

# **Application of a Solar Balloon Activity in a Course for Pre-Service Elementary Education Teachers**

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Education students seeking licensure at the elementary school level at St. Catherine University, must complete three hands-on, inquiry based science courses including “Engineering in Your World,” an applied physics course which emphasizes use of the Engineering Design Process. During the Fall 2013 and Spring 2014 Semesters, high altitude ballooning (HAB) was introduced into the course. Student teams built payload boxes to collect experimental data and participated in a weekend launch that included chase and recovery. Although students enjoyed the activity, the equipment and knowledge threshold is too high for these students to use HAB activities in their own future elementary education classrooms. In an effort to provide our students with a ballooning experience that they could use in their classrooms, solar balloons were introduced in the Fall 2014 Semester courses. In this activity, students applied the physics concepts of forces and buoyancy to build and launch solar balloons to meet design objectives. The use of low cost construction materials and simple construction techniques makes this ballooning activity accessible and usable in elementary and middle school classrooms.

## **I. Introduction**

St. Catherine University offers multiple initial teacher licensure programs the largest of which is an elementary education (K-6) Kindergarten – sixth grade licensure program taught in both the traditional day student program and in the Evening/Weekend/Online (EWO) program. All elementary education majors at St. Catherine University are required to complete a three-course STEM certificate that includes Chemistry of Life, Environmental Biology, and Engineering in Your World. Each course focuses on one core science discipline (chemistry, biology or physics) and teaches content using a hands-on, discovery learning, lab-based curriculum that integrates substantial student work and problem solving. These courses are aligned with both Minnesota and national teacher preparation standards and address the Minnesota Academic Standards in Science that incorporate an increased focus on engineering. All STEM certificate courses are team-taught by science and education professors to fully encompass the need to deliver science content as well as pedagogical knowledge to our students to adequately and appropriately prepare them to teach science content to elementary school students.

## **II. Physics 1200 – Engineering in Your World**

The Engineering In Your World course uses a hands on, inquiry based approach to teach physics and engineering concepts to elementary education undergraduates and graduate students working towards initial licensure. The iterative and open-ended nature of the engineering design process is emphasized during all project based learning assignments and activities. Physics content is chosen to address specific standards at both state and national levels, and project work directly applies the physics content using materials and approaches appropriate in the pre-service teachers’ future classrooms.

HAB was first introduced into the Engineering in Your World course during the 2013 fall term, an Evening/Weekend/Online course (EWO). EWO courses are designed for non-traditional or non-day students. These courses typically meet once every two weeks for either one evening or for one-half a weekend day. During

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the weeks when there is not a face-to-face session scheduled, students are required to complete and document substantial independent work.

HAB was introduced into the course to give students an opportunity to apply classroom based content work using Boyle's Law and the ideal gas law, to ballooning applications. Additional class time was devoted to understanding the layers of the atmosphere and how temperature and pressure changes in these layers through which high altitude balloons ascend. Technology included using an online flight prediction program and tracking the balloon during the actual flight using APRS.FI (Automatic Packet Recording Systems). Post flight data including temperature, pressure and altitude was given to the students for data analysis and graphing. Students also plotted Global Positioning System (GPS) data on Google Earth. Because the actual launch had to be conducted during a non-class meeting weekend, it was not reasonable to expect the students to attend the launch. As a result, only two students participated in the actual launch and recovery. Although all students increased their knowledge of atmospheric science and gained experience working with real life data, the lack of real-time participation by the other students with the launch and recovery means these students gained none of the necessary hands-on experience they would need to conduct their own future launch and recovery operations. Payload boxes were not actually built by the students due to the limited face-to-face time of EWO format classes, but instead by members of the St. Kate's ballooning team. None of the students enrolled in the class had previous HAB experience.



**Figure 1. St. Catherine University students assisting with HAB inflation.**

To improve on student learning, a different HAB experience was created for the spring 2014 Engineering in Your World class, a traditional lab/lecture integrated day format class. Because this class meets two times per week, it was reasonable to devote several class periods to developing experiments and creating payload boxes, and by cancelling a class period, to require student participation in the weekend launch and recovery operations. The class of 18 students was divided into three groups which each built a payload box. Team 1 built a box with two cameras,

an outward facing Go-Pro to watch “Super Hero Erick” in flight, and an upward facing Flip camera to monitor the size of the ascending balloon. Team 2 built a payload box with four temperature sensors each mounted in a different corner of a four-color grid to measure how color affects temperature measurements. Team 3 built a box with a full sensor suite including pressure and humidity sensors, a Geiger counter and several temperature sensors mounted at different heights across the all white payload box to measure the thermal wake effect of the box itself.

Students were required to attend and to participate in a Sunday HAB launch and recovery. Students participated by completing pre-launch flight path predictions and by supporting the flight crew on the launch line with final preparations including tests of the tracking equipment and filling the balloon. Many students helped with tracking by using their smart phones. The majority of students fully participated in the launch and recovery operations and they were particularly excited by the camera data that clearly showed their super hero model passing through the cloud layer and being covered with ice crystals and then melting above the clouds. The sensor data, temperature, pressure and humidity, gathered during the launch, was cleaned up and given to the students for analysis but the amount of data and the time needed to complete the analysis turned out to be beyond the time and knowledge limits of most of the students. Final data analysis was completed by a class instructor and presented to the students.

### **III. Challenges of HAB Implementation**

Adding the specific content knowledge required to adequately address HAB and to build payload boxes for experiments, took up a significant amount of class time, approximately three full class periods, and an additional excused class period as make-up for the required Sunday launch. Students were engaged when actually building the payload boxes but engagement was lost when they began connecting the sensors, as the groups were too large for all students to participate. Some teams finished earlier than others resulting in down time for a portion of the class. Because of limited class time, adequate equipment testing was not completed resulting in data collection errors on flight day. The post flight data analysis was unfortunately crammed into the last week of the semester so students did not have the time they needed to do an adequate job. Students expressed concerns about a required class meeting that was not a regular class period as it was difficult for many of the students to rearrange work and family commitments. When students were asked if they would consider trying HAB in their future classrooms the overwhelming response was that the equipment and knowledge threshold was too high for them to implement such an activity without significant outside support.

An underlying goal of the STEM certificate classes is to give pre-licensure education students content specific knowledge in the core science disciplines that aligns with Minnesota and national science standards, and to demonstrate hands-on and inquiry based teaching methods and activities that are suitable and usable in their classrooms. Although HAB activities met content, knowledge and hands-on goals, many students felt the activity was not suitable for their own future classrooms. In an effort to continue with ballooning as an activity to study equilibrium, buoyancy, and gas laws, and to provide a foundation for possible exploration and use of HABs, solar balloons were introduced as an activity in both the traditional and EWO sections of Engineering in Your World in the 2014 fall semester session.

### **IV. Solar Balloons**

Solar Balloons, also known to as zero pressure balloons, can be easily and cheaply constructed using 0.5 mil black plastic trash bags and masking tape, thereby providing a hands-on ballooning experience with a lower cost and equipment entry threshold. Because solar balloons can be easily, quickly, and cheaply constructed, students have the opportunity to build and test several different balloon designs based on their research and on their personal designs. This process emphasizes the iterative nature of engineering design as part of the ballooning project. Students were able to test different balloon sizes and shapes, methods of inflation, and weather conditions on multiple days to learn how different levels of input factors or variables affected the lift of their balloons. Using this iterative design process combined with calculations of lift based on balloon size and temperature measures, all student teams successfully designed a solar balloon to fly an egg during a tethered balloon flight. The use of inexpensive materials and simple construction techniques allowed students to work in small teams of two or three students, thereby increasing the hands on participation of students. The connections between flight success and input variables were very obvious to student teams. At the end of the activity, all students were able to describe how the same buoyancy and equilibrium concepts that they understood to explain how objects float on and in water, applied to larger and lighter objects floating in a less dense medium, air.

What solar balloons offer pre-licensure education students is an introductory ballooning experience that meets specific content and knowledge goals of STEM certificate classes, but as stated earlier, these balloons were flown

tethered and at low altitude. What solar balloons cannot offer is the opportunity to conduct experiments in near space, the excitement of working in near space, and the content knowledge of tracking a balloon as it ascends and then descends through the layers of the atmosphere. These are very clear limitations of the solar balloon experience. However, as a low cost, hands on ballooning experience, solar balloons met the learning objectives of the Engineering in Your World course and gave students an opportunity to discover the world of HAB, and to think about what HAB could offer as a hands-on experience in their own future classrooms.



**Figure 2. Engineering in Your World day student flying an egg using a solar balloon.**

## **V. Conclusion**

Ballooning has been used as an activity in three semesters of Engineering in Your World courses at St. Catherine University. Although HAB successfully taught the desired physics content of equilibrium, forces, and buoyancy using the hands-on, inquiry based approach of the STEM certificate courses, the knowledge and equipment threshold is too high for most pre-licensure students to consider using HAB in their future classrooms. In an effort to continue using ballooning to teach equilibrium, forces, and buoyancy content but with a lower entry threshold, solar or zero pressure balloons were introduced as an engineering design activity in the Fall 2014 term. Small student teams of two or three students used an iterative engineering design process to build and test multiple low cost solar balloons, using 0.5 mil trash bags and masking tape with the design objective to fly an egg during a tethered balloon flight. All student teams were successful and follow up summative assessment indicated students grasped the physics and atmospheric science concepts. Students also indicated this experience may lead to use of solar ballooning in their future elementary school classrooms as appropriate to meet grade level standards.

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