"High Altitude Ballooning: An Opportunity to take STEM Education Higher in the Secondary Classroom"

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On March 5-6, 2011, a High Altitude Balloon (HAB) Workshop for high school science teachers was held at the Grout Museum District (GMD) in Waterloo, Iowa as part of an Iowa Space Grant Consortium (ISGC) grant-funded collaboration between the GMD and Iowa State University's (ISU's) Space Systems and Control Laboratory (SSCL) High Altitude Balloon Experiments in Technology (HABET) group. The workshop served as a starting point for a new HAB program to be offered through the museum to area schools and teachers and was eligible for continuing education graduate credit for the participants. HAB platforms are ideal for providing research and educational experiences for students in science, technology, engineering, and mathematics (STEM) disciplines. The workshop is used to illustrate the education of teaching staff and the future possibilities and plans for HAB education in the secondary classroom in Iowa.

I. Introduction

Due to an aging technological workforce and dwindling student interest[1-2] in STEM professional fields[3], there has been a strong push to enhance STEM education in classrooms at all levels. By providing students with exciting hands-on experiences to stimulate their interest, educators can succeed in attaining this goal. "Space" science and aerospace-related disciplines are at a great advantage in this area due to the potential high impact of aerospace activities, such as HAB.

High Altitude Ballooning provides a valuable experience for students, not just in science, but also in engineering, technology, and mathematics, making it a rare opportunity to incorporate all areas of STEM into an educational curriculum. The topics and difficulty levels, as will be discussed later, that may be used with HAB are very flexible, making it an ideal tool in the classroom. However, the technology and engineering associated with using HAB can be intimidating for the first-time or novice user. As a result of this, the GMD, through funding from the Iowa Space Grant Consortium, has started a new HAB program aimed at helping to educate and train formal classroom educators in order to help them utilize HAB to enrich STEM education in their classrooms.

Informal education, such as that offered by the GMD, provides a unique opportunity to enhance inquiry-based, hands-on learning in the formal classroom setting. Among the greatest benefits in informal education are flexibility and the hands-on learning approach that is emphasized. As an institution that is committed to inspiring the study and advancement of science, the GMD actively seeks ways in which to foster meaningful and lasting partnerships and support for formal educators. The HAB workshop serves as a new important connection between the GMD and Iowa formal educators. The primary goal of the GMD Continuing Education HAB Workshop was to provide a unique professional development and training opportunity for high school science teachers in Iowa that would help them to excite their students in science and engineering and enrich their academic experience. The workshop equipped the attendees with the skills and knowledge to attract and retain students in STEM disciplines, through the

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use of HAB. This paper will discuss the conception, implementation, and future goals of the museum's new HAB program, as well as the workshop flight operations and development of future classroom applications.

II. HAB Continuing Education Workshop

The GMD's Continuing Education Workshop on March 5-6, 2011 served as a first step in the development of a broader museum HAB program. Staff from the ISU SSCL, led by Matthew Nelson, and the ISGC were instrumental in this program's development and workshop education.

The first step in workshop development was educating the museum staff in the engineering and science behind HAB, as well as the laws and regulations that governs HAB operations. GMD staff worked closely with Matthew Nelson and the ISU SSCL during the development phase of the workshop. SSCL's HABET group was largely responsible for the building and supplying the equipment and materials to be used for a HAB flight, for teaching HAB flight engineering and operations at the workshop, and for leading the actual HAB launch preparations, launch, and recovery. The GMD assisted in these tasks where needed, however the museum staff's priorities were the workshop logistics, marketing, and the development and teaching of the educational applications and opportunities using HAB.

On March 5-6, 2011, four high school science teachers and two HAB enthusiasts attended the GMD's first Continuing Education HAB Workshop, held at the Grout Museum District in downtown Waterloo, Iowa. The two main areas of focus were HAB operations and engineering, taught by the ISU HABET team. Day one of the workshop oriented the participants with the GMD and focused on HAB operations, led by Matthew Nelson. Participants learned Federal Aviation Administration (FAA) rules and regulations, as well as launch, flight, and recovery operations, and the day concluded with an opportunity for participants to ask questions and have the ISU staff elaborate on any needed topics. Day one also coincided with an independent launch by the iHAB group out of Ottumwa, Iowa. This fortuitous launch served as a valuable teaching tool at the workshop, helping to demonstrate many of the operations concepts taught that day. On day 2, which was a half day, the workshop focused on the engineering aspect of HAB and integrating HAB into the classroom. The ISU staff discussed off-the-shelf products and materials that may be used to create a flight data pack. The group examined the flight pack that the ISU SSCL built especially for the GMD workshop. The GMD's Science Educator and Science Outreach Coordinator developed lesson plans and resources over a range of science topics to help get the participants off the ground and started with applying the workshop materials in their classrooms. The final workshop session discussed ideas for various subject areas that HAB may be used to teach, the basics of incorporating inquiry (problem)-based lessons into existing curriculum, and suggestions for using these HAB-themed inquiry-based lessons.

The workshop provided four lesson plans to introduce the participants to how HAB may be combined with existing science units and curriculum. An important goal of the workshop was not only to teach the science and engineering of HAB but to make it easily transferable to the classroom for the teachers. There was an open discussion at the conclusion of the education session, which gave the participants the chance to express their needs and desires for HAB materials and products in the future. These ideas will be used by the museum to guide and shape future programming. The discussion also led to the idea that the group should work to form a HAB Educator group, an online forum where educators can go to connect with each other and with experts in the field. The GMD staff agreed to head up this effort. The participants received a comprehensive packet of workshop educational materials covering all of the topics taught, and a copy of the data collected on the flight, as well as copies of the pictures and video. The workshop concluded with a group HAB launch, flight, and recovery.

III. Workshop Flight Operations

Since flight operations was one of the primary focuses of the teacher training during the workshop, the GMD staff felt that it was important for educators to fully understand HAB operations if they would someday integrate it into their classroom. As a result, a group launch was conducted as the final workshop activity, with flight preparations being led by Matthew Nelson and his staff. The flight served as a valuable teaching tool for the museum staff as well as the workshop participants, giving everyone involved valuable, first-hand experience with HAB operations and launch. This was especially true for the museum staff since the equipment built for the workshop by ISU SSCL belongs to the GMD and will be used in the future to help local schools and groups conduct their own HAB launches.

Flight preparations took approximately 30 minutes and were led by the Mission Manager, Christine Jensen, ISU student; Launch & Flight Director, Matthew Nelson, ISU SSCL; and Recovery & Engineering Director, Ethan Harstad, ISU student. Figure 1(a-d) shows pictures of the flight preparations during the different stages of progress.

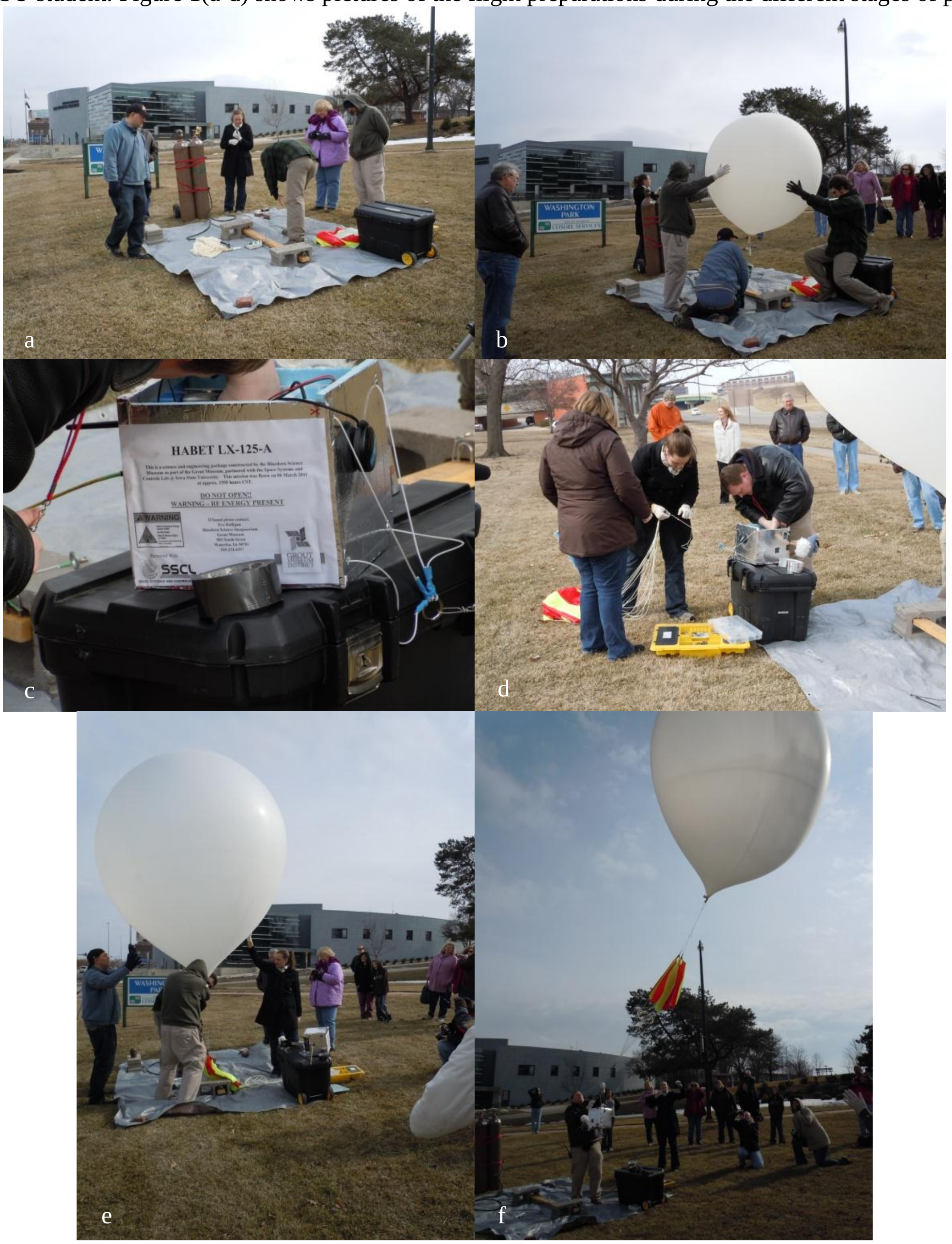

Figure 1. HAB Flight L-125-A launch preparations (a-d) and launch (e-f).

Once a clear and stable signal was established from the radio transmitter to the GPS tracking system, final assembly was completed, the balloon filled, and the pack was go for launch (Fig. 1e-f).

HABET flight L-125-A lifted off at 2:36p.m on March 6, 2001 from the northeast corner of Washington Park in Waterloo, Iowa. The main radio tracker frequency was set to 446.375, 900 MHz ISM radio (telemetry), and the Back-up Emergency Radio Transmitter (BERT) was set at 144.39 MHz. Unfortunately, the main transmitter did experience problems during the flight, so the recovery team relied on the BERT to locate and recover the flight pack. The HAB flight pack contained the following sensors and equipment: internal & external temperature, pressure, humidity, magnetometer, accelerometer, GPS, digital camera, and Digital video camera. The flight pack was manned by the GMD's Einstein stuffed doll, as evidenced from the pictures. Most of the data collected was good, however, due to a few technical issues, the GPS data was missing and the video only captured the first 8 minutes of

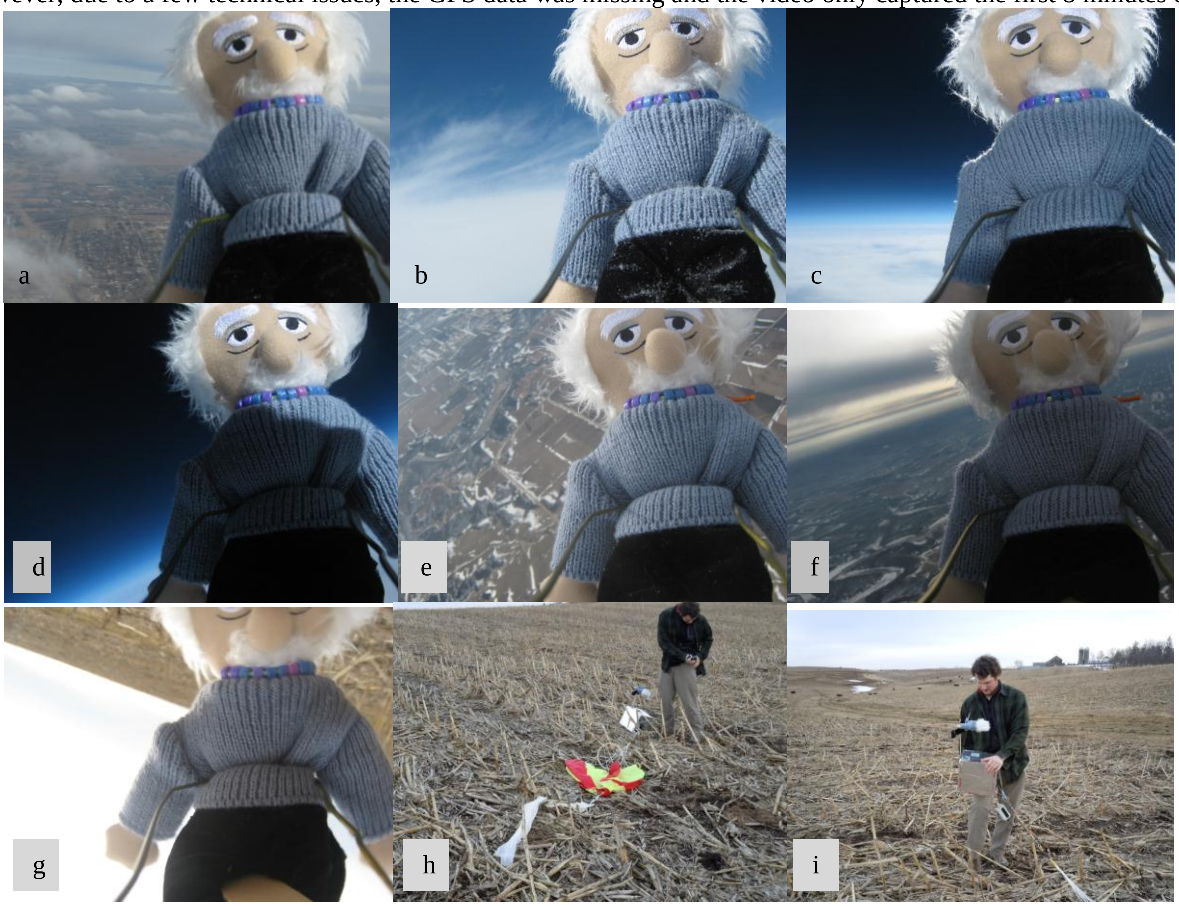

Figure 2. HAB Flight L-125-A in-flight picures. (a)-(c) Einstein ascending; (d) Near balloon burst; (e)-(f) Einstein descending; (g)-(i) Safe landing & recovery.

flight. The camera and other sensors all appear to have worked properly. L-125-A was the first flight for this new pack, so it served an opportunity to de-bug and fine-tune the pack for the future.

The flight lasted 2 hours 29 minutes, traveled approximately 55 lateral miles almost directly to the East, and the pack landed and was recovered approximately 1 mile north of Delhi, Iowa. The flight path made for an easy recovery, and recovery operations went very smoothly. The HAB reached a height of approximately 80,000 feet before bursting. Figure 2 shows pictures at different stages of the flight and figure 3 a map of the approximated flight path.

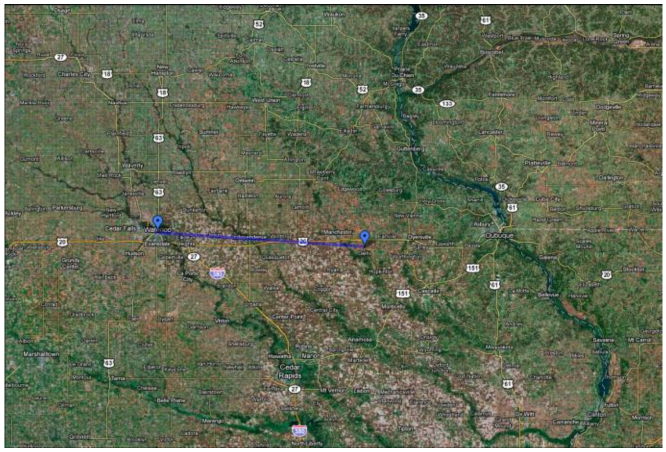

Figure 3. Map showing aerial view of the launch and landing sites. The purple line shows the approximate chase route taken by the recovery team.

IV. HAB Classroom Applications

HAB is one of the cheapest, most reliable and fun ways to access the edge of space. In the challenges of the current economic environment, HAB offers a low-cost and largely off-the-shelf solution to enriching STEM education in the formal and informal classroom. As an added bonus, HAB also provides a high degree of visual impact and the "wow" factor that can help to engage students in ways not otherwise possible.

The GMD HAB Workshop was developed to fulfill and meet the educational objectives and goals put forth by the ISGC and National Aeronautics and Space Administration (NASA), which are very similar. In particular, this program helps to meet NASA outcome 2 which seeks to educate and engage elementary and secondary education level students and teachers. This outcome leads to the ability to "attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers, and faculty"[4]. The HAB project also meets NASA outcome 3: Informal Education (engage and inspire). This outcome focuses on building strategic partnerships and linkages with STEM formal and informal education providers, and the GMD's collaboration with the ISU SSCL clearly demonstrates the importance and advantages in these partnerships. It would have been very difficult for the museum staff alone to develop a successful HAB program. The expertise of the ISU staff and students was vital to the new programs success. In the future, the GMD will work to expand its partnerships with school districts in the local area.

Teachers are under increasing pressure to engage their students in inquiry-based learning, particularly in science. The Iowa Core Curriculum, which is the basis for each school district's standards and benchmarks, stresses the inquiry-based approach. Inquiry-based learning lets the student ask the questions and decide the path of learning[5-6]. This gives students experience in asking appropriate questions and problem solving, both extremely important skills. However, allowing students to guide a lesson can be disconcerting at first for both the teacher and students. As a result, there are varying degrees of inquiry, some with more guidance from the teacher and others with progressively less. HAB has the potential to allow a teacher to integrate the varying degrees of inquiry into the classroom, thus allowing teachers and students to become more comfortable with this educational style.

The GMD discussed a few options that teachers may use to incorporate HAB into their curriculum using an inquiry-based approach. First, educators may build an inquiry-based lesson plan into the end of an existing unit. This allows the teacher to teach the important concepts in a style to which they are comfortable, and the inquiry-based lesson serves to make the students apply what they have learned. For example, a teacher could build a HAB lesson into the end of a weather unit. Most high school students study the structure of the atmosphere. HAB gives the teacher a new way to show the real data to the students and help them to understand the concepts. The key is to spark the students' interest early in the lesson, and then they will learn to lead their own learning from there. It also grants students the opportunity to work with data that they've collected and analyze it. Second, the teacher can create a new unit based on HAB. This could include topics such as scientific method, physics, technology, engineering, or even media (pictures and video). There is unlimited potential, and any new unit would likely integrate several of these topics into one new element of their STEM education. The GMD will continue to work to help provide more HAB-related professional development opportunities to teachers. Now that the museum has a firm foundation and the ability to conduct HAB launches, it plans to develop new curriculum and programs of this nature to offer to schools as outreach in the future. So, even if a formal educator doesn't feel comfortable in doing HAB, they still have the option of offering the opportunity to their students. In this way, the formal and informal educational spheres will continue to have an important connection.

V. Conclusions

In March 2011, the GMD began a new chapter in STEM informal education opportunities through a pilot professional development workshop for high school science teachers. Thanks to funding through the ISGC, teachers across Iowa were given the opportunity to learn HAB flight operations, engineering, and classroom applications. By providing professional development to high school science educators, the GMD hopes to give them a new approach and resource for incorporating more inquiry-based, STEM education into existing curriculum. It is also hoped that the result of this endeavor will be to inspire and excite the students themselves in STEM disciplines, thus helping to prepare the workforce of the future. High Altitude Ballooning demonstrates a great aptitude in helping to accomplish these goals due to its versatile nature, exciting visual impact, and cost effectiveness.

Many important lessons were learned during this initial step in developing a HAB program at the museum, most important of which is the role of educational partnerships and collaborations. The GMD HAB Workshop serves as an excellent example of the meaningful work that may be accomplished when formal and informal educational spheres work together. In particular, the pilot program illustrates the importance of higher education partnerships with informal educators. While the informal educators have a strong science background, they do not necessarily have the background for specific and new projects such as HAB. So, in the end, the result of this pilot workshop was not just professional development for the formal classroom teachers but also for the museum staff. This groundwork laid the foundation for future HAB program development at the GMD.

The Grout Museum District has several new areas of HAB program development that will be pursued in the next few years. First, the museum plans to continue providing professional development workshops to secondary school teachers. Within the coming year, there are plans to hold another workshop that will focus on HAB educational curriculum and using HAB data. The subsequent workshops will build upon the lessons of the first. Second, the museum plans to create a HAB outreach program that will be offered to middle school and high school aged students. The outreach activities will be based upon existing models of taking the museum to the school or "museum in a school" program. Finally, plans are in process to develop HAB summer camps and workshops tailored for specific student grade levels. With the help of these new programs, the GMD plans to help formal classroom teachers and students take their STEM education higher.

VI. Acknowledgments

The Grout Museum District would like to extend a special thank you to Matthew Nelson for all of his time and help in making this workshop a reality, and to Dr. Jay Staker for his help and perspective during the formative stages of the program. Finally, thank you to the ISGC for providing the funding and support for this project and helping to turn our vision into reality.

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