Application of High Altitude Ballooning Activity in a Course for Pre-Service Science Teachers

Timothy J. Kroeger[1]
Bemidji State University, Bemidji, Minnesota, 56601

John Truedson[2], Cooper Blackwood[3], Brianna Fuller[3], Alexander Hendrick[3], Heather Irwin[3], Michelle Jipson[3], Patrick LaBelle[3], Jed Swensen[3]

Abstract: Professional Education students seeking licensure in a middle school or secondary science discipline at Bemidji State University must complete "Integrative Science for Teachers", an interdisciplinary, junior-level course that includes investigative components in Earth Sciences and Physics. High altitude ballooning activities were introduced into this class in the Spring Semester of 2012 have been included annually since then. Student teams designed experiments and payloads to collect the required data; launch/recovery was completed on a class weekday. Student teams presented the results of their experiments at a campus-wide academic conference. As currently implemented, the project is introduced at the beginning of the semester and continues throughout the semester. About eight 2-hour class sessions are devoted to the project plus a full day for launch recovery operations. Only one of seven students had previously participated in a ballooning activity and none were previously involved in designing ballooning experiments. Six of seven students identified the ballooning activity as very appropriate given the multidisciplinary aspect of the class; most students felt fully engaged by the project, especially with the payload design component. About 40 middle school students participated in launch activities providing a unique mentoring experience for the course's students. Challenges include: maintaining engagement throughout an extended project; arranging group work outside of regular class time, meeting specific deadlines for completion of project components, ensuring that adequate post-launch time is available to complete data analysis and prepare oral or poster presentations, and ensuring that adequate class time is available to accomplish other course learning outcomes.

Introduction: Bemidji State University (BSU) originated in the early 20th century as a teacher-training institution. Ninety five years later, professional education remains an important component of BSU's academic programs. Minnesota administrative rules for teachers of science at middle and secondary school levels must gain a broad science background that includes Life Science, Chemistry, Physical Science, and Geoscience; students seeking secondary science licensure must also meet specific subject area requirements. Additionally, the rules require that students gain the ability to make conceptual connections between domains of science [1]. When the "Integrative Science for Teachers" class (SCI 3100) was developed (in 1998), one of the course's objectives was to meet this multidisciplinary requirement. In the intervening years the

[1]Center for Environmental, Economic, Earth, and Space Studies, #27, 1500 Birchmont Dr. NE, Bemidji MN 56601; tkroeger@bemidjistate.edu
[2]Department of Physics, #27, 1500 Birchmont Dr. NE, Bemidji MN 56601
[3]Professional Education Program, #35, 1500 Birchmont Dr. NE, Bemidji MN 56601

course has been changed to present more content material in physics, and Earth and space science, but the multidisciplinary component has been retained. High altitude ballooning (HAB) activities were introduced into the course in 2012 as a learning activity that allowed students to design, test, and fly experiments that necessarily cross traditional boundaries between science disciplines.

Focus of Learning Competencies for HAB project. Our application of HAB within the course focuses on satisfying several learning competencies for teachers of science specified by Minnesota Administrative Rules, 8710.4750 [1]**.** Learning competencies addressed include:

- Several competencies focused on understanding and conducting science inquiry, including development of science questions, experimental design, data acquisition and evaluation, interpretation of data, and critical evaluation.
- Development of an understanding of interconnections between the domains of science and connections between science and technology.
- Understanding and evaluation of sources of error.

Structure of the assignment activity: Of the seven students enrolled in the class, six had no prior HAB experiences; the other student had participated in a previous BSU launch activity as a member of a Science Teaching Methods class. The HAB activity is introduced in the class during the first week of the class (typically offered during Spring Semester). Basic information on our HAB capabilities are provided, students are allowed to self-select teams of two or three, and the teams are given the opportunity to share their thoughts about potential experiments and their design. Student teams are given about a month to develop a final structured proposal for their experiment. During the project planning and development period, weekly classroom time is made available for critical analysis of each team's prospective proposal although non-HAB course activities continue, largely focused on physical science laboratory projects. Final proposals of the experiments are required to include lists of required materials so that appropriate purchases can be made in a timely fashion. The target date for the launch activity was the third week of March; deadlines were established for specific steps in the experimental design and construction to help to ensure that the student projects were ready to launch on time.

The experiments proposed by the Spring 2014 class included: evaluation of ultraviolet light intensities during the launch and comparing the intensities to typical human environmental ultraviolet exposures, development of an Arduino microprocessor-sensor array to collect altitude and ultraviolet intensity data and operate a servo motor to open and close a sampling port on the payload box at specified altitudes, evaluation of survivability of yeast and bacteria to high altitude exposure, and sampling for atmospheric particles a specified altitudes through the Arduino-operated sampling port.

All students participated, during class time, in the final stages of launch preparation including equipment inspection and packing, communications testing, flight prediction, etc. The launch activity was held on a regular class day—students were expected to be able to devote the full day to launch-recovery operations. Spring flight tracks are typically southeasterly requiring significant travel to the launch site to avoid recovery sites within large tracts of forest or peatland. The spring 2014 launch was completed on March 20th from Red Lake Falls, Minnesota; the flight attained a maximum altitude of 29,880 meters and traveled about 50 kilometers east-southeasterly from the launch site where it was recovered from agricultural land.

A ballooning team from Central Lake College in Brainerd, under the direction of David Kobilka and Yoshi Hirai, also contributed to the launch activity; the BSU and Central Lakes College teams had the opportunity to discuss their experimental objectives prior to the launch. About 40 Bemidji Middle School students, under supervision of Mark Studer and Kyle McMartin, also contributed to preparation of a payload box and attended the launch activity. The BSU Professional Education students had limited opportunity to interact with the middle school students during the launch activity.

Each team was required to prepare an abstract describing their experimental proposal for submission to Bemidji State University's annual Student Scholarship and Creative Achievement Conference. Since the deadline for abstract submission occurred before we were able to complete the launch activity; the student abstracts focused on the goals, design, and expected results of their experiments. Student teams had the option of oral or poster presentations at the Achievement Conference. Each student team also prepared a final written report on their project for evaluation by the course instructors.

Conclusions: Challenges Recognized Through Implementing HAB Activity. The HAB activity consumed about 30% of the class time during the semester (including the full day launch activity). This extensive amount of time required modification of the course syllabus by reducing time devoted to other content areas or student projects. Students stayed strongly engaged in the project throughout the experimental design and construction phase. Because some student experiments were essentially completed and ready to fly while other experiments were still being assembled, for some students engagement appeared to wane as the launch date approached. Other experiments did not have time for adequate testing prior to the launch date. Since the post-flight data evaluation and reporting portion of the project occured primarily during the last month of the semester, students had difficulties finding adequate time to thoroughly evaluate their team's data and prepare presentations and reports. Students expressed concerns about the difficulties of arranging out-of-class meeting times given their family, class, and work schedules. March weather in northern Minnesota provides its own special challenges; in this case the launch date was postponed two days due to adverse weather conditions. Several students expressed concern about the difficulties in making up other class activities due to their absence from campus for most of a class day on the day of the launch. Students also expressed a desire to have more opportunities to work with the middle school student participants. They suggested that the BSU Professional Education students share space on the middle school student bus so that they would have more time to explain the HAB activity to the middle school students.

Although the launch/recovery activity was successful, data collection for some of the student experiments failed. Inadequate time remained in the course after the launch activity was completed to revisit the experimental design and construction.

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List of References

"Minnesota Administrative Rules, 8710-4750, Teachers of Science" Office of the Revisor of Statutes, https://www.revisor.mn.gov/rules/?id=8710.4750