IMPACT OF HIGH-ALTITUDE BALLOONING ON WYOMING STUDENTS

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Abstract

For my honors capstone project, I dive deeper into the impact that science outreach programs at the University of Wyoming have had on those who participate in them. The LIFT Project, funded by the National Science Foundation, was a science outreach program that allowed undergraduate students the opportunity to develop a scientific experiment using a high-altitude balloon. The students were also able to develop lesson plans, travel to the partnering K-12 school to teach the lessons, participate in a balloon launch and data collection, and finally analyze the data collected by the payloads. A few years after participating in the LIFT Project, I wanted to reflect on how this experience had affected me and my teammates. Personally, it allowed me to be accepted into new internships and gain more experience in high-altitude ballooning. Recently, I was invited to speak about one of these experiences at the National Space Grant Meeting in Washington D.C. This was true for my teammates as well, who were also offered various scholarships due to their LIFT Project experience, providing an entry point for other jobs and experiences on campus. Using teammate interviews, my own perspective and experiences, and research essays, I was able to see that these types of outreach programs have a generally positive effect on those who participate. Overall, I determined that high-altitude ballooning is a unique yet impactful science outreach approach that is only becoming more relevant. Science outreach programs for kids in rural Wyoming are valuable experiences and should continue to be funded.

Background

Many times, the experiences we encounter in childhood play significant roles for our future career aspirations. Ballet classes can turn into dreams of dancing professionally, and science fairs can spark a curiosity and love for research. Sometimes, even individual field trips or community outreach events can help develop ways of scientific thinking that stay with a child as they grow up. Even if a child does not pursue science in the future, they still gain critical thinking skills that will help them in school and their professional lives (Fleer 2013).

Science has always played a role in my development as a child, sometimes without even recognizing it. When I was growing up in a densely populated area in California, I attended a magnet school focused primarily on math and science that provided me countless hands-on opportunities to learn. It allowed me to develop general critical thinking and problem-solving skills early on that I still use in all aspects of my life today. Throughout the rest of my K-12 experience, I was involved with multiple science clubs and participated in events like Science Olympiad and Future Cities. However, the most memorable childhood experience was being part of LiMPETS, a long-term monitoring and experiential training program for students, on two different occasions. LiMPETS (https://limpets.org/) is a scientific outreach initiative that brings students to the Pacific Ocean to participate in data collection efforts to monitor sand crab populations and tide pool health. These opportunities stayed with me because they were very unique, and it was exciting to feel like I was part of important research at such a young age.

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Children that grow up in less populated areas such as rural Wyoming undoubtedly have fewer unique opportunities for scientific learning than others who grow up in more populated areas like I did. The University of Wyoming does a very good job of recruiting students after their high school graduation, but it can be difficult for students to discover exactly what interests

them before attending new student orientations. That is why science outreach programs, such as those through the Wyoming NASA Space Grant Consortium (hereafter Wyoming Space Grant), are so valuable; they allow K-12 students to be exposed to various scientific disciplines before coming to college. The Wyoming Space Grant provides beneficial programs for everyone involved and have the ability to spark great scientific interest to those who participate.

LIFT Project Overview

The LIFT Project (http://wyomingspacegrant.org/balloonprogram/projects/liftproject/) was an undergraduate fellowship with the Wyoming Space Grant that ran from 2019 to 2021. This grant-funded project invited college students at the University of Wyoming from various majors to apply to the program. The students were organized into teams to collaborate with one another in order to create and teach a science experiment to K-12 students in Wyoming. The twist to this project was that a high-altitude balloon must be incorporated into the experiment for data-collecting purposes. I was accepted to be a fellow for the LIFT Project in 2021 and was put onto a team with three other students from various majors such as computer science and education.

Our newly formed team was eventually partnered with a high-achieving chemistry class in rural Shoshoni, WY. With a population of just under 500, it was highly likely that none of those students had any previous science experiences as unique as high-altitude ballooning. Never having any previous experience with high-altitude balloons ourselves, my teammates and I learned everything we could about how they worked and what they could do in terms of scientific possibilities so that we could provide the most fulfilling experience possible for the high school kids. After many brainstorming sessions during the spring 2021 semester, we

decided on a project to measure the presence of the molecular ozone in the upper atmosphere and explain the chemical reactions that take place to create the ozone layer. The ozone layer is a crucial component of the upper stratosphere that ranges from around 20 to 30 kilometers in altitude. Most high-altitude balloons are able to reach 25 to 35 kilometers in altitude, so this experiment fit very well with our audience. The data collection hardware that we decided to use was an Arduino system due to its simplicity with regard to building and coding the sensors that we wanted to use to record data. This system is very accessible for students to learn and become comfortable with quickly, giving it superiority when it came to teaching our students how to build their own data collection units.

Since this class was high achieving, we decided to split the class into teams and have them design their own payload boxes. Each student was given a role, which included a mechanical engineer to develop the payload box, a computer engineer to build the Arduino, a software engineer to code the Arduino, a public relations expert to document their steps and update websites that highlighted their team, and a research scientist to help all other team members where they needed research. After completing our initial lesson explaining what our project would consist of, what ozone is and its importance, and how to build the actual payload, the teams were allowed to work on their payloads and ask questions as needed. After a month or so went by, we ventured back up to Shoshoni to check their final progress. With our help, every high school team built a successful payload. The next day we launched a 1,200-gram latex balloon carrying the high school teams' payloads along with our own payload as a standard for data. The launch process had some difficulties, but we were eventually able to launch smoothly with the help of a few students who held payloads as we launched.

After we retrieved the payloads following the balloon flight, we took everything back to Laramie where we analyzed and graphed the data, looking for common trends in the data we collected, including ozone concentration, temperature, and UV. Our payload had two sensors that measured high concentration and low concentration ozone, but both graphs showed the same increasing trend with altitude (Figure 1), which was an observation we wanted to highlight with the students.

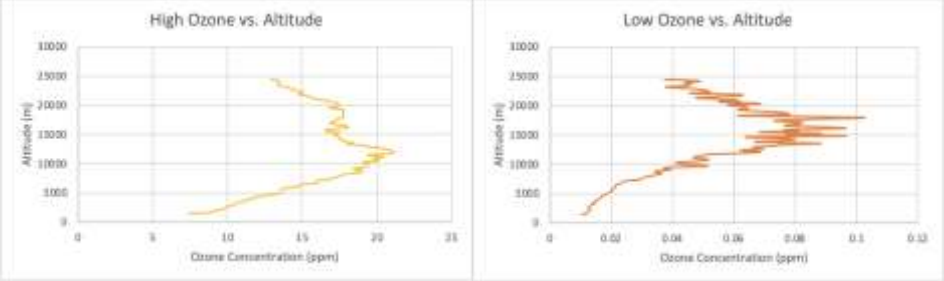

Figure 1: High ozone concentration (left) and low ozone concentration (right) as a function of altitude above sea level.

As for the other data we collected like UV radiation and temperature, we decided to also document their trends as they also related to ozone in the atmosphere. Seen below in Figure 2, there is a very clear decreasing trend in temperature as altitude increases until the payload enters the bottom of the stratosphere (and the ozone layer) at around 12,000 meters. Then, due to the absorption of solar UV rays by the ozone, the temperature begins to rise with altitude. Meanwhile, UV radiation intensity increases as the sensor rises through the ozone layer because fewer UV rays are able to penetrate below the ozone layer.

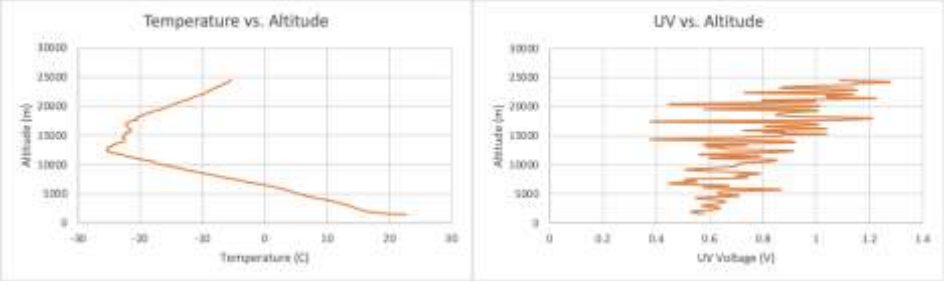

Figure 2: Temperature (left) and UV radiation voltage (right) as a function of altitude above sea level.

With these graphs, our team traveled back to Shoshoni one last time to share our results and help the students graph their data. After giving them a worksheet and time to graph their own data from their payloads and come to their own conclusions about the trends they saw, we showed the class our results and discussed their conclusions. For the most part, all of the data was very similar to one another and the trends were consistent. While there were of course hiccups in the project, such as limited time for lessons and faulty sensors, overall it was a very productive project and a unique opportunity for the students in rural Wyoming to be able to participate in. After the project, the Wyoming Space Grant put together a short YouTube video (https://youtu.be/xB3r5Tp62fs) highlighting the entirety of our project.

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High-altitude balloon ozone analysis became popular in the 1980s due to the increased concern surrounding the ozone layer hole. With the growing hole at the south pole, it allowed an influx of harmful UV-B rays to make it all the way to Earth's surface and began to increase the surface temperature and risk to human health at the poles (De Gruijl 2000). The Department of Physics and Astronomy (and later the Department of Atmospheric Science) at the University of Wyoming was one of many contributors that used high-altitude balloons to measure the vertical distributions of ozone to measure the growing ozone cavity (Hofmann et al. 1987). Due to the observations and analyses of ozone and the efforts taken to reverse the damage, the hole has been

shrunk and almost completely restored. The University of Wyoming continued to use balloons for data collection through the mid-2010s and holds the record of being the longest institution measuring stratospheric aerosols, dating back to the early 1970s (UW News 2012). Today, high-altitude ballooning has continued to be quite a popular method for collecting data in the atmosphere due to its versatility.

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Effects of LIFT Project on Teammates

I really enjoyed the entirety of the project, especially the community outreach component. Being able to apply the things our team had learned about in our respective majors to a real-life project was a valuable experience. It felt very rewarding being able to go into a classroom of kids from rural Wyoming and teach them about a very unique science topic that has great potential for a career in larger corporations all around the nation. Living so far away from anything close to that type of hands-on scientific outreach, they will most likely never have the opportunity to learn about this again until college. The work I did with these students during this project caused me to refocus my career toward the community education and outreach components of science rather than the field of research.

After my time with the LIFT Project was over, I stayed in contact with the Wyoming Space Grant and learned about similar internships and careers I could pursue in the future. Over the summer of 2022, I was awarded an internship in the BOREALIS Program at Montana State University as a representative of the Wyoming Space Grant. The main goal of this internship was to prepare for the Nationwide Eclipse Ballooning Project (https://eclipse.montana.edu), where teams of high school and college age students all across the country are able to sign up and build payloads for high altitude balloons that will be launched along the path of totality during the

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2024 total solar eclipse. In order to do so, the BOREALIS interns were tasked with designing and testing multiple projects to finalize what would be flying on the payloads. Most of this effort was engineering-focused and not in my expertise, but I had the advantage of previous ballooning experience and an open mind to learn as much as I could. With this mindset, I learned quite a bit about engineering and how to collaborate with teammates with different perspectives on how to solve problems. The community outreach component on this internship was quite slim which was a bit disappointing, but I still learned valuable lessons and would not have been awarded this internship if it wasn't for the Wyoming Space Grant.

I never imagined the LIFT Project At Wyoming would bring me the opportunities I have received today. At the beginning of March 2023, my BOREALIS teammates and I were invited to speak at the National Space Grant Meeting in Washington D.C. about the project we worked on during the summer internship and talk about our overall experience with the Space Grant Program. This allowed me to not only boost my resume but also gave me the ability to network with Space Grant directors around the country and other NASA employees.

As for my LIFT Project teammates, I was curious if their experiences with the project were similar and whether their childhood experiences played as big of a role as mine did in leading to this point of their career. After a brief questionnaire was distributed to my teammates, I came to multiple conclusions. The majority of my teammates were exposed to some sort of community outreach science programs during their childhood due to where they lived. These experiences helped develop an appreciation for the outdoors and some even sparked a love for scientific research. Being exposed to organizations such as the wildlife service and marine biology institutes as children expanded their worldview and helped them determine the careers they wanted to pursue. For many of my teammates, LIFT was their first large extracurricular

activity they participated in and found the project to be an overall beneficial and valuable experience to be a part of.

Since the LIFT Project was such a unique program, it opened doors for many of my teammates. One of them was awarded multiple scholarships and led them into the University of Wyoming community for campus jobs and other experiences. For others, it gave them the upper hand when applying for jobs because it had helped them become more well-rounded individuals. All of my teammates agreed that this experience didn't ultimately change their career path; instead, it reinforced their career aspirations and provided a way for them to collect more experience in those areas.

Final Thoughts & Conclusions

High-altitude ballooning is an interesting and vast field of growing science. Its uniqueness allows scientists to tailor new experiments that are limited only by one's imagination. This is one of the reasons why it is important for organizations like Wyoming Space Grant to continue to receive funding for K-12 community engagement programs. Being able to provide students with knowledge and experiences like this before they get to college can point them in all sorts of career directions; it has the possibility of capturing their interests so they can participate in similar experiences at the college level, like me and my teammates. With more consistent statewide science outreach in rural Wyoming, I believe that these valuable experiences truly do spark children's curiosities to explore the unknown and encourage them to further explore all of the opportunities offered at the University of Wyoming.

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