in the course were motivated to work in collaborative groups. Students came after school to work on the project and asked questions on *Edmodo* (a social learning platform for teachers, students, and parents) after school hours. During the launch students took video and pictures to share with their families and friends. The excitement was contagious, the administrators and other IB teachers showed high interest in the project.

We recommend that university ballooning groups interested in working with high schools should reach out to schools in their community by contacting the principal or science department chairs. We feel that any motivated science teacher could participate with his or her students as long as there is basic support from the university partner for payload design and flight operations. University partners should not get discouraged if teachers are initially uncomfortable with the idea of engaging students in balloon science because they feel that it is beyond their capabilities.

Acknowledgements

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