

Elementary and middle school student participation in high altitude ballooning: Teacher-student perspectives

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The Bemidji State University high altitude ballooning program has involved middle or elementary school students with high altitude flights since spring of 2013. A total of about 110 students from the Bemidji Middle School (BMS) and 20 elementary students from the Schoolcraft Learning Community (SLC) have participated in four flights over four years. Student projects were designed to help illustrate authentic science investigation and meet parts of the Minnesota State K-12 Science Standards.

One author made five visits to work with SLC students, introducing them to science and engineering fundamentals and payload/experiment construction. Elementary students participated in the launch activity but not the recovery. Two other authors coordinated activities with the BMS through one pre-launch visit—middle school faculty supervised the design and construction of the payloads. An example project involved sending up three types of beans for a controlled experiment. The students visited the BSU laboratory for final payload construction and review of launch protocols. The students participated and assisted in the launch and recovery activities

The post-activity feedback from students suggests: additional participation opportunities in HAB be made available including more involvement with BSU faculty, increasing direct student participation in the launch/recovery, and continuing the current program. Feedback from teachers suggests: modeling the launch activity in the classroom is beneficial, transportation funding is a critical issue, students were excited and engaged, multiple state learning standards were met, and middle school students' introduction to STEM activities at a university may potentially encourage them to pursue a STEM degree.

I. Introduction

Bemidji State University (BSU) introduced high altitude ballooning (HAB) to its first students in 2011, and shortly thereafter, expanded participation to the community by involving K-12 classrooms and area science centers. Through summer science workshops, regional elementary and secondary teachers have received an introduction to HAB and consequently, have enabled some of their students to contribute items and investigations to payloads of BSU's typical once-a-semester launch and recovery activities. In the Spring 2013 semester, two science teachers from Bemidji Middle School (BMS) teamed up with BSU faculty members to provide an opportunity for a select group of sixth, seventh, and eighth grade students to design investigations for, and participate in, a HAB launch-recovery experience. The following year, in Spring 2014, the two teachers, and some of the same students – a grade level higher – plus several new sixth grade students, again participated in another HAB launch-recovery effort. No collaboration occurred during the Spring 2015 semester, but the HAB launch partnership resumed once again in the Spring 2016 semester, with a returning teacher and one new teacher. Participating teachers and students shared their perspectives and provided feedback about the activities, which is discussed herein.

During the Fall 2014 semester, a BSU faculty member initiated a HAB partnership with a fifth-grade group of students and their teacher at the Schoolcraft Learning Center (SLC) in Bemidji. Twenty fifth-grade elementary

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students learned about the science related to HAB and participated in the payload design and launch; given time constraints, they were unable to share in the recovery effort (since the bus had to return for after-school activities). The BSU faculty member made five visits to the elementary classroom to introduce topics, teach launch procedures, and share video and data from the HAB experience with students.



Figure 1. Payload box with items selected and contributed by students McGregor Elementary School.

II. HAB at BSU

We initiated high altitude ballooning at Bemidji State University in Fall Semester of 2011 and we have maintained our goal of completing a HAB activity once per semester. In addition, we have completed launch/recovery activities during the summer as a component of summer courses or workshops focusing on continuing education for primary and secondary school teachers or through the Headwaters Science Center in Bemidji. Our HAB activities during the academic year have consistently focused on teaching elements of project design and construction with pre-service teachers (both elementary education and secondary science education students). Some of our work with the secondary science education students has been the subject of a previous report (Kroeger and others, 2014 [1]; Kroeger and others, 2013 [2]; Urban and Kroeger, 2014 [3]). We have maintained a collaboration with Central Lakes College (a 2-year community college) and their students have also contributed payloads to our HAB activities. Primary funding for our HAB activities is through the Minnesota Space Grant Consortium; additional funding through the Northwest Service Cooperative and Hamline University TIMES Project have also been used to support the in-service teacher workshop activities.

A. Preparation with BMS

Students and faculty from the Bemidji Middle School participated in three HAB activities (Spring of 2013, 2014, and 2016) as a “HAB Club” extracurricular activity. One of the BSU faculty members would introduce the fundamental components of HAB to the HAB Club in one or more after-school sessions several weeks before the scheduled launch. During these sessions the students were introduced to the capabilities and limitations of the balloon and payloads, the telemetry systems, the flight prediction software, and the types of environmental data that

would be available to them from the on-board sensors. Depending on the payload space available, the HAB club teams were allotted one or two payload boxes for their experiments. Student payload teams then asked questions about the design or feasibility of the experiments they were considering including in their payloads. After the teams completed design and construction of their experiments under the supervision of the middle school teacher(s), they completed the final payload construction and reviewed their launch responsibilities at one of the BSU laboratories, typically the afternoon prior to the launch. Launch activities took place during the school week—parents were notified that the students might not return to the middle school by the normal dismissal time. Primary launch procedures were completed by the college and university faculty and BSU’s and CLC’s student HAB teams—each of the college and university teams described their HAB experiments to the middle school students as the balloon was being inflated. Once the middle school payload boxes were attached to the payload string, the middle school students were primarily (impatient) observers.

B. Preparation, Project Design, and Participation with SLC

Twenty fifth-grade students from the Schoolcraft Learning Community participated in one HAB experience during the Fall 2014 semester. Over a period of about five weeks, one BSU faculty member traveled to the school and provided a one-hour lesson each week to students. The five lessons consisted of topics related to atmospheric science (e.g., atmospheric pressure and temperature trends, gas composition of the atmosphere, surface pressure from overlying mass of gases), the science of how high altitude ballooning works (e.g., buoyancy of helium gas balloons and necessary lift to transport an average of 10 pounds of payload), basic concepts related to how data is sent from the command module and backup systems aloft to the ground, general launch preparation and recovery procedures (e.g., ground set-up, inflating the balloon, attachment of payloads), design of investigations to be included in the payloads, and afterward, sharing videos, data, and investigation results from the launch/recovery. One in-class activity consisted of groups of two or three students performing a test launch with party balloons (filled with helium) and tethered (with string) payloads of paper clips, cardstock squares (about 2 cm x 2 cm), and other lightweight materials to simulate and model the HAB components and launch processes. The activity included a countdown and calculation of ascent rate to the ceiling, which the teacher then (after the BSU faculty member left) had students graph, determine an average for, and discuss in comparison to the approximate 1200 foot/minute ascent of a typical BSU HAB. In this way, the classroom teacher utilized several of the BSU faculty member’s presentations to springboard into follow-up lessons to meet curricular needs and specific benchmarks of the *Minnesota Academic Standards* in Science, Math, and even Social Studies [4].

Throughout the various lessons with the BSU faculty member, students were asked to problem-solve, make predictions, participate in activities (e.g., can crush, pressure at different depths in a column of water), analyze results, and construct explanations or conclusions. The culminating activity prior to launch involved students’ coming up with investigations to include in payloads for BSU’s Fall HAB launch in October (during a school day). Example investigations included: 1) sending up a calculator in a payload box to see how it would handle the cold temperatures and low pressures aloft; 2) sending up radish seeds both inside and outside the box; 3) including ingredients for S’Mores (i.e., graham cracker, marshmallow, and chocolate bar); and 4) inflating several different sized (ranging approximately from 4-8 inches in diameter) of party balloons and attaching them to the outside of the HAB materials. Students were guided to consider variables and controls of their ideas for investigations, and eventually the class as a whole came to a consensus on which of their numerous ideas would be used due to limited available space in payload boxes. For the calculator investigation, tests of performance were conducted before sending it up; classroom temperature was recorded and approximate surface pressure determined; and a control calculator of same model and make remained in the classroom. A control packet of the same radish seeds remained on the ground. The S’Mores ingredients provided an informal qualitative way for students to gauge the degree of jostling during the flight (as graham crackers break apart) and conditions inside the box (marshmallows and chocolate bar could expand, melt, freeze). The party balloon investigation allowed students to concretely observe any changes in pressure, since a video camera filmed the balloons during the ascent, and students could note the size changes of different balloons. The teacher handled all logistical communication with parents, and nineteen of the twenty students participated in the HAB launch. The students observed and helped minimally with the various stages of on-site pre-launch setup. Due to the length of the overall trip (travel to launch site; set-up; follow-along and tracking of balloon in flight), the school bus with students and teacher needed to turn back before recovery to arrive back to school at a pre-arranged time.

II. Teacher Feedback

A. Middle School (BMS)

During the late spring of 2016, one BMS teacher who participated in all three launches provided his written thoughts about the HAB program and collaborative relationship with BSU. From the teacher's comments, a few important pieces of relevant information were identified: 1) the partnership should continue, though perhaps should involve, or emphasize, other classes; 2) funding for transportation is a challenge (lack of transportation funding prohibited BMS participation in HAB in Spring of 2015); 3) the collaboration provides a good after school opportunity for students; 4) students are interested in having more meetings (with university faculty) to delve deeper into the science of HAB and investigative processes; 5) students are interested in taking on a more "active role" in the set-up, launch, and recovery aspects of HAB.

The activity lead teacher at BMS is a life science instructor. He indicated that instead of life science, perhaps earth science or STEM may be a better fit given the topics that can be covered through HAB (e.g., meteorology). After speaking with the STEM elective course instructors, there is evidently interest in having the STEM course collaborate with BSU on future HAB launches. Since the university's goal for HAB is to tie it more specifically to STEM, the teacher felt involving the BMS STEM course could be beneficial. A teacher-identified challenge for BMS is funding expensive transportation costs associated with bussing groups of students to destinations for the HAB launch and recovery activities. Given Bemidji's location, and the desire to avoid our payloads landing in the vast forests or numerous lakes in the region, university faculty typically identify potential recovery zones based on ideal recovery conditions (e.g., agricultural areas with reasonable road access) and a probable flight path based on winds, and then work backwards to select an appropriate launch site. This often requires traveling 70-100 miles to the west of Bemidji. Combined with the ground track of the balloon while in flight, and the return trip to the BMS, this can result in considerable mileage for transportation (and usually requires 6-8 hours of total trip time). During the first two of three HAB launch/recoveries in 2013 and 2014, BMS paid for transportation costs; for the 2016 trip, BSU through MN Space Grant funding, covered bussing costs. In the comments shared by the teacher in conversations with middle school students, the students would like to have more instruction about how HAB works (e.g., mechanics of balloon launching, tracking, and recovery) and scientific investigative processes (e.g., methods of data collection). Additionally, the students are interested in becoming more active participants in the set-up, launch, and recovery activities themselves.



Figure 2. Students from BMS going out to retrieve downed payload materials.

B. Elementary School (SLC)

One of the BSU faculty members interviewed the elementary teacher from SLC whose class of students participated in a Fall 2014 HAB launch. The shared responses highlight important and useful information: 1) elementary student engagement was very high during the HAB preparation and launch activities; 2) several multidisciplinary MN science standards were able to be addressed through participation; 3) scientific methods and processes (i.e., inquiry) were practiced through designing investigation/project ideas; 4) the overall experience of participating in HAB was positive and memorable (and will likely stay with them for a long time).

The teacher stated that “kids were enthusiastic” and eager for the days when the BSU faculty member would arrive to present lessons and teach about HAB. The teacher indicated that the activities provided good hands-on opportunities for students to learn topics and integrate other science disciplines. Specifically, the teacher’s comments suggested that the topical approach taken with lessons (e.g., “What is air?”), classroom demonstrations like the can crush activity, stepwise approach to the HAB process, and identification of relevant vocabulary kept students engaged and interested. The teacher felt that the activities related to HAB, and the HAB participation opportunity itself, was appropriate for the upper grade elementary students, saying [paraphrased] “the kids can understand it, bring background knowledge to the experience...[and] come up with creative ideas for their payloads.” The teacher particularly emphasized the value of the party balloon in-class simulated launch, and was “pleasantly surprised” at the students’ excitement about that aspect. Although specific benchmarks and standards were not identified, the teacher stated that through HAB participation a number of MN state standards were covered. The teacher noted that allowing students to ride in the bus, with the balloon overhead, observing the flight path real-time through wireless internet access (on the bus) and utilization of the APRS.fi website, helped students understand that even though the balloon was out of site, it was still being tracked. The teacher and students planted the different groups of radish seeds (i.e., control, inside and outside box samples) and the students collected data about the growth, analyzing for differences, which worked well as a long-term project, offering a means to further inquiry and scientific investigation even after the HAB experience ended. Given the novelty and student involvement opportunities provided by HAB, the teacher felt the experience was memorable and would stick with the kids for a long time.



Figure 3. Students from SLC helping with inflation of the balloon prior to launch.

III. Student Feedback

The lead teacher at BMS solicited feedback from student participants in the March-April 2016 HAB experience through a five-question survey. Several of the questions (1, 2, and 3) were used to inform the teacher's understanding of what students may have learned through the scientific investigations included in the HAB payloads; while other questions could be used to determine a sense of efficacy for the HAB experience (question 4) and future potential avenues of study (question 5). Between four and seven responses were obtained on each survey question. The survey questions have been identified below, and summarized responses (grouped into similar categories) to questions 1, 4, and 5 are also provided as the most relevant to the topic of this paper.

A. Survey questions

1. What was your experiment?
2. What were the results of your experiment?
3. What would you have done differently to improve your experiment?
4. What did you enjoy the most about the High Altitude Balloon Adventure?
5. What are other experiments that you would like to try next year?

B. Student Responses

Several different experiment ideas were advanced for including in the payloads of the Spring 2016 HAB launch: 1) two groups of three different bean types (with control group on the ground), one inside the box and one outside, to be planted and grown upon return to the class; 2) a marshmallow, to see how pressure would affect it; 3) a container of hydrogen peroxide, to see if it would turn into water; 4) send a corn plant and sunflower plant into the upper atmosphere to see how conditions would affect them; 5) send up water balloons to see if and when they would explode; 6) send up raw eggs (farm fresh and store-obtained) to see what would happen (which might burst first). Some potential experiments (e.g. water balloons) were excluded to eliminate potential damage to sensors and other equipment. The student comments in response to question 4, about what they enjoyed, was particularly relevant, and included: "the launch and the retrieval," "the bus ride and when we saw it landed in the lake," "I was...excited because I got to tell people that it [HAB and payloads] went up into space," and "everything!". Of the responses to the final question, the most salient related to involving students more in the setup procedures of HAB, providing more time to plan what to include in the payloads, having more meetings, and including more student participants.

[No data was collected directly from SLC students, only those anecdotal comments from the teacher already shared in previous sections of the paper.]

IV. Conclusions

HAB at BSU has involved elementary and middle school participants at local schools for several years. Feedback collected from two teachers, one new to student launches with HAB and one veteran of several launches with students, has highlighted many benefits of these collaborative ventures and also provided insight into some of the challenges. According to the teachers, HAB is engaging and interesting for students, providing a way for students to learn and apply STEM meaningfully, while potentially meeting MN academic standards. Funding for transportation is a critical challenge for continued BMS participation in HAB with BSU. Feedback collected from several middle school students who participated in the most recent HAB launch activity at BSU revealed interest in involving them more heavily in the actual on-site setup and launch/recovery procedures and a desire to devote more time to planning investigations for inclusion in payloads. The authentic science experiences excite and motivate many students, evidenced by self-reported survey responses indicating positive feelings and an interest in expanding their involvement and contributions to the HAB activities.

Our take-aways focus on accommodating the schools through flexibility in scheduling launch activities to encourage additional participation, providing more opportunities to gather with students to teach about the science and mechanics of HAB, and possibly offering sustainable funding for transportation (through MN Space Grant or other grant initiatives). We recognize the importance of continued collaborative involvement with local schools, because introducing students to positive and engaging STEM activities may potentially encourage them to someday pursue STEM degrees.

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