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Understanding Effects of Engineering Outreach on Elementary Students

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Honors Research Project

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Executive Summary

Problem Statement

Currently, there is a desire to increase engineering understanding held by elementary students. As such, there needs to be a way to stimulate not only engineering, but other science, technology, engineering, and mathematics (STEM) topics in a young student's lifestyle. One way to emphasize the importance of STEM while also showing how fun it can be is through different hands on activities led by individuals partaking in undergraduate studies or the industry. While having the students participate in the activities, it is important to understand what the students are learning and how the activity overall is viewed. The purpose of this study is to reach out to a group of students in elementary school over the course of a semester to determine what perceptions of engineering they have and how they change after a series of different activities each week.

Results and Conclusions

Due to the nature of the study, the results taken were more qualitative than quantitative. Each question asked warranted different responses from the individual students each week. The first question regarding what an engineer does showed that students initially saw an engineer being very hands on. As the semester progressed, the students learned from the activities and gave responses regarding the engineer designing different systems, going as far as saying "[Engineers] design stuff by following engineering design" referring to the design process. The second question asked the students to describe what they wanted to be when they grow up. The question was asked to try and discern whether the exposure to the STEM topics alter the outlook on the students futures. From the responses, there was no significant change over the weeks, suggesting that there is little conscious change in the students to gravitate toward engineering. With regards to the third question asked, most activities yielded a response of higher than 2 with several exceptions. The activities that received a rating lower than 2 were the baking soda and vinegar rocket, the egg drop, and the catapult activity with responses of 1.57, 1.87, and 1.88, respectively. The low responses for certain activities show which ones need trialed again or improved. Overall average of the activities was 2.14. The fourth question asked what the students learned about each activity. This question yielded varying results that were ultimately regarding what the students did as opposed to what they learned. Some activities, such as the slime one, did teach the students about various polymers and terms (i.e. initiator) that stuck with the students even after a weeks' time passed. The complete list of responses can be found in Appendix C.

Recommendations

In the future, the program itself should be ran similarly but several changes do need to be made to improve on the experience and the results. The first change that needs to be made is to start planning the project earlier, as the time it took to not only start the program but to also get IRB approval took longer than expected. Another change that should be made regards the survey. The first two questions should be asked only at the beginning and end of the sessions, not every week. If the questions are separated, there is a better chance for the students to not become bored by the same questions and to give better responses. Regarding the activity itself, the material should be presented to the students after the activity was completed to better establish the STEM topic.

Project Implications

While I never expected to become as involved in outreach as I have been over the past few years, due to the fact that I have never had a knack of relating to children very well, I found that I enjoyed working with these students much more than I ever imagined. Initially, my intentions were to reach out to children as part of a competition; as part of a job I thought had be given to me. With the passing of time and connections made with children, I realize now that outreach is much more important not only to the development of the future leaders and inventors, but to the understanding and growth of myself as a human being. Children are much more innocent, yet brutally honest, and never want to hide what they really think or feel. Even through troubling times and acts of defiance it seems that young students will always come back rearing for more with the expectation that you will too. If for any reason you do not come back with enthusiasm and understanding of what is desired, the students take advantage of you and the time you dedicate. Equally, though, they are just children and really want to find who they are and what makes them happy as much as the researchers reaching out to them, if not more. It occurred to me far too late, as it usually does, that I was learning more from the children than they were from me. Understanding the amount of effort, preparation, and patience that must go into teaching provides a new respect for those that taught me. Equally as important, it has also taught me how to be a better listener to the children and understand what they want, even if they have no idea what it is themselves. From what I have read and come to understand before, I know the problems of the future are solved by those younger than myself. From what I have learned from these young students, I know it is of paramount importance and of no nobler cause as to ensure that future is bright by enabling those younger than myself to do solve these problem through teaching in any way possible.

Introduction and Background

Demand for all disciplines of engineering is projected to increase by approximately 10% over the next ten years [4]. With this, the number of graduating engineers has been on the rise as well. In 2017, the number of engineers graduating with a bachelor's degree hit a 10 year high and reflected an increase of 10% over 2016 numbers [7]. It has not always been that way. To try and mitigate any prospective downturn in supply of engineers, reaching out, teaching, and inspiring future generations is necessary. The primary objective of this study is to determine how students' perception of engineers is affected by the outreach activities of undergraduate engineering students. The secondary goal is to understand the students' current perception of engineering, regardless of race, gender, or wealth, by utilizing instruments already proven to be effective.

The Akronauts Rocket Design Team (ARDT) was started in the spring semester of 2014 at the University of Akron, and has since grown from a small 10-person team to over 90 active members in the 2018-2019 year. With the increase in size comes the increase in the ability to diversify from a focus on the design and build of rockets to other important aspects of engineering, including outreach to future engineers. Initially, the ARDT was tasked with reaching out to 250 children within the K-12 grades through the NASA Student Launch Initiative program. Since 2014, the team has increased its outreach activities to reach over 3,000 children a year throughout Ohio and Pennsylvania. A key finding from all of these activities is that the most impactful opportunities are those where the mentor learns the names and faces of those they reach out to.

Members of the ARDT assisted in the activities of this study. As a requirement for research involving minors, both the University of Akron (UA) and Akron Public Schools (APS) Institutional Review Boards (IRBs) needed to approve the project. For the University of Akron IRB, the project was classified as exemption 2 – Research involving the use of educational tests, survey procedures, interview procedures, or observation of public behavior. The reference IRB number is 20181101. The Akron Public Schools IRB approved the study on March 14th, 2019.

Students involved in the study went to the Akron Public School System with one group from the National Inventors Hall of Fame STEM Middle School (NIHF) and the other from the Akron I Promise School (APS). The NIHF is located in the city of Akron and "is a unique and comprehensive…school that promotes problem-based formal and informal learning."* Students at NIHF are chosen by lottery to be a part of the school and are taught a variety of different courses that promote uncommon methods of thinking about school and the world around them. There are an array of exceptional children that, although still young, think and act in incredible, unexpected manners.

The Akron I Promise School is extraordinary not only for the children it houses but also the support and structure it gives the community around it. Aimed toward families that are struggling in and around the community, the children at the school are surrounded by a staff that envelopes the students with a feeling of togetherness and family that they might not have at another school. In addition to the sense of belonging, the students are also given opportunities to develop habits that promote a healthy lifestyle by eating food of good nutritional value and exercising. Upon graduation with a 3.0 or higher, the students are also given the opportunity to attend The University of Akron for free. Not only do the students have options for improved lives, through the community pantry and financial aid, so do their parents and families. Overall, an incredible community is created around these students and being a part of it can be overwhelming yet mystifying.

Literature Review

Engineering by the Numbers [7]

Every year, the Engineering Society for Engineering Education (ASEE) publishes a report outlining the number of students enrolled in higher-education engineering programs, including all disciplines. During the 2017 year, the number of total engineering undergraduate degrees awarded reached the highest level in ten years, a 10% increase over the 2016 year. Other notable trends include a much slower increase of enrollment to masters and doctorate programs as compared to undergraduate, as well as an increase in female engineering graduates from 2016.

Understanding K-12 Outreach Programs [5]

Jeffers et al. performed an in-depth literature review of over 45 different studies regarding STEM outreach programs and their similarities and differences. The study was conducted with the goal of gathering information on outreach in one place to help other universities become more proficient at developing the future engineers. Through the analysis of these reports, it was reported that several common approaches were found, including:

- *Develop classroom material including Web-based resources*
- *Conduct outreach activities on the college campus*
- *Conduct outreach activities at the K–12 school*
- *Conduct or sponsor engineering contests*
- *Sponsor teaching fellows or offer service-learning courses*
- *Offer professional development for K–12 teachers*

Other notable concerns brought up by the research team were that engineering is not in most K-12 curriculums and that teachers of the K-12 grade levels are not proficient in engineering.

Lessons Learned in K-12 Engineering Outreach and Their Impact on Program Planning [1]

Carroll et al. acquired grants from Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP) to perform a study to increase the college readiness for a group of minority and low-income students by hosting STEM-focused activities throughout the academic year as well as week-long summer camps over the course of 6 years. The program was focused on the same group of students, following them from 7th to 12th grade. Several important notes from the study revolve around the individual people involved in the study, the resources that were or were not available, the mental framework of both the teachers and the students, and the authenticity and content of the entire project. The lessons learned from the program also include the total amount of time required to start a new program and that students ability to participate completely will diminish over time due to other extracurricular activities taking up more of the students' time.

A middle school engineering outreach program for girls yields STEM undergraduates [2]

Demetry et al. noticed that women in engineering were not adequately represented at the Worcester Polytechnic Institute (WPI) as compared to even the national average. From the realization that women were underrepresented, Demetry et al. set out to determine if a two-week STEM focused program had any effect on the application, acceptance, and enrollment of individuals that partook in the program to WPI. Through and exemption of the WPI Institutional Review Board, the researchers developed an algorithm to compile the records of over 700 girls over 13 years. The program analyzed whether the individuals applied, were accepted, and enrolled through a series of yes-no constraints. To ensure the algorithm was accurate, the team double checked the results by hand. After debugging, the algorithm was deemed accurate and it was determined that the alumnae of the STEM program were more likely to apply, be admitted, and enroll with a p-value of less than 0.005.

Change in Elementary Student Conceptions of Engineering Following an Intervention as Seen from the Draw-an-Engineer Test [3]

Diefes-Dux et al. studied 2nd through 4th grader conceptions of engineering through the Draw-an-Engineer Test (DAET). The DAET asks students to draw an engineer working and to write about said engineer's job. The study looked at a total of 173 students before and after an academic school year from 19 different classrooms. During the school year, the teachers' curriculum was altered by adding units from the Museum of Science, Boston through the *Engineering is Elementary* program. It was noted that students moved the perception of engineering from that of a mechanic or laborer/builder to a designer after the course of a year.

The Benefit of Outreach to Engineering Students [6]

Pickering et al. observed a surge in educational outreach from the collegiate engineering community and showed interest in determining the effects on the ones leading the program, especially the females. The study interviewed and surveyed 23 engineering students involved in outreach, 13 of whom were male and 10 were female. The interview pertained to the students' experience in outreach and the impact outreach has on engineering skills. The survey also referred to the personal impact the outreach held on the students' personal lives. Overall, the study found outreach has a greater impact on females over males, yet issues surrounding communication / presentation skills and time were impartial to gender.

Method

Through the help of various sources, the program established by the ARDT was modified slightly to include a method to quantify results. At the NIHF, the students were asked to partake in a weekly program offered by the ARDT, where the program was pitched to the students as a way to participate in fun and exciting activities where they would also learn more about science and engineering. At the IPS, the selection process was conducted a bit differently. The time for the program was scheduled during the final period of the day, during a period allotted for various activities but mostly geared towards a free period. The teachers of each classroom selected a student that they believed to be deserving of attending the program, either through good behavior, good grades, or a combination of the two. The program itself for each school, though, was shaped the same way. The students were selected by teachers as being exceptional in class or showing a great desire to learn.

The program was run at the NIHF for 2 semesters while, due to the time to obtain administrative approval, the program was run for one semester only at the IPS. Each semester ran for approximately 7 weeks with variances due to both expected and unexpected time off of school, as well as ARDT member availability. The total number of students that participated in the NIHF activity over two semester was 29 with only several repeat students between the two programs. The number of students from the IPS totaled 12.

At the start of each activity, the students were asked to fill out a survey with questions asking their knowledge of engineers, what the students desired to be as they grew up, a rating of the previous activity, and a description of what was learned from the previous activity. The final version used each week can be found in Appendix A. Aside from the data gathered from the surveys, conversations with the students gave further insight into their understandings of the activities.

A variety of activities were completed over the course of the two semesters, with varying amounts of success for each group. A list, description, and how successful each activity was can be found in Appendix B, yet every week followed the same general format. Upon arrival, the students would, with candy incentive, take the aforementioned survey while waiting for the ARDT to finish the arrangement of materials. After the surveys were turned in, a presentation or explanation of the activity ensued where the students were asked about their understanding of the science relating to that activity. For example, during the slime activity, the students were asked initial questions about their knowledge of polymers. Through the presentation given and a form of the Socratic Method, the students came to the realization that they knew more about polymers than initially perceived.

Discussion

Data from the surveys was collected and can be seen in Appendix C. Through the surveys, individual responses were recorded that answered questions one through four seen in the sample survey in Appendix A. For question 3, the response was given a number, where if *A* was chosen, the number 3 was recorded. If the letter *B* was recorded, the number 2 was recorded, and so on. Through tracking the number value of each students' response, an average for each activity was taken to determine the quality of the activity. For the other responses, the students were asked to answer the questions posed in their own words.

Due to the age restriction of the students at the I Promise School, as well as the literacy level of the students, it was challenging to receive sufficient data to adequately measure the progress made with the students. Instead, the team spoke with the students to determine the understanding of the activities. The discussion also allowed for more questions to be asked as well as for a better understanding of the researchers and students alike.

For question one, different students understood and responded to the questions as they desired. For the sake of trying to get an honest response, the researchers did not interfere with the students' answers. Due to the lack of guidance, varying responses were found from each student. For example, student 1 did not appear to grow through the course of the semester with responses such as "Makes stuff" given almost every week. On the other hand, certain students showed growth each week after the activity and retained knowledge of the previous week. For example, student 20 began with the statement "(An engineer) does something to make life easier" and each week after talks about what he/she learned from the previous week, with statements such as "(An engineer) makes and designs towers" after the marshmallow tower activity.

With regards to the second question, it is believed that there is a flaw either in the question or in the operation of it from the unchanging responses given by the children week to week. For the most part, the students either gave the same response, admitted to not knowing what they wanted to do, or gave an ambiguous response (i.e. "A very successful person that makes a lot of money"). For the future, this questions should either be phrased differently or only asked at the beginning and end of the session to try and better gauge if an impact in career choice can be made.

The third question asked provides a quantitative insight to the activities given. As can be expected, some students enjoyed each activity much more than others. The general trend of their responses, though, show an overall level of enjoyment from the total group. The level can be seen in respect to the extremes with a maximum average of 2.47 for the slime and a minimum of 1.57 for the baking soda and vinegar rocket. It should be noted that the baking soda and vinegar rocket experienced issues that caused it to not operate as intended, proving to be a failed experiment. The overall average of the activities was 2.14, showing that the children, for the most part, enjoyed the activities provided. For the future iterations of outreach, these numbers and this method can be used to determine what changes need to be made to be more successful. Input from the ARDT presenters were also taken into account for each activity with suggestions taken into account for future iterations of the program. Feedback included suggestions such as changing from doing marshmallow bridges to towers, dropping objects other than eggs for the parachute activity, and more. Overall, suggestions were very helpful in improving the activities and teaching more about engineering.

The fourth question provided input on the grasp of the topics that the students had and how much the students were learning. For many responses, the students reiterated on what the activity was regarding (i.e. "That you can build towers out of marshmallows and toothpicks"). On a few different activities, though, the students were very responsive and understood the activity particularly well. For example, one student proclaimed that "borax is an activator" regarding the chemistry behind the activity. Certain activities had better results due to overall interest in the activities. The activities that the students enjoyed more typically showed an increase in retention from week to week, while those that the students were resentful of did not show any retention in learning.

Aside from taking surveyed responses, interactions with the students also provided insight to their understanding of the science and logic behind the activity. At the I Promise School, the students were engaged in activities that allowed them creative freedom while also guiding them to learn more about the engineering and science part of it. In the paper airplane activity, for example, the students were given a basic guideline to make the planes but allowed to make their own. During the process, basic guidance was given and suggestions on how to make the plane different. For example, it was suggested to add paper clips to the front half of the plane and then the back half to see a difference. The student concluded that the plane dived when the clips were placed toward the front, and was forced up too much when placed on the back. The student also concluded that if the clips were placed in the middle, the plane would fly just as good as before if not better. Similar points of revelation for the students occurred during the catapult activity as well.

Summary and Conclusion

Differences from child to child is inevitable. Each student has a distinct way of learning and will retain information not expected at all. Through the time spent at each different school, the ARDT worked with each student individually and obtained a lot of information. From the enthusiasm on a successful rocket launch to the disappointment of a failed slime experiment, the students withhold no opinion. Overall, the students proved that through a weekly program that STEM topics can be learned while still enjoying the activities that teach them.

As the responses from the students at the NIHF show, perception of engineering varies from student to student. Through the outreach by undergraduate engineers, though, the image of what an engineer does is expanded to ideas such as designing and building bridges, using chemistry to make materials that have various purposes, and even work with machinery and robots. The outreach performed at the IPS showed that students from all walks of life have the ability, even at a young age, to understand what being an engineer means and what work is done. The students at both schools learned about the methods of being an engineer through design, trial, analyzation, and redesign, showing innate abilities to actively apply the process without second thought.

Overall, the research proved to be beneficial not only to the students but to the researchers reaching out to future engineers and scientists. Enthusiasm from the researchers quickly spread to the students and made learning about various STEM activities straightforward and entertaining. It can be easily concluded that, while it may be difficult to determine what impact outreach has specifically, spending time with young students individually provides for a positive and constructive experience not only for the children, but for the researchers alike.

Recommendations

As mentioned by Carroll et al. [1], the time it takes to start a new program is immense. From initial idea to implementation of a compromised plan, a program as small as the one described can and will take at least 3 months to start, often taking an entire semester. It is recommended by this study to start a weekly meeting between all parties to create and implement a plan to start the desired program. As the plan is executed, it is of paramount importance to create and complete action items generated by the team. Along with this, it is important to determine as many obstacles upfront so as to mitigate as many issues as early as possible, due to the fact that motivation and discipline are tried more and more as time passes.

Obstacles that were seen from running the program varied. The first large obstacle began with determining effective methods to answer certain questions. Extensive research as well as contact with others that have done similar studies can help determine which questions suit the age and literacy of the students. Another obstacle found is getting research approval from the various IRBs required. It is recommended that this approval process be started as soon as the proposal is approved. The required materials for each IRB vary and need to be completed before submission. Although there are many more, the largest obstacle found was researching and modifying the different activities each week. Before the program is started, extensive research should be done to create a plan of each activity. After a plan is generated, each individual activity should be trialed for time to troubleshoot any issues that may arise.

Regarding the NIHF, a lot was learned from the students. The surveys that were passed out generated more resistance by the children the more they needed to be completed. By the final few sessions, each student complained about being asked the same or similar questions week after week. Because of the resistance, it is recommended that the first two questions of the survey be presented on the very first day and not brought back up until the very end. This would allow for the students to not become complacent when answering the questions and thus give more honest responses than otherwise found. Regarding the final two questions, due to their short time demand, they should be given out every week for the most accurate data on the activities. On the topic of surveying students, with the advent of technological advances provides opportunities to take responses electronically, drastically decreasing the analysis process of each data set while also providing an easier option to keep responses anonymous.

When performing the activities at either school, it was discovered that presenting some, if not all, material being learned after the activity was completed provided for a better understanding of key topics. If the students were given minimal instructions and allowed to discover different methods and ideas than initially provided, both the student and the researcher alike learned more about the activity. The concepts would then be cemented more due to the discovery of facts by one's own means cuts deeper than being informed of the same fact. For example, the first time a child is told the stove is hot, often he or she would not completely understand until personal discovery. The same can be said for scientific discovery.

With regards to the students at IPS, children at that young of an age either do not notice when their career choice changes or it changes so often that it is difficult to tell what they actually want to do. From that thought, a possible better way to gauge the impact made on the students' career choice is to design a study to look at their career choice upon graduation and compare it to a control group. Another method of analyzing the change in students can be seen from different instruments, like the ones mentioned by Diefes-Dux et al. The DAET might provide more insight into what a child is thinking but unable to articulate.

Though it is of good practice to have undergraduate and even practicing engineers give time to teach STEM topic to children, as mentioned by Pickering et al., ultimately it would be beneficial to expose young students to engineering topics/methods within the designed curriculum. The base knowledge of engineering could then be built upon by aspiring and practicing engineers for a benefit of all parties.

On the last day of meeting with the children, they were asked a series of questions about the program. Through this conversation, the students gave honest answers of what activities they enjoyed and which they did not, as well as thoughts on the program overall. After listening to each separate group, it was quickly communicated that all activities were good and informative with some more fun and exciting than others. It was also communicated that, if the activities were different and they were given the opportunity, the majority of students would participate again.

A final recommendation for an easier way to determine how students are effected by different forms of outreach is to track application, acceptance, and enrollment of students to the University of Akron after attending various STEM-based events held by the university or its affiliates, as done by Demetry et al.[2]. In addition to what has been done, tracking the graduation rate and degrees, as well as extracurricular activities and motivations, could provide insight to the effects of outreach, as well as methods to give young students the best tools and opportunities to succeed.

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Appendix A

Below is a sample of the survey used to gather the data from the children. Although the data was gathered from this, more about the children's understanding and knowledge came from interactions with each individual.

Name: ________________________ Date: _____________

1) What work does an engineer do?

____

____

____

____

2) What do you want to be when you grow up?

____

____

____

____

3) How much did you like the activity?
   a. It was the best
   b. It was great
   c. It was okay
   d. I didn't like it

4) What do you remember from last week's activity?

____

____

____

The above survey is to be completed voluntarily, and the findings from the study in no way represent the philosophy and beliefs of the Akron Public Schools school district.

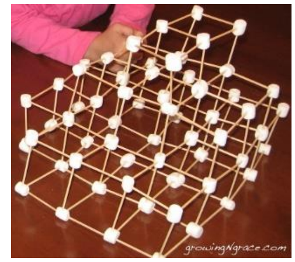
Appendix B

Table 1 – Description of activities performed with the students. Additional activities were done with the students but they included other design team projects.

Activity name	Description / Successfulness	Materials	Average Student Rating (0-3)	Picture
Paper Rockets	The students are tasked with building rockets out of paper and other available supplies. Through examples, there are recommendations that can be made, but three absolutely necessary parts to the rocket are the nosecone, fins, and body tube. These are not only the parts that help the rocket fly, but provide a good Segway into the different parts of a real rocket. The constraints that need to be met are: the body tube needs to have a big enough diameter to fit around the launcher and the rocket needs to be a sealed vessel. Otherwise, the children should be given freedom on how to make it. If time allows, iterations on building is recommended so the children can determine what the best attributes are. Overall the activity has been a resounding success throughout a variety of students once the rockets start to launch. Each student wants to fire off the rocket multiple times, which should be allowed if there is enough time.	Minimum: Paper and launcher. Other materials can include toothpicks, Popsicle sticks, and any other arts & crafts supplies	2.41	

Baking Soda and Vinegar Rockets	Students are tasked with making a rocket that has the best aerodynamics to fly the highest and/or has the correct amount of materials added. The water bottle should be filled with a known amount of vinegar and the baking soda should added. The team found that making a "packet" of baking soda by wrapping a pile of the material in a porous cloth (i.e. tissue paper) was a good way to delay the reaction slightly. After the baking soda is added, secure the cork to the "nozzle" and turn the bottle upside-down. Stand back and watch the rocket fly. The only requirements by the design is that the rocket must be able to stand freely with the nozzle facing down and off the ground. This can be easily achieved by gluing Popsicle sticks 120° around the body of the water bottle. The students can also try to determine the amount of vinegar and baking soda they should add by performing another experiment to see what builds the most pressure. This would also be a good introduction to chemical safety and PPE. NOTE: Can be a bit messy. Be sure to do experiment outside or with clean-up in mind. Overall the activity has not been very successful. The corks either work too well and stop the rocket from launching or let the liquid out before building enoguh pressure. Further investigations into more consistent ways to release the pressure all at once should be done before bringing the activity to students.	Baking soda, vinegar, water bottle, cork, and desired materials to make the bottle more aerodynamic	1.57	

Slime	Students are tasked with making a material that is non-Newtonian in nature by the addition of water, borax, and Elmer’s glue. The team should create a super-saturated solution of borax in water by heating up the water and adding borax until it does not dissolve anymore. After that, the best slime is made by adding one part water to one part glue, and adding a little borax to the solution at a time until the desired consistency is found. The slime should be made in a plastic Zip-Lock bag to allow the children to adequately mix the contents without getting too messy. The team found that clear glue works the best, while adding a few drops of food coloring to the mixture allows for the desired color to be made. A challenge can be designed by bringing in different alternatives to water, such as soda, tea, coffee, etc. The team tried various materials with varying results. The only material that did not work well was vinegar, of the materials tested. NOTE: Can be messy, should be done with clean-up materials around (paper towels, soap and water, etc.) Overall this is typically a favorite of the students, largely due to the creativity that is allowed with the activity. The activity also teaches a lot about chemistry that "sticks" to the students.	Elmer’s glue (clear if available), borax, water, food coloring (if desired), other alternatives to water (if desired)	2.47	

Toothpick Towers	Students are tasked with building a tower out of toothpicks and marshmallows. It is beneficial to show the students ideas for the designs, such as cubes and other supported 3-D shapes. Some challenges to consider are giving them a limited amount of materials or challenging them to work as a team to build the tallest free-standing tower possible. Alternative task can be to have the students build a bridge and see what can hold the most weight. NOTE: Children will have strong desire to eat the materials. Solution was not found to completely mitigate this. Overall, though, the students enjoy this one so long as a vested interest or goal is made. The students like to see how their towers or bridges shape up, especially when a competition is involved.	Marshmallows, toothpicks	2.00	
Parachute / Egg Drop	Students are tasked with building a parachute to slow the fall of a specified object. The students should be given scrap/spare parachute material (if available) or plastic bags to cut and modify. The students should then attached the parachute to the desired object using string. The team used several different objects, such as eggs and matchbox cars. The eggs were wrapped in plastic wrap and then placed in Zip-Lock bags to reduce any mess or potential premature breakage of the eggs. The team found that using hot glue to keep the parachute together worked the best, and hot gluing the string the parachute held well. To challenge the children, the drop tests should be timed to determine whose parachute had the least impact force. Overall the activity has been a success. Students like to drop things (unsurprisingly) and thus enjoy dropping the egg. The students also like to see the eggs fail.	Weight (egg, matchbox car, etc.), parachute material (or plastic bag), string, hot glue or tape	2.29	

Catapults	Students are tasked with creating catapults out of Popsicle sticks. The students should be able to create the catapult based on the designs shown. Once the catapult is made, it should be set next to several meter sticks laid down in a line and the students should launch different materials given to determine what flies the farthest. They should also try to determine an explanation for what some objects flew farther than others. This is also a good opportunity to talk about potential energy and how the catapult can be improved. Overall the students do not enjoy this one as much, though it is believed that this is due to the pitch and lack of any true goal in mind. In the future, the students should be shown different ways to be creative (i.e. longer launch stick).	Popsicle sticks, hot glue, rubber bands, bottle caps	1.88	
Paper Airplanes	Students are given materials to make the paper airplanes. The materials could include cutouts and places to fold, or just blank sheets of paper. The students, if not known already, should be shown how to make different styles and versions of the planes. Different sizes can also be made for comparison on the ideal size. The students should then throw the planes to determine the farthest distance and see what factors affect it the most. Another point to show is how weight effects the flight by putting paper clips on the front or back of the plane. The paper clips provide enough weight to bring the nose down or pull the nose up. Doing various placements of the paper clips can also show the best amount of weight needed to go farthest. Overall the activity is successful for some and boring for others, depending on attention span. The activity should be improved by adding more substance.	Paper, Paper clips	N/A	N/A

Photo Credits

Green Slime. Digital Image. *Our Best Bites*. https://ourbestbites.com/kids-in-the-kitchen-slime/

Sample Baking Soda and Vinegar Rocket. Digital image. *We Know Stuff*. https://www.weknowstuff.us.com/2016/06/baking-soda-rockets-for-kids.html

Toothpick Tower. Digital Image. *Tes Blendspace*. https://www.tes.com/lessons/QlrBnixuyJ_p2g/begin-with-the-end-in-mind-building-a-marshmallow-and-toothpick-tower

Egg Parachute. Digital Image. *Pinterest*. https://www.pinterest.com/pin/553731716658393197/

Popsicle Stick Catapult. Digital Image. *Little Bins for Little Hands.* https://littlebinsforlittlehands.com/popsicle-stick-catapult-kids-stem-activity/

Appendix C

Table 2 – A sample of the raw data collected. The remainder of the raw data can be found in the embedded file.

Event Date	1-Oct			
Name	Q1	Q2	Q3	Q4
Student 1	Makes stuff	-	2	How to make a nosecone
Student 2	Builds or fixes electrical or mechanical equipment	forensic scientist	3	How to make rockets
Student 3	Make stuff	Basketball player	2	How to make rockets
Student 4	Designs things and builds stuff	Not sure	1	Flying rockets are a thing
Student 5	-	-	-	-
Student 6	Build and design models	Engineer	1	Nothing
Student 7	Builds cars	Engineer	3	Nothing
Student 8	Design stuff	Engineer	3	How to make rockets
Student 9	-	-	-	-
Student 10	Works on engines	Police Officer/CIA	3	Stuff about rockets
Student 11	They design	an animator	3	how to shape up my rocket and form it
Student 12	Designs things to help people and life/discovers things to make the world better	Author/illustrator, space jumper, artist, hunter, video game design	0	Nothing
Student 13	-	-	-	-
Student 14	Make something to solve a problem	computer engineer	3	How to make rockets
Student 15	Build bridges and new technology	Game designer	3	To be creative
Student 16	Make models and test things	Surgeon	2	About nose cones
Student 17	Build and create stuff	Baseball player	3	-
Student 18	Design, create, and engineer	Aerospace engineer	3	Nothing
Student 19	An engineer designs	Artist	3	What the nose cone and fins do
Student 20	Does something to make life easier	Astronaut	3	If you need help ask a friend

File of raw data:

Thomas Cobb
Honors Survey Resp