Progressing Science, Technology, Engineering, and Math (STEM) Education in North Dakota through Near-Space Ballooning

Marissa Saad
Master of Science in Space Studies
University of North Dakota
Academic High Altitude Conference
June 26, 2014
Past Experience

- Bachelor’s in Astronomy, minored in Education.
- High school Earth Science teaching license (MA)
- Attended first HAB launch fall 2011
- Obtained my HAM radio license 2012
- Organized UND’s local launches, Kempton, ND
- Team lead on UND’s High Altitude Student Platform (HASP) team 2011-2013
- Coordinator of the 2012-2013 Near Space Balloon Competition (NSBC)
- Thesis work 2013-2014
Introduction

• Master’s thesis project
  – 8th grade Earth Science class (124 students) at Valley Middle School
  – Integrated a high altitude balloon mission into their curriculum – astronomy, meteorology, remote sensing
  – Evaluated the students with a pre- and post-survey
• Wanted to this to complement yet contrast NSBC
  – Kids are already interested in STEM activity
Near Space Ballooning

• Here at UND:
  – Helium, latex Kaymont balloons (1500 grams)
  – Safety launch regulations:
    • Federal Aviation Administration (FAA)
      – NOTAMs
    • Federal Communications Commission (FCC)
      – HAM Radio Operators
    • UND Flight Safety Office (FSO)
      – In 2012, GFK was ranked 17th busiest airport in the country

http://www.grandforks.org/pages/success_story?r=7E2QJ8J9CT
Hypothesis

Middle school students who have practiced the scientific method in a real world application of Near Space Ballooning will have an increased affinity to STEM subjects.
Methods

- **Participants**
  - 124 participants (54% female, 46% male)
  - All were students from Brent Newman’s 8th grade Earth Science classes (Valley Middle)
  - Voluntarily completed the surveys
  - Identities were kept anonymous
    - Used background demographics to compare data
Methods

• Procedures
  • In 12 teams, participants were expected to create experimental payloads
    – Hypothesis
    – Design
    – Construct
    – Launch and Chase
    – Data Analysis
    – Final Report
Methods

• Measures
  – Pre- and post- surveys
  – UND IRB permissions (IRB-201310-142)
  – Participation consent and assent form (13-14 years old)
  – The analysis was performed by:
    • Likert Scale – style questioning
      – (Strongly disagree, disagree, neutral, agree, strongly agree)
    • Weighted Average
    • Student’s t-Test (Welch’s)
      – two population variances are not equal
Results

• The t-test was calculated with alpha set at 0.05.

1. The result of the “I Think Engineers Work Alone” survey question demonstrated a statistically significant change, supporting the hypothesis.
   \(( \bar{X}_1 = 2.44, n = 118; \bar{X}_2 = 1.86, n = 113; p = 1.16 \times 10^{-6}, \alpha = 0.05)\)

2. The remaining seven Likert-scale Student Response questions demonstrated no significant change, supporting the null hypothesis.
Results

The following survey questions displayed no statistical change from the pre- to post-survey.

1. I think Astronomy is interesting – Agree
2. I want to go to college – Strongly Agree
3. I would like to attend UND – Neutral
4. I plan on joining an extracurricular activity in high school – Neutral
5. I wish to get a job in a science field when I’m older – Neutral
6. I have a specific career in mind - Agree
7.
### Females' Most Anticipated Classes for High School

<table>
<thead>
<tr>
<th>Subject</th>
<th>% Change</th>
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<tbody>
<tr>
<td>Fine Arts</td>
<td>-8.2</td>
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<tr>
<td>Math</td>
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<td>Science</td>
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<td>Social Studies</td>
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<td>Health/PE</td>
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<td>Business/Marketing</td>
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<td>Foreign Language</td>
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<tr>
<td>English</td>
<td>-33.3</td>
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<tbody>
<tr>
<td>Fine Arts</td>
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<tr>
<td>Math</td>
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<td>Science</td>
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<tr>
<td>Social Studies</td>
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<td>Health/PE</td>
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<tr>
<td>English</td>
<td>100</td>
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</table>
### Females' Least Anticipated Classes for High School

<table>
<thead>
<tr>
<th>Subject</th>
<th>% Change</th>
<th># of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Arts</td>
<td>-36.6</td>
<td>6, 4, 33, 34</td>
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<tr>
<td>Math</td>
<td>25</td>
<td>13, 12</td>
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<tr>
<td>Science</td>
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<td>19, 18</td>
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<tr>
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<tr>
<td>Health/PE</td>
<td>0</td>
<td>9, 8, 12</td>
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<tr>
<td>Business/Marketing</td>
<td>0</td>
<td>9, 8, 12</td>
</tr>
<tr>
<td>Foreign Language</td>
<td>-62.5</td>
<td>24, 21</td>
</tr>
<tr>
<td>English</td>
<td>33.3</td>
<td>15, 12, 16</td>
</tr>
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<tr>
<td>Fine Arts</td>
<td>-36.6</td>
<td>15, 11, 12, 16</td>
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<tr>
<td>Math</td>
<td>25</td>
<td>7, 10, 11</td>
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<tr>
<td>Science</td>
<td>30</td>
<td>3, 3, 3, 10, 13</td>
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<tr>
<td>Social Studies</td>
<td>36.6</td>
<td>16, 13, 8, 8, 24, 21</td>
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<tr>
<td>Health/PE</td>
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<td>13, 13, 8</td>
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<td>Business/Marketing</td>
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<tr>
<td>Foreign Language</td>
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<td>8</td>
</tr>
<tr>
<td>English</td>
<td>-14.3</td>
<td>8</td>
</tr>
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</table>
Student Responses: "If I Want to Work in a STEM Field, I Have to Work Solely for NASA"

(\(\bar{X}_1 = 1.81, n = 118; \bar{X}_2 = 1.85, n = 112; p = 0.41, \alpha = 0.05\))

- 23.9% decrease
- Only survey question displaying significant change
Student Open Responses

"Please Describe How You Felt About the Entire Ballooning Process"

- Fun: 57
- Educational: 21
- Experience: 13
- Interesting: 9
- Cool: 9
- Collaboration: 8
- Exciting: 7
- Frustrating: 7
- Boring: 6
- Good: 4
- Opportunity: 4
- Proud: 3
- Amazing: 3
- Great: 3
- Loved it: 2
- One-Time Experience: 2
- Awesome: 2
- Confusing: 1
- Enjoyed coming to science: 1
- Hectic: 1
- Rushed: 1
- Waste of Time: 1
- Fascinating: 1
- Risky: 1

Number of Student Mentions
### Considerations for Future Instructors

- Have smaller groups (2)
- Teachers should **assign roles**
- Who holds the payloads when they’re launched
- End of school so it would be **warm** (2)
- Have a little more interaction with the balloon while it’s in the air

### Bus Chase Considerations

- **More people** go on the bus (7)
  - Two people per team
  - **Everyone** (6)
- People voted for someone else for the bus chase (2)
## Time Concerns

<table>
<thead>
<tr>
<th>Concern</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longer time in class to design/build payloads</td>
<td>16</td>
</tr>
<tr>
<td>Use your time wisely with construction</td>
<td>6</td>
</tr>
<tr>
<td>Deadlines further away</td>
<td>3</td>
</tr>
</tbody>
</table>

## Future Advice for Other Students and Instructors

<table>
<thead>
<tr>
<th>Advice</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students should be graded on communication</td>
<td></td>
</tr>
<tr>
<td>Put kids in the same group where they all get along</td>
<td>2</td>
</tr>
<tr>
<td>We would work a lot harder and better together if we got to pick our own groups</td>
<td>2</td>
</tr>
<tr>
<td>A lot of people weren’t getting their work done</td>
<td>2</td>
</tr>
<tr>
<td><strong>Do your job</strong> because some people had to do other peoples’ jobs</td>
<td>4</td>
</tr>
<tr>
<td><strong>Nothing</strong></td>
<td>28</td>
</tr>
</tbody>
</table>
Presentation Day
October 31, 2013

- Assent Forms (Consent forms were previously completed)
- Pre-surveys
- Assigned Project Roles
  - Each team unconsciously appointed a team leader, 8 team leaders were females students
Student Experiments

- Acceleration 1
- Acceleration 2
- UVB
- Humidity
- Temperature
- Wide Range Temperature
- Carbon Dioxide
- Oxygen
- Magnetic Field
- Pressure

- “Space” Banana
- 2 Canon Digital Cameras
- GoPro Video Camera
Design Phase

• Students on the design team worked in class Friday, November 1, 2013 and over the weekend

• Students could create any design to support their assigned data logger
  – Cubes, Pyramids, X-shape, hybrids

• Newman reported that students voluntarily stayed after school to work on their projects!
Construction Phase

• Tuesday, November 5, 2013
• Deadline of Thursday, 4:00 PM
  – Majority of females took lead
  – Education advisor, Dr. Ingwalson impressed

Post Survey
• Students requested more in-class time
## Materials

<table>
<thead>
<tr>
<th>Launch Preparation</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>HARRIS 0-200 PSI Regulator</td>
<td>2</td>
</tr>
<tr>
<td>Filling Hose</td>
<td>2</td>
</tr>
<tr>
<td>200 ft³ Helium Tanks</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Payload Materials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NeuLog Sensors</td>
<td>10</td>
</tr>
<tr>
<td>Banana</td>
<td>2</td>
</tr>
<tr>
<td>GoPro Video Camera</td>
<td>1</td>
</tr>
<tr>
<td>Canon cameras</td>
<td>2</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Balloon Tracking</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1500 gram Kaymont Latex Balloons</td>
<td>2</td>
</tr>
<tr>
<td>Kenwood D700 Transceiver</td>
<td>1</td>
</tr>
<tr>
<td>Kenwood D710 Transceiver</td>
<td>1</td>
</tr>
<tr>
<td>Handheld Kenwood TH- D72A Transceiver</td>
<td>2</td>
</tr>
<tr>
<td>SPOT Tracker</td>
<td>2</td>
</tr>
<tr>
<td>Microsoft APRS MapPoint</td>
<td>1</td>
</tr>
</tbody>
</table>
Launch Day!

• Wednesday, November 13, 2013
• First time performing a simultaneous launch
• 45 minutes behind schedule, but successful
• 12 students attended the chase, one from each team
Chase Team

- Expressed interest throughout the entire trip
- Received altitude updates from another chase vehicle
- Students learned many technical issues may arise out in the field.
- One male student inquired about studying astronomy

- 4 chase vehicles
Conclusions

• 3 weeks of this hands-on activity was not effective in influencing students’ opinions of STEM.

• Students enjoyed and found this balloon project educational

• Students extensively experienced the engineering method while working in teams, realizing engineers do not work alone.
Outline

• Thesis Statement
• Review of the Literature
• How Does Ballooning Assist This Study?
• Methodology
• Results from this Study
• Ballooning Project Results
• Conclusion
• Future Work
• Acknowledgements
Recommendations for Future Middle School Launches

- Present this activity as an 8th grade “Capstone” project; culmination of everything they learned throughout the year
  - Science
  - Math
  - Art and others

- A launch in Spring will be much warmer for the students

- Increase in-class work time

- Create additional activities for the students during the filling process
  - Measure the inflated balloon (ideal gas law, ascent rate, size at altitude)
Thesis Documentary Video


Thank you all!

Dr. Ron Fevig
Dr. Gail Ingwalson
Dr. Paul Hardersen

Mr. Brent Newman and all 8th grade students!
North Dakota Space Grant Consortium
Dr. Santhosh Seelan
Ms. Caitlin Nolby

Photographers!
Caitlin Nolby
Jonathan Schiralli
Thomas Cook

UND IRB
Bev Fetter

Launch Teams!!
Mr. Ben March
Mr. Jon Schiralli and Mr. Brian Badders
Thank you!