

Developing A Fifth Grade Lunar-Themed Science Curriculum Unit

An Interactive Qualifying Project Report:
Submitted to the faculty of the
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science

By:

—
Minkyu Lee (RBE/ME)

—
Jake Schomaker (AE)

—
David Irwin (AE)

Approved:

—
Prof. John Wilkes, Advisor

This report represents the work of three WPI undergraduate students, submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review.

Abstract

Our project, at the bare minimum, was to develop an alternative science curriculum for a fifth grade class at Elm Park School, a public elementary school in Worcester. The current science curriculum consisted solely of the students reading the chapters of the textbook out-loud to each other. They read over lab experiments in the book, but rarely performed them, nor were the students permitted to take the textbooks home. We felt this was an inadequate way to teach and inspire interest in science and technology. Therefore, the first objective of our project was to develop a science curriculum that would still cover all of the concepts in their text that would be covered on the MCAS test in the spring, but would be more interactive and engaging, or at least interesting. Our belief was that if we could make learning more relevant and full of surprises, the students would better retain what they were being taught, and perform better on the MCAS than their peers. We also wanted to change their image of science and make it the “fun” class that did not rely so much on the text. We wanted them out of their seats and doing things in groups, or at least seeing dramatic illustrations using props. Ideally, they would participate in designing a lunar base, despite the fact that their text made it seem like it would be impossible to live there.

However, our project was also conceived with much greater potential in mind. The best-case scenario would be that our project would increase interest in science and technology, raise MCAS scores, and to expand our project beyond the one class we were working with. We hoped to make a strong case for disseminating our project’s core idea of a one-month break from the text to talk about science with a thematic focus to more schools in Worcester, or even to schools in other cities via the AIAANE network. While our first responsibility was to the one class we were working closely with, we also maintained the goal of creating a base of interested students in Worcester that would pursue STEM-related career fields. To this end, we also had the goal of having our alternative curriculum having

a lunar theme to it, as all basic science concepts would apply to a base on the moon. Biology, chemistry, physics, anatomy and physiology just to name a few, would all be critical understanding how a base on the moon would work. We were creating a small Earth-like biosphere in an alien environment and explaining why something that would be a threat on the Moon would not be a threat on Earth.

Our project culminated in a MCAS Review Day, held at WPI. It would have tours of the library and some of the labs for our partner schools, a lecture from a guest speaker we wanted to bring in, and seven other “stations,” covering everything from a lunar greenhouse and an expedition from the south pole of the moon to its equator (to check out a suspected cave in the Marius Hills), to different types of robots that could be used. On this day, we brought in seventeen 5th grade classes from seven different elementary schools. We also went to one other school separately that could not attend the event, since they responded after the set deadline. We did the design review station with them. They also got to see a videotape of Dr Fred Bortz’s presentation at WPI and at the request of their robot club, got to see a few of the smaller robots Minkyu displayed at MCAS Review Day. They did not get to run them and did not get to see Moonraker, but Minkyu had a video of Moonraker in action to share with them.

All the three events, MCAS Review Day, Bortz in the classroom, and McAuliffe Center, were successful. However, our MCAS Review Day provided the most educational value for its cost. Of the seven schools that participated, six gave extremely positive reviews while the seven gave mixed reviews. The teacher we worked most closely with was tremendously pleased and sent our advisor the following email, “Hi John we would appreciate 60 copies of the MCAS review. It is a great piece of work and is beneficial. Also, is there a time when you and the guys could come in for a final visit? The kids want to make cards and present them for all of your hard work. Fran.”

Contents

Abstract.....	2
Introduction	6
Problem Statement.....	6
Project Statement	7
Background and Related Works:.....	8
The Space-Theme Science Project	10
Engineering Design Project	11
Introduction	11
Background Research.....	11
Methodology.....	13
Earth and Moon Lesson	17
Introduction	17
Methodology.....	17
Result	18
Crater Activity	19
Sound and Light Lesson.....	21
Introduction	21
Methodology.....	21
Periscope Making.....	23
Results:.....	27
The Rock Cycle Lesson	30
Introduction	30
Methodology.....	30
Result.....	32
Force Lesson.....	33
Materials	33
Introduction	33
Methodology.....	33
Result	35

Lunar Base at Elm Park School	36
Introduction	36
Solar Flare Group	36
Robotics Group	38
Expedition Group	38
Dr. Bortz at Elm Park School	40
MCAS Review Day	44
Introduction:	44
Methodology:.....	44
Conclusions and Recommendations:.....	54
Trip to the McAuliffe Center	58
Results, Conclusion and Recommendations for Future Project	60
Completion of Project Objectives	60
Appendices.....	63
Teacher, Principal, and Student Feedback.....	63
CORI Request Form	67
Verizon Grant Application.....	69
Proposal	69
Conclusion.....	70
5 th grade MCAS review day, Plan and Schedule for Each Activity	71
MCAS Review Day Comprehensive Study Sheet.....	73
Impact of Asteroid - Handout	80
Elm Park’s Standard Science Curriculum Schedule.....	84
Melting Points of Some Metals and Alloys	85
Flyer for Dr. Alfred Bortz.....	86
Photos	87
Bibliography	89

Introduction

Problem Statement

The science curriculum for 5th graders in Worcester consists primarily of reading from the text book. This is the case even in a class like the one we observed, which had the advantage of a teacher well versed in science and exceptionally interested in science and space, Fran Mahoney. We were shown the schedule he felt compelled to follow and when we asked to mix the plant and light sections to fit our lunar base theme, this created a problem. They were scheduled to be done in different terms. We needed the permission of the principal to depart from the plan to this degree.

A few teachers add some more than just reading since activities are suggested in the text, but most do not. Fran did make the effort, requesting a rock collection kit that the system had so that he could actually do the streak and harness, color etc. Activity suggested in the text. However, we waited two weeks for this equipment, again got out of order and stressed about how that would create problems later, though he was determined to get and use this hands on class enhancement. Few teachers are this committed to actually doing some science. They just stick to what the curriculum coordinator in science, acting for the curriculum committee and following the State science curriculum frameworks, suggests as what chapters should be covered during the year, in what term and preferable in what order. This is because they are pressed for time and must hit their deadlines to cover the materials likely to appear on the state achievement test. The problem with this is that it creates a dull curriculum for the students and when science becomes just another class reading class one risks losing their interest and the chance to do some critical thinking and logical problem solving exercises. If the students are not interested in the material, they will not learn or at least not retain everything they need for the MCAS or master the foundations for more advanced material.

Project Statement

We aimed to create a 5th grade science curriculum that would catch the interest of the students and entice them to learn more. We decided that an interesting topic already well developed by prior WPI student work was a lunar theme for this curriculum. This would also allow us to draw on our background in the topic from the recent SHIFT Boston contest. The curriculum would be still based on the book and cover everything the students need for the MCAS. However, ours would incorporate more hands on activities as well as in class work from the textbook. The activities would allow the students to learn how the topics from the book relate to real world objects. With this addition to the science curriculum we expected the students to learn more than students just reading out of the book with no hands on activities.

Our project involved teaching and stimulating interest in the areas of science, technology, engineering, and mathematics (STEM) among fifth-grade students. We worked closely with one fifth-grade class (Teacher Francis Mahoney) at a public elementary school in Worcester (Elm Park), developing a new science curriculum for them for two months of their school year. Our curriculum was developed using their textbook, covering concepts that would appear on the Massachusetts Comprehensive Assessment System (MCAS) test in the spring of 2011, while enriching the science program by incorporating a lunar-base theme and hands-on experiences. We also explored how to best use \$1,000 that the American Institute of Aeronautics and Astronautics, New England Chapter (AIAA NE), had voted to use to supplement the public school science curriculum each year, such as by going on a field trip or bringing in a guest speaker. The ultimate goal of our project was to determine if our modified curriculum engaged and excited students about science; but we knew that if the program was to continue, it also had to better prepare students for the MCAS test than the curriculum currently in place.

Background and Related Works:

Our greatest asset was the knowledge and experience of Professor Wilkes. He helped tie everything together with his background based on past IQP projects and his standing as chairman of the AIAA New England Chapter. With this history Professor Wilkes pushed for our project to do well knowing that within the past fifteen years, WPI IQP teams have only conducted two other community outreach projects that have had a noticeable impact on the city. The first, in 1995, was a major study done that created a database on cognitive learning styles that showed a bias in the SAT (and later MCAS) test. In 2004, a student team conducted a gender comparative study of the aspirations of Worcester high school students, which created a program for 11th grade girls interested in science and technology that was run for three years. It too involved a day at WPI, and a tour and visiting “stations,” one of which was robotics, but without the lunar theme or tie to the science curriculum. That program faltered since WPI was called upon to pay for the buses from each High School in Worcester. We learned from this and insisted that each school provide its own transportation to come to our event- and they did. They considered it a bargain, since there was no entry fee by the student as there is at a museum. We asked that they be prepared to spend \$100/class to pay for the speaker expenses only. Then we wrote a grant proposal and managed to get that paid for them after all, but they would have paid that much to come, and that was the point.

Even though only two other teams have recently conducted successful community outreach projects, other than our group, many IQP projects pertained to our lunar base topic. This is where Professor Wilkes wealth of knowledge proved to be an invaluable asset. In the past five years Professor Wilkes personally advised six IQP teams with topics related to our lunar base theme which include; “Harvesting He-3 On The Moon,” “The New Moon Race: Lunar Agriculture,” “Lunar Property and Mining Rights,” “Sustaining Agriculture on the Moon,” “The Educational Case for a Simulated Lunar Base,” and “The New Space Race Initiative.” He brought the data collected and conclusions by all of these groups to

our group to our use without having to read them all, except our immediate predecessor project “The Educational Case for a Simulated Lunar Base”. This project produced the table top lunar base model we actually used to cap off our class. He knew the pieces were there for our project. He just had to help us put them into place by advising when our group didn’t know how to proceed; the professor used the prior teams’ successes and failures to guide us in the right direction.

One of these pieces was extremely important, “The Educational Case for a Simulated Lunar Base.” This project took place in 2010 and dealt with building a model lunar base and determining the educational value of the lunar base theme. This is important to us not just because the model was used in an event for our project but because it was tested at Elm Park Elementary School. During the project, the team and Professor Wilkes developed a good relationship with the school. Using this relationship, Professor Wilkes easily worked it out for our curriculum to be tested in Elm Park. This prior project also allowed the professor to see how a field trip to the New England Air Museum runs. With this background, we used him to help compare useful information to determine the best way to spend \$1000 for a field trip.

Professor Wilkes also provided us with a key note speaker for our event, Dr. Fred Bortz. Over the summer he was visiting his son in Pennsylvania and the two of them went to a book fair. At the book fair, Professor Wilkes came upon a book for 5th graders by Dr. Bortz, who he didn’t know at the time, which looked very interesting. The two of them started talking and from this conversation came our key note speaker.

On top of all the previous duties, Professor Wilkes also served as our ambassador to the AIAA New England Chapter. Talking with them throughout our project, he was able to secure us a small amount of funds. These funds would go a long way for the success of our project. We could buy demo equipment, toys, and would not be short of hands-on craft experiment materials or money for a field trip or speaker.

The main scheme behind the background of our project was Team Goddard's Lunar Base design for the SHIFT Boston contest. Our team, especially Professor Wilkes, was a part of the design team. The contest was to design a lunar base that could house 60 people in 2070. The people would have to be able to live there for one year so all the basic supplies must be produced there to ensure their survival as well as paying for itself in a trade system. With our knowledge of the lunar base, later known as Craterville, we based the entire curriculum around the base.

Interdisciplinary themes have little place in a battle for space in the science curriculum between Earth science, Biology, Chemistry and Physics, although the technology educators have carved out a space for technical design and some problem solving questions. We think we hit all these bases and did it in dramatic style, working space science (other than astrology) back into the curriculum from the modest beachhead of three pages we had in the text on the moon. We even changed the message of these three pages in the text from the moon is empty desolate and hostile to life, to an engineering challenge that can and will be met by our generation or that of the 5th graders coming along next. Furthermore, in space terms, the moon is resource-rich, and will critical to the emerging space trade system driven by liquid-oxygen (LOX) and Helium-3.

The Space-Theme Science Project

When we started our project in September, our faculty advisor first had us assist "team Goddard," produce graphic art displays. This team was designing a second-generation lunar base for an architectural competition run over the summer by an organization name Shift Boston. There were about one hundred entries from all over the world and this base concept would go on to tie for first in the "technical feasibility and elegance" prize category. Our advisor felt that by working on simple visual presentation for the lunar base project, it would give us a background vision of the goal and practice in the art of conveying technical concepts without lots of words. This would greatly increase our

understanding of how to teach science concepts using illustrations from both the moon and Earth. Teaching about the atmosphere is far more interesting when compared to the moon's lack of an atmosphere, and learning about how much our atmosphere protects our planet from meteors and solar radiation.

Engineering Design Project

Introduction

Objective: Let 5th graders experience Engineering Design Project from the subject of Weather based on real disaster from the past. Can they use things that would have been lying around on the island of Galveston at the time a hurricane flooded the island, first cutting them off from the mainland and then sweeping over the whole Island. 8000 lost out of 42,000 residents.

Topic: Galveston hurricane weather disaster- worst incident

Background Research

- Occurred on September 8, 1900
- Biggest city in Texas at the time, Capital, 42,000 residents
- Tropical storm is observed going through Cuba but ignored
- Picks up strength over the Gulf of Mexico
- Head of Weather Bureau Isaac Cline thought Galveston would not be harmed so no preparations were taken.
- Hurricane hit Galveston and was measured as a Category 4
- Created a 15 ft swell that leveled the city (highest elevation in Galveston is 8.7ft)
- About 8,000 people killed
- Very little fresh water and food left after hurricane

- Relief arrived from the U.S. Army a couple days after the storm- but the city would never be the same. Capital moved inland. Rebuilt as much more of a seasonal resort area

Methodology

Materials:

Subject	Materials	Budget
Lumber	Popsicle Sticks	\$1
Small Lumber	Toothpicks	\$0.69
Pipes	Straws	\$2
Rope, Chain, and Cable	Yarn (White, Gray, and Black)	\$9.97
55 gallons of drums	Gummy Bears	\$0.99
Mortar	Play-Doh	Around \$8.00 of materials
Fish Netting	Nylon-Mesh	\$7.99
Cinder Blocks	Legos	\$14.98
Logs	Styrofoam (Round insulation)	Could not get the materials
Other things you would "find"	Make them out of Play- Doh	
Total		\$45.62

Story: You live on an island, and a hurricane with a low pressure area in the center has created a huge tidal surge that is coming towards you. Since there are no hills or mountains, the entire island will be underwater for about 8 hours after the wave hits it. There are some 2 story buildings and trees, but nothing higher than that, and there will be things picked up by the water that will be like battering rams when the waves sweep over the land. Few buildings will survive.

There is a junkyard near where you live, with a bunch of logs, boards, barrels, rocks , 50 gallon drums, pipes, ropes and chain and cable and others things you might expect to find there. Of course this is an

island so there are fishermen with nets and small boats, and some bait and other fishing supplies there. Using the junk, docks, house parts, fishing supplies etc., you and your “housemates” must build something that will float and keep you alive for a few hours until the water level subsides and you can go back on land. Keep in mind that the island will be destroyed, salt water in everything- including all the wells so anything you will need to survive until help comes in 2-5 days , you should try find a way to keep some supplies safe and secure so that you can find it again. Further you have to keep from being swept out to sea or crashed into the shore by hurricane winds which tend to travel in a big circle, but die out over the land. So, you can’t be sure they will bring you back to where you started if you go out to sea and the closer waves get to land the steeper they are and then at some point they “break”. Where will you go? What kinds of things do you need to live? How could you store or protect those things?

Time: Total of 45 minutes available. First 5 minutes will be introducing background and question. After that about 20 minutes will be used for doing the craft activity in 10 teams of 3 each. Then 2- minutes per team for telling what they decided to do to the rest of the class (20 minutes). . Rest of available time will be getting feedback on how good their chances of survival were and going over the results compared to the solution of the science assistants, who had to come up with one to be sure it was possible.

Results: 5th grade students were enjoying and participating very eagerly to the activity. There were very creative ideas from the activities such as building a bunker (with a platform on stilts) instead of building boats. There was very specific design comes out that we were thinking as our answer to this question. Kids were partially understanding materials and learning from the activities. One group comes up with great idea of using a pre-positioned anchor and rope (and another idea of using a fish net to hold canvas in a form that would work as a sea anchor) to stay on or near the island and lots of group starting to adapt this idea when we point it out this is good design. However, most were going to use a sail or oars

to get back. There were differences in ability in each group and not all the groups developed a good design in this activity- but they all saw the elements of a good answer. Also there were few problems arises from the use of materials. Instead of what we intended for materials (Gummi bears, Lego) are used for different intention. This was showed from most of the groups. Also nearly all the groups use Play-Doh as their base for a boat design instead of using Popsicle-stick or toothpick to build a raft. However, given the time constraints from warning to inundation there would not be time to build a shaped boat. We wanted them to use the Play-Doh to hold things together, not build, but only those teams closely supervised by one of us made that adjustment.





Earth and Moon Lesson

Introduction

Objective: Let 5th graders learn the knowledge more about Moon how they are different and similar to the moon.

Topic: Earth and Moon

Sub Topic:

- Similarities and difference between Earth and Moon
- Phase of the moon
- Eclipse (What and Why)
- Vocabularies : Moon, Crater, moon phase, eclipse, refraction

Methodology

Plan:

- If reading assignment is possible, we will be more flexible to teach what we want to teach
- To teach the “Phase of the moon”, we will make small activity description is under
 1. Person in the center another person holding the ball half colored black and half colored ball yellow. Sun could be person or just location.
 2. Demonstrate Moon phase by rotating around the person.
- Also from demonstration, teach how and why eclipse works.(Show pictures of eclipse)
- Vocabularies : Moon, Crater, moon phase, eclipse, refraction
 - Teaching Vocabularies through books and reminding them occasionally.

Activity: The Crater Making Activity detailed plan is on the next page.

Materials:

Subject	Materials	Budget
Round (Colored)	Rubber Ball or Balloon	Free
Pictures (Eclipse, Crater)	Each Picture Printed by 4 A4 papers.	Free
For Activities	Specified on other page	

Time: Total of 45 minutes available. First 5 minutes will be introducing background and question. After that about 10 minutes will be used for reading and reviewing the materials from the book. 15 minutes demonstrating and explaining Lunar Phase system using colored ball. Last 15 minutes going over the materials such as fill in the table or questioning them.

Result

This lesson was the first one we taught, and so was our trial-run. Here was the first time we taught a class, and observed how much attention the students' paid to us, how engaged they were, and how well they absorbed the material. We found that since in that past, all they had done for science class was read from the book, absolutely anything we did was new and exciting. While we taught them the vocabulary in the book, we brought in props to illustrate concepts. We brought in different size spheres to simulate rotation and revolution of the moon, Earth, and sun, and discussed how the same side of the moon always faces the Earth. Sometimes, however, the students were so excited by our visuals, props, and activities that they didn't always pay attention to what we were trying to teach.

Crater Activity

Introduction

Teaching the students how craters are formed and how crater size can be different.

Methodology

Requirement Materials: Flour, Marbles, Large Ruler, Smaller Ruler, Deep Plate that will contain Flour

1. Spread and clear out Flour on plate.



2. Drop the marble at 20 cm, 40 cm, and 80 cm.



3. Measure the crater made by dropping the marble.



4. Repeat drop from each height 3 times.

Result

Result of the test from methodology. We have done test three times of total 9 times of each height.

	Trial 1	Trial 2	Trial 3
20 cm (1)	1.9 cm	2.1 cm	2.0 cm
20 cm (2)	2.2 cm	1.8 cm	2.1 cm
20 cm (3)	2.2 cm	1.9 cm	2.2 cm
Average	2.1 cm	1.933 cm	2.1 cm
40 cm (1)	2.4 cm	2.5 cm	2.5 cm
40 cm (2)	2.3 cm	2.6 cm	2.4 cm
40 cm (3)	2.4 cm	2.3 cm	2.4 cm
Average	2.367 cm	2.467 cm	2.467 cm
80 cm (1)	2.8 cm	3.0 cm	2.7 cm
80 cm (2)	2.9 cm	3.0 cm	2.9 cm
80 cm (3)	2.8 cm	3.1 cm	2.8 cm
Average	2.833 cm	3.333 cm	2.8 cm

Average of each result: 20 cm height – 2.044 cm

40 cm height – 2.434 cm

80 cm height – 2.898 cm

Sound and Light Lesson

Introduction

We aimed to teach 5th graders about the characteristic of light and how to bend, magnify, reflect, and refract light through a lesson and an activity. This was achieved by first, going through the text book and teaching the students the basic concepts and characteristics of light. These concepts included magnification, reflection, and refraction. Once the concepts were understood, they were demonstrated by allowing the students to look through the prepared materials. The final activity, which tied into the lunar base, required the students to use all their knowledge of light to accomplish the goal of growing plants in an underground greenhouse.

Methodology

Materials:

Subject	Materials	Budget
Magnifying, Refraction	Binoculars, Magnifying glasses, Refraction glasses	\$25.00
Reflection	Side watching Binoculars, Periscope	\$25.00
Plant and Light Bending Activity	2 Plants, 1 Box with nothing added, 1 box modified with three periscopes in the top and a light source curtain	

Lesson:

A total of 45 minutes of class time was available. We will be using the first 10 minutes to explain basic characteristic of light by going through the book looking for concepts. Next divide the class into three groups and pass around binoculars, magnifying glasses, and other prepared materials. Individual instructor goes to group. Have the group guess how many mirrors are in the periscope and kaleidoscope

then explain how light behavior inside the device and what feature of the device is enabling their function. Every 5 minutes pass the materials to a new group and start process over again.

Plant and Light Bending Activity

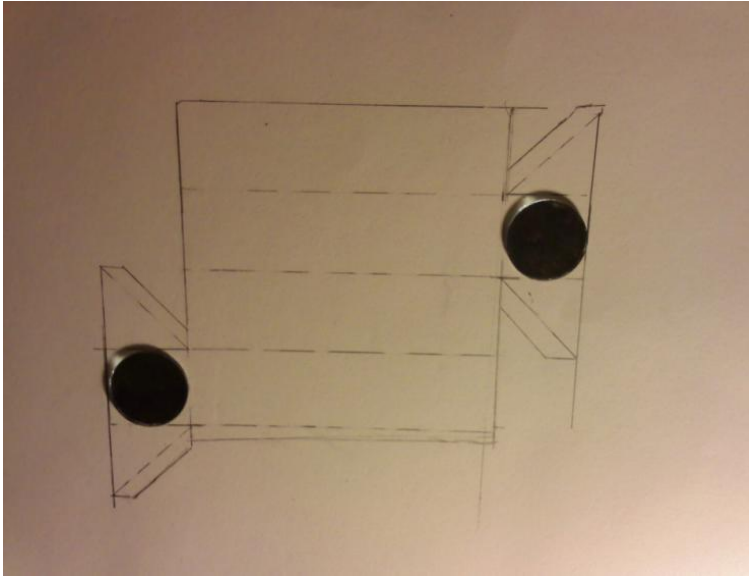
Introduction

This activity tied the lesson into the lunar base theme of the curriculum. It also required the students to use everything they learned in the lesson to create a hypothesis to what will happen.

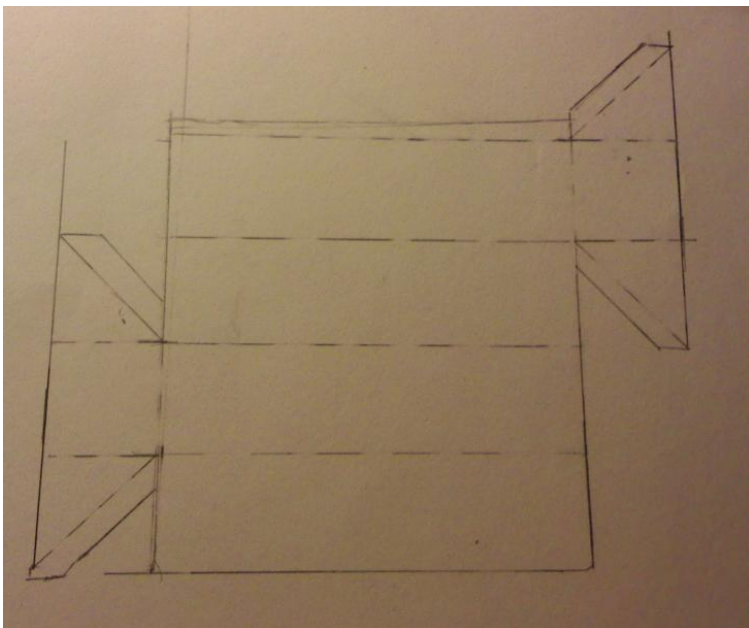
Methodology

First make three periscopes, the directions on how to make them are on the next page. Next cut three holes in one of the boxes and insert the periscopes. Attach the periscopes securely to make sure they won't move once in place. Then say before we put a plant in here we have to know how to direct the light where we want it to go. Allow two students to work together, one with head in the box, but off to the side and the other to shine the light through the periscopes. The inside plant person reports where the light is going in each case though it always comes from the same side of the box. Next they decide whether to have the students all take turns with these roles or move on to directing the light to a prearranged spot where the plant would be put. This is done by having one student putting his head in the light source curtain and telling what way to turn each periscope. The second student follows the first's directions and turns the periscopes to point the light at the plant. The plant in the box activity is ready to begin and will take weeks to complete. The students should check on the plants regularly to get an accurate timeframe of when each plant dies. Also, the plants should be watered regularly. It will take a while before the carbohydrates stored in the roots are exhausted and the inability to produce more will take its toll. In the actual experiment there are two boxes, one with all the light access areas taped and the other with a single large periscope in place to throw light on one of the plants that is otherwise in the dark.

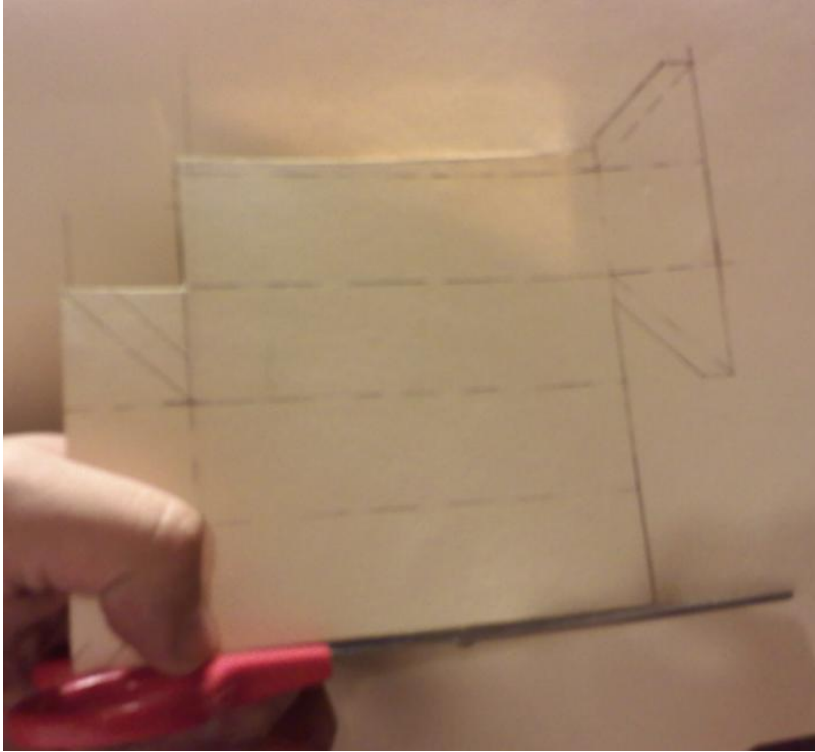
Periscope Making



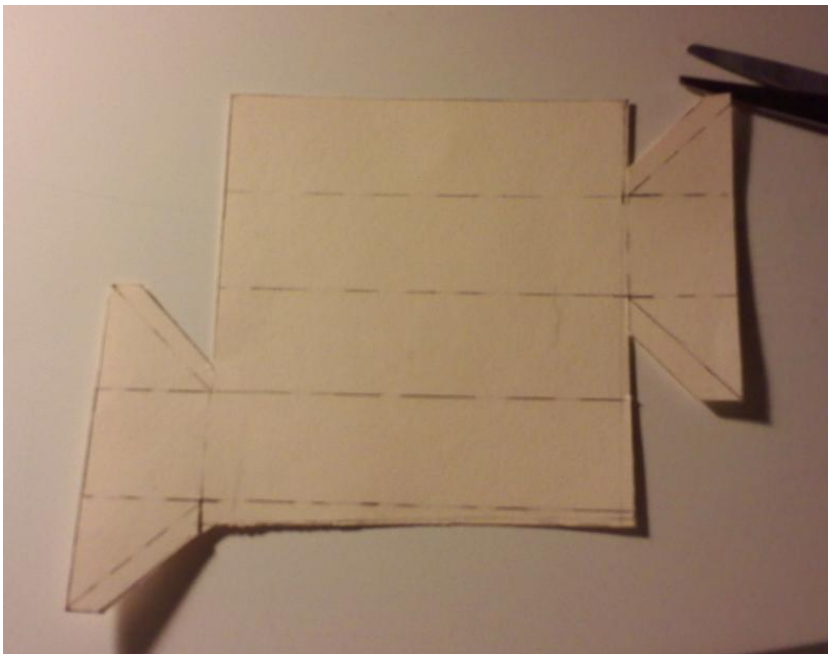
1. Draw the line according to dimension of mirror



2. Finished drawing



3. Cut the bold line only. Do not cut section line



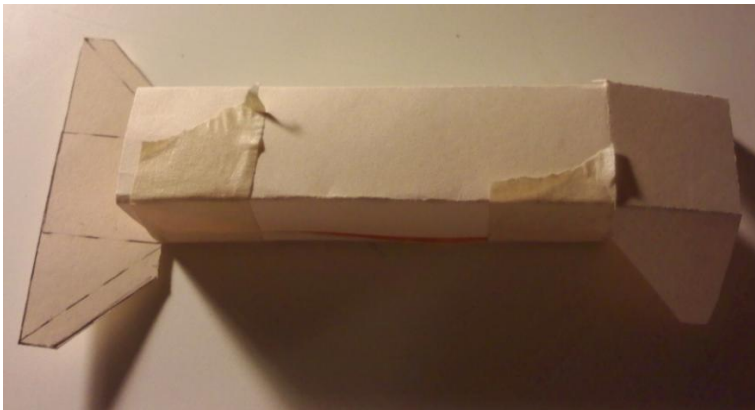
4. Finish cutting



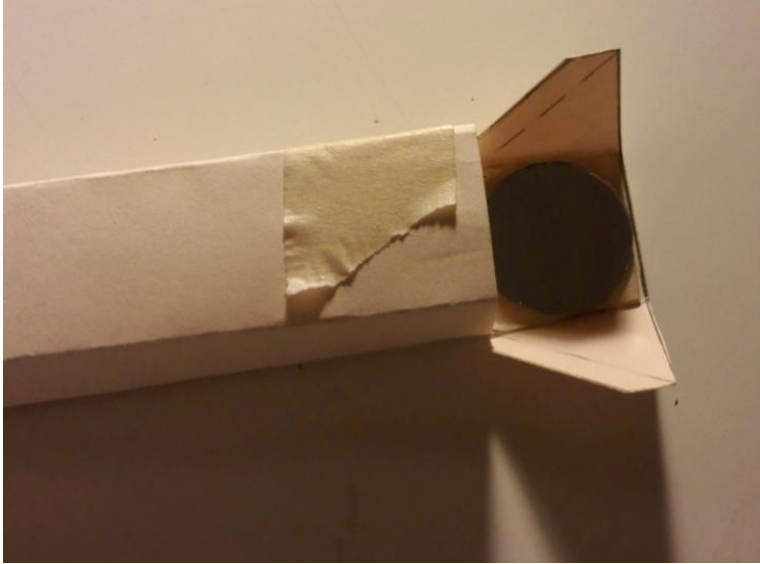
5. Fold section line



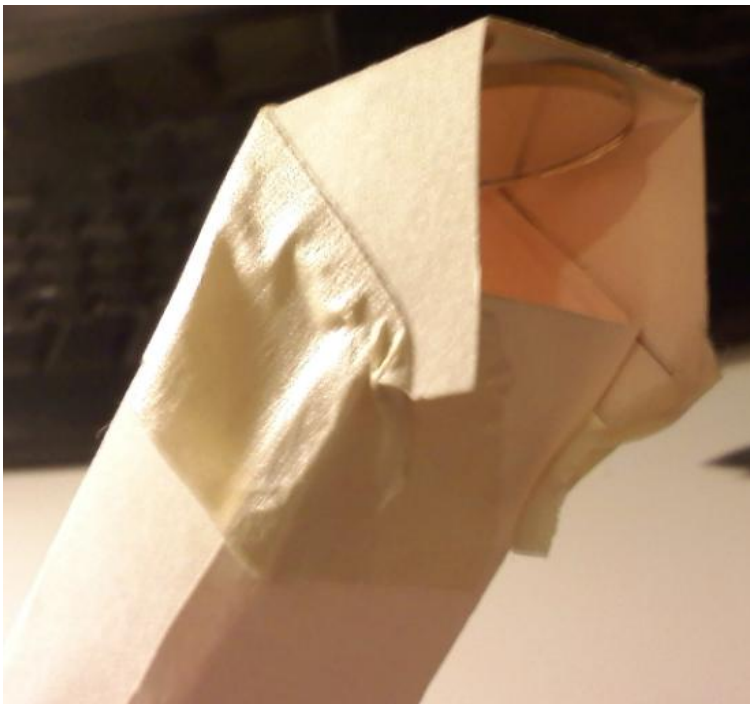
6. Finished folding



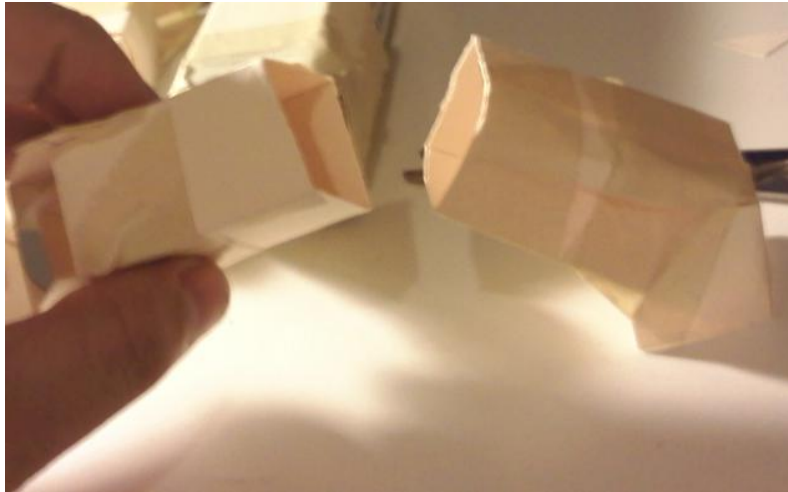
7. Tape the edge



8. Attach mirror



9. Tape the top edge



10. Cut the middle part



11. Put them together using hole

Results:

Students were very excited and interested in the lesson and what we brought. They got slightly distracted by the fact they had cool lens and mirror toys to play with, but they understand basic concept through playing around with it. They got more clear understanding toward how can light be bent or reflected through glasses and mirrors and by combining them they can make binoculars or periscopes of their own. Thus they do not have to take apart the toys to understand how they are set up inside since they can duplicate the effect. . After the students understood that light can be reflected around corners, the demonstration flowed very smoothly into the activity because they knew that one way to get light underground to plants is by reflecting it down one or multiple periscopes. To this we add the

information that radiation will not be reflected and will go straight through the glass, so the light and radiation can be separated as the light is redirected where we want it.

The activity started with the class confidently theorizing that the plant getting the reflected light would thrive longer than the other. However, in fact both of the plants died at about the same time. Since we were not the one who was controlling the experiments, we could not get accurate information, but we assumed that the light position was not aimed at the plant inside the box or there was too little light hitting the leaves. This could have happened due to experimental error or due to the amount or kind of light being inadequate even with a mirror. In any case we know there is a problem; it is not as simple as it looked. We think that because elementary school students were moving the box to give them water and check the plant inside and then the experiment hit the Christmas break so then were no longer regularly tended that it was experimental error. Our advisor thinks equipment failure (the mirror came loose and shifted position) or actual light insufficiency is the cause. He also wonders if it is the visible part of the light that the plants need to “cook” food or heat we should have been trying to be sure got to the plants.

The plants were alive before the break and almost dead after so an exact timeline could not be established. However, because of this, we could teach students more clearly about experiment process. They understand order of experiment such as starting from hypothesis and checking hypothesis through experiment. They then had to try to make sense of an unexpected finding, and that would require more experiments with different conditions controlled.

The activity did not work out as expected for us but the students did understand the theory behind it and why we test theories that seem sure to work. In this case there may also be a temperature issue since we left several seeds in the open trying to sprout them, and NONE sprouted over the break despite having light and water. Perhaps it got so cold in the school that they stayed dormant? In any case, we recommend trying the experiment beforehand to ensure that it works

properly unless you want the student to have to deal with a failed hypothesis to underscore the importance of empirical testing. .As for the live plants that did not have to sprout, it would be interesting to figure out how to increase the amount of light reaching the plants using concentrating lenses at the access to the periscopes and diffusing lenses to light up the whole chapter and not just one spot.

The Rock Cycle Lesson

Introduction

This was not an experiment we set up. As observers we can report that the goal was to teach the 5th graders the concepts behind rocks and minerals. The textbook suggested the activity and this time the materials were available to do it. The concepts included were the properties of minerals, rock formations, weathering and erosion, and the rock cycle. This was done by a detailed lesson and an activity on the softness and hardness of different rock types.

Methodology

Materials:

Subject	Materials	Budget
Rocks and Minerals	a cast iron fry pan, aluminum tray, steel nails, titanium drill bits and glass discs and marbles	\$0; borrowed
Mineral Properties Activity	the kits provided to the elementary school along with the textbook	\$0, provided by school

Lesson:

This chapter we taught the concepts from the text book, which included the vocabulary. In order to relate the different types of rocks and minerals to real life; we brought in multiple household items made of different minerals. For example, we brought in a cast iron fry pan, aluminum tray, steel nails, titanium clad drill bits and glass marbles.

Mineral Properties Activity

Introduction

This activity teaches and reinforces the concepts of mineral hardness and streak, two of the three properties of minerals discussed in this lesson. It also leads into the lunar theme of extracting useful minerals from basaltic lunar regolith.

Methodology

First split the class into two groups and give each group a kit of ten minerals. The students should make a table of the minerals' names, color of minerals, report hardness and if the mineral left a streak and what color the streak is. Each student then scratches the streak plate with each material and records what they see, this is their results. After all the students have results, the class is regrouped as a whole and goes over what they all saw. Then explain how these streaks relate to hardness and streak of the minerals. One of the minerals in the kits is basalt; make sure the students get to specifically hold this material and point out that it is volcanic, not sedimentary. Explain that from the Basalt, we can pull out iron, steel, aluminum, titanium, glass, and calcium and again show them what each material is from the previous demonstration. Tell them that regolith is just powdered Basalt and all those materials can be found on the moon's surface in a convenient form for processing. Also, other rocks have these metals- and iron pyrites or fool's gold is probably in the kit. Any rusty rock probably has a vein of iron and Quartz is obviously glasslike. Look for an "oxide" from which oxygen could be extracted, though on Earth there is no need to do so. Things are different on the moon and you take your oxygen where you can find it. Then turn to the coal and discuss what that is used for and where it came from, and why you would not find any on the moon. Without coal and oil on the moon the energy system there to process metals will need to be quite different than on Earth.

Result

The students really enjoyed the mineral activity and seeing which minerals left streak marks and which didn't. They were also excited to learn about the different ways rocks form. They also learned how water causes weathering and erosion, and why that is such a major difference between the Earth and moon.

One thing we noticed was that some students applied much more pressure than others when scratching the minerals against the streak plates. Consequently, some students were able to get streaks while others weren't. We did not perform the activity ourselves beforehand to know what to expect. However, the students still managed to get streaks from some minerals and not others, so the objective of the activity, to teach about systematic observation via streak and hardness, (and show that they were correlated) was accomplished.

Force Lesson

Materials

Subject	Materials	Budget
Magnet	Magnet sphere, Battery, Nail, Copper wire	\$30.99
Gravity	Tennis ball, Moonboots	\$29.99
Friction	Plastic bag, aluminum container, pencil, water, big bucket, towel	\$0, borrowed

Introduction

The objective for this chapter was to teach the students what forces are, and about some very important forces, such as friction, gravity, and magnetism. We did activities to demonstrate all three of these forces. Buoyancy did not get so much attention but we talked about holding a ball under water and then letting go. We also talked about getting a helium balloon. Like our plan to get some dry ice to show the students carbon dioxide the logistics were too hard for people living on a campus who do not get out and around in the city much or know where to find things. We identified a source of dry ice in Worcester, but it was not close to campus and there is only one.

Methodology

Lesson:

In this lesson, we taught the students that a force is a push or pull on an object. We taught them about gravity, friction, and magnetism. We referenced the moon and space chapter when discussing how friction affects meteors and spacecraft entering our atmosphere. We taught them about how the Earth is a giant magnet itself, with positive and negative poles. We also taught them about how gravity causes the Earth to retain its atmosphere, as opposed to the moon, which has almost no atmosphere.

The magnetosphere field around the Earth and how it is like the field around a wire that we turn into an electromagnet is where we want to go, but first they have to handle a regular magnet.

Friction, Gravity and Magnetism Activity

Introduction

The activities we did for this chapter illustrated the concepts of friction, gravity, and magnetism. For friction, we started by having the students rub their hands together, and feel the warmth it generated, as well as an experiment with a plastic bag and water. For gravity, we brought in a tennis ball and moonboots. For magnetism, we constructed an electro-magnet from simple materials.

Methodology

We had a total of 45 minutes available per class, and spent two classes on this lesson. For the first day, the first 5 minutes were spent introducing what forces are and what kind of forces are the most important. Next, we spent 10 minutes demonstrating what a basic force is by simply pushing and pulling on the desks and walls of the classroom. Next, we spent 10 minutes teaching what gravity is, demonstrating with a tennis ball. For last the 20 minutes, we taught about friction, and had a friction and heat activity.

For the friction activity, we first filled up both a plastic bag and an aluminum container with water. Put a bucket or towel underneath the plastic bag and aluminum container and then make a hole with pencils (keep the pencils in hole). Look at what is happening - water will be only coming out from aluminum container.

For the second day of class, for the first 5 minutes we reviewed the Force chapter. For the next 15 minutes, we taught about magnets through a demonstration with magnetic material and letting them pass it around. For the last 25 minutes, we showed how electricity generates magnetic field. We took a battery, iron nail, and copper wire, and made an electromagnet out of it. We used the makeshift

magnet to pick up paperclips, and amazed the students when paperclips made a chain without interconnecting them.

Result

Our demonstrations for friction and magnetism astonished the students. They were extremely interested in learning about why the balloon did not leak water, but the aluminum did, and how wrapping copper wire around a nail and hooking it up to a battery made it into a magnet. We tied in friction with the space chapter from before, by explaining how friction causes meteors to burn up in the atmosphere, and how important re-entry heat is to space travel. Additionally, we discussed why the space shuttle Columbia crashed, and the role friction played in the accident. Also, we explained to the students how just like magnets have a positive and negative pole, so does the Earth, which is really a huge magnet. Finally, the Earth's stronger gravitational field holds its atmosphere. The moon, on the other hand, has a different type of core, and does not have a magnetic field or strong gravitational field, or atmosphere. As with our other lessons, the students' enthusiasm for demonstrations keep them engaged, and always looking forward to when we teach class.

Lunar Base at Elm Park School

Introduction

The Lunar Base Activity was used to wrap everything the students learned into an interactive event. This was a crude model of a lunar base built by a student team 2 years ago out of Styrofoam and junk. The first part of the day, we explained what each part of the base did and allowed the students to ask questions until they could explain why the base needed each part. The students also were preparing to explain the science behind everything included in the base to a visitor we told them was coming in about a month. The class was then split into three groups, for an activity; robotics group, expedition group, and solar flare emergency group.

Solar Flare Group

The solar flare emergency group was assigned the responsibility of building a vehicle to get astronauts to safety in case of an incoming solar flare. The students were told the background of this solar event, which was,

“NASA can detect a solar flare about 8-5 hours before it hits the moon. Since the moon has no atmosphere, unlike the Earth, it is not protected from this radiation and whoever is caught on the moon’s surface during a flare will die. The astronauts need a fast means of transport to get them to safety. This vehicle is called a hopper and uses a rocket to propel itself into a sub-orbital hop. This hop will launch the hopper up to a hundred miles in one leap. In a few quick and long hops the hopper and people inside will get back to base and underground to a bunker or under a pool of water – a place of safety- before the flare hits.”

A picture of a solar flare is then shown to the students in order to help them put the severity and power of radiation surge associated with a solar flare into perspective. Finally the students are let free to build a hopper. The students were very enthusiastic about this activity and the chance to add on to the base. They were limited by the materials we had available for this group. They were given K’nex

and Play-Doh and the materials just didn't cut it. The K'nex are very one-dimensional and made it difficult to build what was desired. The Play-Doh is just not strong enough to be used as a building material and because of this the Play-Doh was more of a distraction than a beneficial material. The students wanted to use the Play-Doh desperately and tried to use it for everything but were unable to do so and hold to the theme

Another problem was the students didn't fully understand the concept of a hopper. The students originally thought of a frog like vehicle with legs to hop rapidly back to base; maybe they thought a launch of the vehicle in low gravity did not require a rocket. However, with a little coaching and explanation the students understood the concepts behind the hopper and quickly changed their design. I recommend using Legos instead of K'nex because they are much better to build with. Do not use Play-Doh at all, as it was just a distraction. Then, just make sure the students are coached through the design to make sure they do not build a frog design, and instead use a sub orbital hop rocket to propel the vehicle.

Besides the few problems, the students understood the danger and the activity but we saw it as analogous to the Galveston flood activity translated to the lunar environment and they either did not see or care about the analogy we were so careful to set up. . The pictures of solar flares really put the magnitude of the event in perspective for the students and allowed them to realize how powerful a flare really is. The materials really limited what they could build but listening in on their conversations, I could tell they understood what the goal was. The students worked together as a group and came up with a design that worked. Half of the students built a cab for the vehicle equipped with 4 passenger seats and a driver's seat and protected it. The other half built the propellant system. At first they built legs like a frog to propel the vehicle but I then coached them toward the right path. Once the students realized the right path, they added on a rocket system. The system included a rocket pointed toward the ground and a fuel tank. They kept the legs for landing gear since the legs were already built but that was there

only use. Overall it was a very worthwhile event and could be even better if in the future my recommendations are followed.

Robotics Group

The Robotics group had to design a few of the robots that can be used on the moon. There were lots of different kinds of robots suggested such as excavation robot, fixing robots, gardening robot, and humanoid for researching. We suggested robotics group to build robot that they can control from the Earth and give them specification of what job they have to do. However, the matter that they are designing robot make them distracted from the suggested robots. They started to design robots with missile or robot from the animation or cartoon except one kind of robot that was designed for excavation. So the next day to rein them in we were specific about having them design the school for the teacher in space and the robots that the students back on Earth would get to drive. The result was very humanoid-(sort of like the robot being designed by Japan for a lunar base with no humans). This was the 5th graders alter ego on the moon, their presence since they could not be there. It would be our challenge in the later Robot station event at WPI to get across the idea that most robots do not look humanoid and are functional, and are just designed to do specific jobs on the moon. It was time for them to see the Moonraker Robot, and that could be arranged. Meanwhile they got to make robots out of Play-Doh and again the predominant image was humanoid or maybe inspired by a transformer.

Expedition Group

The expedition group had to design vehicles for a convoy from the south pole of the moon to the equator of the moon, a journey of at least 1,000 miles. The vehicles could either be manned or unmanned, and the students were provided with \$500 worth of Legos to build their designs after drawing them. Most of the pieces were generic blocks and wheels, with few specialized pieces.

The students were extremely excited to be able to build with Legos, and eagerly started building trucks. However, we quickly discovered that while there were plenty of wheels, pieces to make axles, and chasses, there were no single-pieces to attach axles to the chasses. Therefore, we spent most of the rest of the time jury-rigging axles to the chasses for them, while they built the chassis on their own. They also had some of the Play-Doh available to them, although we found that Play-Doh and Legos don't mix well, as the Play-Doh tended to get stuck in the holes within the Legos, and when it did was difficult to remove.

Some of the students built vehicles with seats so that passengers could ride along. Some of the vehicles had attachments, whether arms to pick things up, drills to mine, or even in one case, a laser to blast rock. Our team didn't go through the pieces extensively prior to this activity, and thus had not determined how good the Lego pieces available were for this purpose beforehand. We played with Legos as a kid, and had enough specialized pieces that I was disappointed with the pieces we had for our activity. However, we came to the realization that these students didn't have the same access to Legos at their homes; they didn't know what else was out there, and so they were eager just to use what we brought for them. They took what was provided and did the best they could with it, and still managed to make some cool designs. There was a moment when the solar flare team and the expedition team recognized that people could not go on the expedition unless the solar flare evacuation system was in place to keep them from being catch exposed on the surface during a flare. Discussion centered on sending robots ahead to dig a secure bunker before the people went more than half way—about the distance that we figured they could get back to base in time to be protected in case of an emergency.

Dr. Bortz at Elm Park School

The day before the WPI MCAS Review Event, Dr. Fred Bortz went to Elm Park Elementary School for a private event. This was planned for two reasons, first because Elm Park played an instrumental part in this project and Dr. Bortz wanted to meet the 5th graders we had worked with and talk to them. Second, we wanted to know if a guest speaker worked out better at the home school or whether it has worked just as well or better to gather students from several schools in one place, which would make the event cheaper on a per person basis. Dr. Fred saw all the 5th and 6th graders (about 100 students) at Elm Park School for about \$500, but his normal fee is \$1000 plus expenses. This was an experiment on both sides.

The next day he saw 375 students in two runs of 150 to 170 students per seating (he had already seen the 54 from Elm Park school the prior day) and gave them the same presentation at WPI, also for \$500 (normally, \$1000). His travel and lodging expense ran to \$900. Therefore, to repeat the WPI presentation would be about \$2000, but one could seat 400 students, about 20 classes in two sessions on the same day. That means \$100/class or \$5.00 per students would cover it.

The real cost of an Elm Park style event would be \$20.00/ student, though the travel costs could be spread out over several schools if he went from one school to another every day for a week. It is still going to be at least twice as expensive to do the traditional Bortz program. Of course, there are also bus and lunch costs to consider, but the schools were coming to WPI for a field trip anyway. He was just the keynote speaker at the event. This event at Elm Park School also gave our team valuable information about how well the new curriculum unit on space is preparing the students for a talk like Bortz's. They would also then experience a field trip to WPI without having Bortz be part of it and we could see how they reacted to that with a tour instead of a speaker. They could report whether having Bortz come to their school was as good as having a trip to WPI, without the two kinds of events being mixed though they were complementary.

In preparation for the day, two to one weeks before the day Bortz came we asked the 5th and 6th grade teachers to have their students read a chapter of Dr. Bortz's book and write a short report on the chapter. Three teachers took us up on it, including Fran Mahoney our partner in the project. His was the only 5th grade class to do the project and he decided that only 6 of his 18 students were strong enough readers to do it. Four of them took on the challenge. The other teachers also limited participation to about the same degree so in the end there were 12 essays to review. Once the reports were received, the best out of each class was chosen to get a copy of Dr Bortz book as a prize. Dr Fred, as he likes to be called, got the essays the night before the event at dinner. He would select with winners overnight.

The day started for us 30 minutes before the school day with a few people setting up the model lunar base (again) in the middle of Fran Mahoney's 5th grade class . The students had not seen the base for a month. What would they remember about it and could they explain it to Dr Fred? Then at 8:30, Dr. Bortz arrived and the class explained to him what everything was and what it did- with only a few hitches- usually one student making an error and another student politely disagreeing and correcting them. At 9:00 all the 5th and 6th graders were brought to the cafeteria for Dr. Bortz's presentation, which lasted for an hour. At the end of the presentation the book award for 5th and 6th graders were presented to the winners. Dr Bortz did this very well; having selected the best essay and reading parts of it had the author identify herself—to the cheers of 100 of her classmates.

After the presentation, Dr. Bortz returned to the class with the new curriculum. He spent a half hour talking to the class about his presentation. The class asked questions and talked about their opinions. They had just been told that the story of life on Earth "will not have a happy ending" and in a billion years we would have to evacuate to Mars and terra form it. There was plenty to talk about. These were the students who had been thinking about space and lunar bases for 2 months. Then Dr. Bortz went to a classroom with the other two 5th grade classes who had had none of this background. . This hour ran just like the last half hour, the students asked questions and talked to Dr. Bortz but there

was a difference. This talk was about getting the facts straight. The other one had been about what it all means. Both groups had had a huge knowledge jump in a so short time and were processing but the second group had farther to come and actually did surprisingly well. An hour break for lunch was taken next but once lunch was over Dr. Bortz talked to the 6th graders for the final part of the day.

Having Dr. Bortz at Elm Park was a valuable resource and allowed us to gather comparative data. With Dr. Bortz talking to the 5th graders with the enriched curriculum and the rest of the 5th graders separately, we saw firsthand how well the enriched curriculum prepared the students more than the standard curriculum. This comparison was seen after the presentation when Dr. Bortz was talking to the classes separately. The class with the enriched curriculum was more on topic with Dr. Bortz. The questions were all about his presentation or went more in depth. An example of this is in his presentation he talked about going to Mars and living there. The students were really interested in it, so they asked questions about how someone would get there, how long, and what they would eat. The class was very interactive feeding off each other's questions. This session was very productive.

The other half of this data is the question and answer session with the other 5th grade classes. From the questions they asked Dr. Bortz, it could be quickly seen that they were less prepared. These students asked more background questions about Mars, the moon, and the science behind it. For example, the plant concept of humans breathe in Oxygen breathe out CO₂ and plants breathe in the CO₂ and breathe out Oxygen had to be explained to the standard curriculum students, but the prepared group we had worked with took this background knowledge for granted and went from there. In addition, the difference in atmosphere between the planets and the moon was talked about in the session after Bortz presentation, with the moon coming up even without one having taken the unit on the lunar base, probably due to how much it was stressed in the text.

This qualitative, observational data showed us that the enriched curriculum better prepared the students for a space program like that of Dr. Bortz than the old curriculum, even though Dr. Bortz was

Mars, rather than moon, focused. The students were better oriented to a non-Earth-like environment and it allowed them to have an idea exchange with Dr. Bortz about his presentation, and not just clarify the background and science concepts. These students already knew the vocabulary of discourse in this field because the enriched curriculum stressed these concepts and taught them in an interesting enough way that the students remembered them, could use them and sometime correct one another when someone made a mistake or could not answer one of Dr. Bortz's questions. There had been no review the day before and the program had ended before they went on Christmas Break. This was pretty good evidence that the science in the space enriched unit was memorable - and being retained.

MCAS Review Day

Introduction:

The MCAS Review Day at WPI was designed to give 5th graders of Worcester a fun day of activities that would also help them review key topics needed for the MCAS test and tell us whether the lunar base theme had broad appeal to teachers and students at this age. The topics covered were drawn from several different chapters of the textbook dealing with physical science. In order to accomplish this, we set up eight stations all with different topics and activities, which are explained in the methodology. The second reason for this event was to determine the best way to spend \$1000 on a fun event with curricular connection, a review justification and a key note speaker, in this case Dr. Fred Bortz, was one of our three policy choices. By collecting reactions from the students, teachers, class guides, and from personal observation and experience, we could compare this way of spending resources on science class enrichment against the other two possibilities under consideration. The third reason for this affair was to compare how the class from Elm Park, which experienced the enriched curriculum compared to classes from other schools in terms of getting something out of such an event. Was it important to prepare students for this kind of field trip, or didn't it matter? We wanted to answer questions like, "Was the class from Elm Park noticeably better prepared than classes from other schools when they went through your station?" Our group used this event for all three of these purposes. It was the culminating moment of our project, though there would be mopping up to do afterwards.

Methodology:

As previously stated the MCAS Review Day was achieved by creating eight sessions where the classes could go and participate in an activity. The following are all the sessions:

Dr. Fred Bortz Lecture:

Dr. Fred Bortz was brought in to be the keynote speaker for the whole event. He is an award winning lecturer and author for the elementary level and specializes in space topics. He was the perfect person for this event. His lecture was “How, When and Why people will settle another planet” about living on a different planet, Mars and then another solar system.. He gave two lectures, one in the morning and the other in the afternoon, with half of the classes going to one and the half to the next one. His basic message was given what we know about how stars age, the human race has no choice but to leave the Earth or die with it, however we have a long time to get ready for that moment. The more likely end of civilization on Earth will be the way the era of the dinosaurs ended. That could be much sooner so having another branch of the human race elsewhere would be prudent. His graphics and delivery were first rate, but some teachers felt he was talking over the heads of 5th graders. The questions the students asked suggested otherwise, but that could have been a minority who clearly got it that space travel was natural and probably inevitable for humans, if they were to have a long term future.

Robotics Station:

This session was run by Minkyu and requires a background in Robotics in order to operate. The session itself teaches the students a bit about robots and the engineering behind them. Also, it lets them drive one and so has them in autonomous action mode. This was an exciting first-hand experience for the students.

Subject	Materials	Budget
Robots for demonstration	fire fight robot, light bulb changing robot, researching robot, excavation robot	\$0; borrowed
Robot for control	5 vex base-bot	\$0; borrowed
For Activities	detachable wall, table	\$0; borrowed

Introduction – 3 minutes

- Explain basic concept why we need robots on the moon and space. (Gravity, air, heat, etc...)
- He had a systematic list of the kinds of robots needed to build and maintain a lunar base, but he did not distribute it.
- Signal concept, when earth send signal to the moon, moon receive it 3 seconds later because of speed of light.

1. Robot introduction, demo – 3 minutes each

- Firefighting robot: Firefighting robot is important to keep green house under control. Since green house is critically connected to human survivor on the moon. If candle is available, show robot turning off the fire. If candle is not available, share the video footage.
- Excavation robot: Regolith that can be collected through this robot can be used for making steel, iron, etc... Teach students about rocks.
- Researching robot: Explain that robot is semiautonomous, can go off on its own or be subject to remote control

2. Robot control

- Let the kids surround the wall. From left to right, let everyone have chance to control the robots.

Expedition Station- A Mission and Vehicle Design Problem

This session was run by Dave Irwin and Jake Schomaker and allowed the students to build individual rovers for a caravan travelling to the equator of the moon. This specific session was not run at full capacity due to the fact Dave and Jake were dealing with last minute logistic issues for the event. There were no pictures or rehearsed story at the session but it will be explained as if it did run at full capacity in order to duplicate at a later event.

Subject	Materials	Budget
The Moon	Poster size picture of the Moon	\$0, printed for free
Solar Flare	Poster size picture of a Solar Flare	\$0; printed for free
The Caravan	As many LEGO's as possible	\$0; borrowed

The only set up required for this session is \$1000 worth of Legos with lots of wheels tracks and special parts and enough table space for the kids, two big tables should suffice, and computer screen, a wall or board to show pictures of the Moon, the terrain to be crossed and the Solar Flare. Then once the students arrive, explain to them the situation. We told the mission along these lines,

“You are all astronauts on the moon, stationed on a Lunar Base located at the South Pole (point out on picture). You need to get to the equator (point out on picture) and study the lava tubes there. Lava tubes are giant tunnels in the ground and they may make a great place to build another base but we will not know until you check them out. A Japanese satellite has located a promising site to find at least one with a cave like opening to the surface in the Marius hills. Your mission is to build a caravan of rovers, both robotic and human controlled, to get you to the equator. However, you have one big obstacle to overcome, solar flares (point at picture). Solar flares are massive amounts of radiation emitted by the sun. On Earth, we do not have to worry about this since the atmosphere protects us but the moon does not have an atmosphere. If you are on the surface of the moon when a flare hits, you will die and nobody wants that. Earth can detect a flare about 8-5 hours before it hits the Moon. To protect yourselves from a flare you must build one of three vehicles. The first is called the turtle method and it is a giant bunker that the caravan would drag behind it. Once a solar flare is detected, everyone would get inside for protection. The second is the sand crab method and this is a vehicle that would bury the part of the caravan that is human habitats with 10 meters of regolith for protection rather than the 2-3 meters we need to block 90% of solar radiation on a normal day. The third method is the frog

method and this is a vehicle also known as a hopper. This underpowered rocket vehicle propels regolith or fuel fired with oxygen derived from regolith downward and in the lower gravity of the moon can “hop” across the surface in a series of blastoffs. Each hop is hundreds of miles and in a relatively short time everyone would be back at the base and safe deep underground and under water. Water is a good radiation barrier.”

Once all the students understand what they are doing let them build for the rest of the time. While the students are building, walk around and make sure they are doing everything correctly. For example, do not let them build an airplane or helicopter or add frog legs to the “hopper” and if they do coach them why it will not work on the moon and gently push them in the right direction.

Lunar Base Design Review Station:

This session was a way to incorporate all the students learned in science to a specific topic, lunar bases. The presentation shows many different designs for lunar bases from the SHIFT Boston contest. The presenter goes over the pros and cons of each design with the students and then they vote on which one is best in their minds- meaning the one they would most like to spend a year in at age 40.

Subject	Materials	Budget
Presentation	Projector and screen with all hooks for a laptop or USB drive	\$0; borrowed
Voting	Paper or some means for the students to vote on the best base	\$0; borrowed

The entire presentation is set up and on a USB drive. The presenter must show the presentation and go over the pros and cons of each base. If possible, allow them to come up with the pros and cons but if pressed for time or too many students just go over them. Take questions after each base in order to ensure all the students understand the pros and cons and the concepts behind each one and are satisfied that they understand their choices in terms of open design and radiation risk. The goal is to

illustrate design tradeoffs and the importance of aesthetics in engineering design. These are not man in a can bases, but architectural works for a second general lunar base circa 2069, 100 years after the first lunar landings. Ideally the students are in groups of 3 and discuss the pros and cons and vote as a group on a sheet of paper distributed to them. Once the presentation is over have the students explain the reasoning behind their vote and decision about where they would want to live. They don't have to agree with their partners on this part. There are also some bases with obvious problems and errors that were submitted to the competition and some of these were shown. The students got to pick out what was wrong in a base with a windmill or an oil derrick.

Physics Club Presentation:

Two students from the WPI Physics Club ran this session. The main topics covered were electricity and fission/fusion energy generation.

Subject	Materials	Budget
Electricity	Projector for presentation and Van Der Graaf Generator	\$0; borrowed
Fission/Fusion	Projector for presentation	\$0; borrowed

This session was independently designed and operated by the WPI Physics Club. The session incorporated electricity and fission/fusion in a presentation. The station ended with a hands-on activity with the Van Der Graaf Generator.

Greenhouse - The Plant and Light Station:

This session was incorporated to teach the students about light and plants on the moon. The plant part demonstrated how to grow plants on the moon with the limited resources and which plants could grow in this environment. A light section was incorporated as well because since the base would

be underground the only way to get the sun light for the plants is to use mirrors to bend the light to the plants.

Subject	Materials	Budget
Plants	Cattails and any other plants that would be able to grow on the moon	\$0; borrowed
Light	Model telescopes and periscopes	\$0; kit paid months ago

The person running this session should start by explaining the concepts behind plant growth, photosynthesis, etc. Then talk about the harsh condition on the moon for plants and the best plants for a lunar base and why. Since plants need sun light and the base is underground, the sun light must be reflected through mirrors in a periscope. Allow the students to look through the model periscopes and telescopes provide to understand this concept. We recruited a biologist for this activity, who already had an immense background in this topic and this is highly recommended. He tried to convince the students they should grow Cattails, Quinoa, Bamboo and Yams on the moon. By the end they understood why these would make a good biosphere complement to humans.

Plate Tectonics Presentation:

This session went more in depth into the topic of plate tectonics, which was helpful because the 5th grade textbook barely touches upon the topic.

Subject	Materials	Budget
Plate Tectonics	Projector	\$0; borrowed

This session was completely run and designed by Professor Janice Gobert and her graduate student independently. None of us actually saw it but we were told it was like a game in which you could move the plates and see what happened interactively

Moonraker Station:

This session reinforced the robotics session but was only about one robot, Moonraker. This is a more advanced robot and was literally designed to move regolith on the moon. It was also included to show what WPI students can do and how great WPI is. This is actually the event that started the whole idea of a field trip. We offered to bring Moonraker to Elm Park School by way of showing off our celebrity robot that won a \$500,000 NASA Centennial prize in 2009. There was a videotape of it in action moving twice as much simulated regolith in half an hour than the second place winner. The state of the field trip was when Ruth Ann Melancon, Principal of Elm Park school said she wanted her students to go to WPI to See Moonraker, not have Moonraker brought to her school that the whole idea of the local field trip took shape. As part of this station you see simulated regolith, talk about what can be gotten out of it and get a real chemistry lesson as well as get the idea of a lunar base in which the labor force would stay on Earth and it could actually be profitable and support itself with this kind of infrastructure. It is the perfect complement of “Craterville” the most popular lunar base, which was a mining camp with 300 such robots.

Subject	Materials	Budget
Moonraker	Moonraker and a protector to show the video of it in operation as well as the presentation	\$0; borrowed

This session is all about Moonraker. The presenter should go over everything about Moonraker. Talk about the NASA contest it won and show the video of Moonraker in operation. We recruit a robotics professor, Professor Michael Ciaraldi, who had a background with Moonraker and knew everything about it to run this session.

Moonboots Station:

This session was not part of the original plan. The original plan was to have some people from New England Air Museum do a station on “flight”. When they cancelled they suggested that their place be taken by a teacher at the West Boylston Middle school who had developed an apparatus to simulate weightlessness- or micro gravity with straps and counterweights. However, in the end she could not make it either, and needed to recruit and train a new team of assistants. So, when that station was removed from the plan the fallback was to have students who had done everything else try the moonboots. But because of the number of students, we needed to include it. All that is needed are Moonboots and then have the students walk a short distance and then report to their classmates what it feels like. The instructor then explains why moving on the moon would feel like that. Make sure at least one adult is holding on to their arm in case they fall as they get adjusted to a super springy step, like Erath trained muscles give you on the moon. . The boots only roughly approximate 1/6th gravity like on the moon but it is instructive if handled by someone who knows what the astronauts who were there did and reported. Of the ten students who tried wearing the moonboots that day , two of them had enough difficulty adjusting that they refused to do more than walk slowly in them and wanted to get them off ASAP. The other eight students were able to get over the initial awkwardness, and three of them became so comfortable that they were bouncing around in them within minutes.

Lunar Lunch

For lunch, we had a meal that could be made on the moon. The two choices were tofu and tilapia, with soy milk, lemonade, quinoa (the highest protein plant on Earth), salad, a vegetable, and a banana bread slice for dessert. Only meal items that could be grown or made in a lunar base, similar to the one we helped design, were offered in this meal. This choice was offered to three different schools to give their students a better “lunar” experience. During this lunch, a video was played, which we had prepared earlier.

The video was a skit about a day on the moon through the eyes of a robot controlled by a student on Earth. We borrowed three robots from WPI. We had an Elm Park student simulate controlling the robot, similar to the proposed idea of having students on Earth control basic robots on the moon as an educational experience. In our idea for 2070, a student on Earth would be able to virtually control a robot on the moon. There would be a small, contained area for the student to move around in – as the student walks forward, the robot moves forward; as the student lifts their arm, the robot lifts its arm; where the student looks, the robot’s camera points, etc. We simulated operating the robot, filming it, and had it leave the room. We then cut to a scene of it in a greenhouse, where it was exploring, until it happened upon a statue of a hippopotamus, at which point the student controller was startled and fell over, and thus the robot fell over. The gardener on the moon came across it, picked it up and set it upright. It followed him around, and then he discovered he was being watched by students on Earth, picked it up and angrily brought it back to the classroom in the lunar base, complaining about nosy students and lack of privacy. This was a short, fun video to illustrate the “Teacher on the Moon” concept that has been talked about, and to provide an activity during lunch. Minkyu went above and beyond the call of duty by putting together the videos that weren’t required, but were a great additional tool we used on a few occasions.

Conclusions and Recommendations:

Individually all the sessions ran smoothly and were very successful. Each one peaked the students' interest in the subject material and allowed them to have fun while learning. The one complaint from some of the stations was too many students to handle at once and the stations too close together. The number of students was a problem for the robotics, plant and light, and sometimes the expedition sessions. The robotics and plant and light sessions could not handle the high numbers because they are very hands on and higher numbers mean fewer students can participate. It was a problem with the expedition session sometimes just because there was not enough Legos to go around. The Moonraker and Physics Club sessions were sometimes too full but this was a matter of space, seating and noise. That could be easily fixed by putting them into a bigger room or lecture hall. The remaining stations were already in a lecture hall and had plenty of space. Their problem was that people did not want to leave Alden Hall to go find them in Salisbury Labs and in one case the guides took them to the wrong room. That lunar review session turned into a general discussion of what it was like to go to WPI that some teachers considered the high point of the day.

Overall, the overcrowding was the biggest issue during the day. This was created by the massive amount of interest shown by the Worcester school by accepting our invitations at a rapid rate. It was also caused during the day by classes decided to follow their own schedule and not the one we provided for them. Since some classes did not follow our schedule, they were at certain sessions that a different class was at and overpopulated the activity. In the future, make sure that only one class, max of 20 students, is at the robotics and plant and light sessions. Then allow the amount of students at the expedition session that the LEGO's can handle. For the rest of the presentations, allow how many the room can hold, usually 3 classes max. However, the Physics Club is interactive so cap the students at two classes is our recommendation. This could be achieved by adding more sessions or to have the cut off

for invites early then we did, a week in advance. If the amount of classes is known early, the event can be expanded accordingly.

After the fact, the opinions of the teachers and guides were received about the day. The other overview of the day was about its adequacy in terms of MCAS review. The reviews from all but one Principal were very positive. Her major complaint was that Dr Bortz talk was over the heads of her students. However, the reactions seem to be to the whole event as a consciousness raising experience. Everyone likes it and the students were clearly thinking about college, it was important to the staff that this had happen at a college that was up and running and their students got to see and meet WPI students. They did not seem to care much about how it stacked up as test review and preparation.

The WPI student guides were more critical. They unanimously thought the day did not include as much MCAS review as had been advertised. The original plan was to have each group have a review handout for all the students that arrived at their sessions but this was not accomplished. We feel this was not done because of the last minute scheduling issues and planning, as well as the massive amount of paper needed to make all the copies. Even station masters that had a handout did not know where to go and who would pay to make 400 copies. Only the Moonraker station was fully prepared for the crowd, and got a handout to just about every student. This oversight could be fixed by giving more time to plan and schedule all the sessions. Then give the people running each session a deadline to create a review sheet if they want the copies made from their master and delivered to them on the day. .

To make up for this mistake our group created a master review sheet with all the topics covered on it and distributed it to all the participating schools. We sent the master electronically and then offered to bring paper copies. Elm Park School took us up on the paper copy offer so 60 were delivered there for distribution. (This master review sheet is based on the text, included in the Appendix, and is to be given to each student so they can take it home to study. They cannot take the test home. The test is in late March.).

On a whole, the day ran smoothly except for the couple of oversights previously stated. The kids and teachers had a great time. Even though we came up short on the MCAS review, the students did learn certain things just not as much as we hoped. We were able to collect all the observational data we needed from this event to compare to the other two situations. Also, we were able to compare the reaction of the Elm Park class that participated in the enriched curriculum and all the other classes at different schools as they came through our stations. The WPI student guides also offered to react to the stations they saw “as if” they were 5th graders and they even told us what their cognitive/ learning styles were. These comments were very helpful and it became clear that each type had at least one station that they loved and our Expeditions station had been especially popular among “problem solvers” who like to build things their own way and seem to love the freedom of expression possible with Legos.

Our biggest recommendation is to give more time for planning. This whole day was planned in two weeks and too much was left until the last minute because WPI’s concerns kept adding to the logistics workload and the actual event did not get as much time as it needed to be a smooth operation.. To have this event approved by WPI, the dean must give the ok. She is concerned about the safety of the kids and the liability risk facing WPI. We had overlooked some of the things the campus police wanted and she presented us with some scenarios to think about. As a result, we ended up having to have a formal training program for the guides and might more documentation of exactly who was to be where and when than expected. It proved to be useful stuff to have, especially when a guide overslept and we had their phone number so they arrived by the second station their group was to see. However, the study sheet problem was a direct result of the increased logistics requirement added in in the final week before the event. If one had another week to plan, the day would have run smoother. The problems that occurred were not serious from the perspective of those who came, but those of us behind the scene knew that everything was barely done in time. The stress level could have been greatly reduced if we had more time to plan everything, but of course, this was not what our project started out to be. We

had an opportunity and choose the seize it and have no regrets, though we could do it better if we ever did it again. Our own expedition station suffered due to the competing pressures of organizing the rest of the day. Still, it was a popular event.

Trip to the McAuliffe Center

Part of our project was to determine the value of going on a “normal” field trip. The year before, two classes from Elm Park School had gone to the New England Air Museum, which focuses purely on aircraft, as opposed to spacecraft. They only taught about lift, drag, gravity and thrust, but they did teach it well, having a station for each topic. Therefore, we decided to look into taking a class or two to the McAuliffe Center in Framingham, MA. This center houses a mock Mission Control based on Mars. At this center, one class would act as Mission Control on Mars, while the other acts as a team in flight that is arriving on Mars to rotate personnel. Then, they switch, and the Mission Control team becomes the Flight team, heading home to Earth, and they drop a probe onto Phobos on the way.

Originally, we were going to bring 5th grade classes from Elm Park School, since these were the students we had been working closely with, were more prepared, and we had come to know. However, due to a few complications, the Elm Park students couldn’t go, and so we instead took two classes from Goddard School in Worcester. The Goddard School offers a more science-oriented program than other schools in the city, and so these students had some background anyways. Their students gave positive reviews of the MCAS review day, and seemed to be the most interested, and so when we offered, they even gathered their own money to fund half the trip and the cost of the bus.

The students had a great time, simulating being navigation officers, communications officers, scientists, and doing experiments on Mars. There was also a team in a mock clean-room that prepared the probe for its mission on Phobos. The students loved the event, and the teachers want to do the trip again in the future. Since they had also attended the MCAS Review Day, we asked them to compare the educational value of each event. In their opinion, the McAuliffe Center was a better experience because it was most polished and structured, however, that our MCAS Review Day was also very interesting, and

has the potential to be an even better experience than the McAuliffe Center. The McAuliffe Center suffers for lack of space, being confined to only three rooms.

Results, Conclusion and Recommendations for Future Project

Completion of Project Objectives

The minimum of our project was to develop a lunar-based science curriculum for a fifth grade class and make learning science more engaging, which we accomplished. We made science the fun class and WPI the place to go to college for many people. Maybe we even recruited some aerospace majors, as the idea of a lunar base captivated a majority of the 5th grade students. We also evaluated how best to use \$1,000 after bringing in a guest speaker to Elm Park (Bortz) to the event at WPI, and after taking a class of 25 Goddard School students to the McAuliffe center in Framingham. They reported that the Mars simulation was better than the speaker alone- but the teacher considered the WPI so promising that she thought they could be comparable events, and clearly ours was cheaper. The greatest indicator of the success or failure of our project is whether or not the Elm Park students we taught perform better on the MCAS than their peers. The Elm Park teacher loved having us teach class, and told us his students were much more engaged for us than in September when he had taught science as he was expected to do it.

It is important to note that many of the activities we did, did not go well the first time through. Roughly half of our activities, we had to repeat a second or even third time to get the kinks out and make it work so that it would best teach the concepts we were covering at the time. We quickly learned how important it was to try the activities on our own first, rather than trying it for the first time in the classroom.

For the Review Day, both the teachers and students reported having fun, but that the guides felt they had probably missed the embedded concepts in the station presentations. The problem was that the people running each station had not read the 5th grade text. Only the Physics Club did that for their chapters and they did not have the resources to produce a study sheet for each visitor that came to their station. The Moonraker presenter did do a handout, but had not read the text. Therefore, to

supplement the stations, we ended up producing a comprehensive list of concepts in all the chapters covered and the additional concepts discussed that were not in the text, but were critical to the topics covered. We are making arrangements to get a copy to each student to take home and have, before they take the test. Our teacher reviewed it and was very pleased as he now had a full review list that he could send home with the students, and asks them which things from the trip with associated with each concept.

We are hopeful that the Review Day event will also make a difference to the other sixteen classes that came to WPI, but candidly, the teachers and principals do not seem too concerned about that part. They have already endorsed it as a consciousness-raising event that changed lives. Some talk about the raised level of interest in going to college, some talk about the greater interest in science and some talk about the kids who have stars in their eyes because they “went to the moon”, and then started drawing their own version of a lunar base and drew themselves into the picture. The feedback from the event at WPI is quite positive and the educational potential in the lunar theme has stunned both Dr. Bortz and the fifth grade teachers.

The event has also generated a lot of interest amongst different organizations in Worcester. Committees at different levels are now being formed to look into where this stunning event came from and how it can be expanded and continued in future years. Our sponsor, the AIAA NE, is obviously please and has been advised to compete for a public outreach chapter award on the strength of this initiative.

Even if our project turns out not to be as momentous as we would have liked, insofar as raising MCAS scores are concerned, the enthusiasm of the Worcester Public schools has all but guaranteed that we have started a successful annual outreach event for the AIAA NE. WPI was also watching and has concluded that it really should be doing something like this on an annual basis, possibly not so large, but

do it 2-3 times a year if staffing can be found. The STEM enrichment goals that we set and met, with few monetary resources, could result in a sustainable program that runs for many years to come.

Appendices

Teacher, Principal, and Student Feedback

John, Martha,

Thank you so much! The program yesterday was great - kids and teachers loved it and really enjoyed being on a college campus. It gives them so much to talk about now. Your WPI students were wonderful. Please let me know if you would consider doing this next year and we can form a planning committee.

Kathy Berube
Science Curriculum Coordinator, Worcester Public Schools

Hi John,

My students and staff had a *wonderful* experience at WPI. Many, many thanks to you and all that made this field trip possible. Looking forward to continuing our association with WPI in the future.

Best,
Paula Proctor
Principal, Wawecus School

Just a note of THANKS for all your hard work! Our students were very excited about their experiences at WPI today. Dr. Bortz's presentation was interesting, the hands on workshops were challenging and fun, and the college students were wonderful role models for our kids. Please keep us posted on any future presentations.

Fran Shepard
Teacher
Vernon Hill

John,

The feedback I received from staff and students was that they loved the activities but felt it was too crowded having everything in one room. The students reported that they could not hear well and that it was just too many people in one space. I did not receive positive feedback on Dr. Bortz. The teachers thought most of his talk was over the heads of the students. Students thought so as well. All in all the feedback was that the stations were great but just needed to have them in different rooms. The children loved being on the campus and working with actual college students and professors.

Patricia McCullough
Principal, Clark St School

John, Kathy & Jeff,

Our 5th grade students had a great time today. They really loved everything about the day. I think they especially enjoyed being on a college campus and working with a college student. I arrived late due to a system wide meeting this morning. The morning activities that I saw seemed well organized, fun and educational. (Imagine, the kids had fun while they learned!) Dr. Fred was very interesting. I wonder how he knew we brought a few aliens with us.....

Anyway, no event of that magnitude goes without a lot of planning. I appreciate the "behind the scenes" work you all did to make today a memorable one for Tatnuck Magnet students. The kids and adults were filled with positive comments. It's hard to keep everyone happy, but today, I think you did just that!!!

Sincerely,
Erin Dobson
A Principal at Tatnuck Magnet School

John,

My children were thrilled. Herlin came to me at dismissal saying "I went to the moon, Miss, I went to the moon!" Hasel could not believe the school [WPI] and wants to know if college is really like that because NOW she is interested in working hard to attend. Linette and Miranda also were so excited about what they saw and how WPI connects to our school wide theme of wonder. I could go on and on but the proof is from the students. It was a success.

Marion Guerra, Principal, Goddard School

As I walked through the halls of Elm Park School, I ran into 2 of the 3 teachers that went on the WPI field trip and was thanked personally for the chance to come to WPI – there were additional comments about how lucky they were to be close so that the students (both WPI's and theirs) can walk back and forth.

John Wilkes

WPI Professor

Thank you Dr. Wilkes! I think you will be amazed by what these children took away from this field trip. We talk college every day in our class. For these children to experience an actual college classroom, to meet college students, to see college student projects....this was an invaluable experience. Your students did a professional job of moving the groups and talking to them about what they do. Thank you (see enclosed notes from my students).

Debralee E. Seles, Teacher, Goddard School

The text of five of the ten messages from Goddard students received are as follows:

“Dear Dr. Wilkes and Dr. Fred,

Thank you for the great information. I thought that we would never live on Mars or the moon. I had a lot of fun learning about the moon, plate tectonics, cattails, robots, making robot cars and about where we will go in a few million years. It was fun and interesting learning about everything! I do not have a lot of favorites but this was the best field trip I have ever gone to. I was thinking that for collage I will choose WPI for collage. Nice classes there! Once again thank you!

Sincerely, Rosa”

“Dear Dr Wilkes & Dr Fred,

Thank you for the fascinating tour of WPI. IT was amazing. Like the autatorium with all of that stuff espacly the robatic work you guys do. You guys think really big and I had know idea that the world wont end till like 5 billion years know I can sleep in peace with no worrys I learned so munch thank you again.

From Joah”

“Dear Dr. Wilkes & Dr. Fred,

Thank you so much for showing me what a college class was like. I learned so much from both of you. I hope when I go to WPI I have professors like you to teach me. Both of you made me learn so much. I got a wonderful time learning. I never got to learn so much before. I got to expcirence what college classes are like. I got very intrested on what will happen in millions of years. I had the most funnest time ever.

Sincerely, Peter N.

P.S. Great lecture Dr. Fred!”

“Dear Dr. Wilkes + Dr. Fred,

Thank you For the field trip to WPI. Thank you for let us play with Lego robots, controle robots, and for comments of the robots. Thank you for comments of the moon and how we are going to live in mars. Thank you for the wonderful things I learned thoughtout the field trip.

Sinceraly, Ashley Rivera”

“Dear Dr. Wilkes and Dr. Fred,

We had a very fun day at WPI thank you for having us it means a lot to us at Goddard. I had fun having a whole day away from school maybe I can come back next year and see me a little taller in 2012 when I’m about to graduate. The most fun I had was the robotic cars with the controls. I think that I will get to be in a robotics club with Mrs Ziavaia. Maybe 2012 isnt real but that’s what humans like to do EXPLORE! Today I have a homework to creat a moon habitat its gonna be fun.

Bye =) Thank you

Sincerely, Jenny Tran”

* Note: All student notes from Goddard School are transcribed here with the original grammar, typed to facilitate reading, but otherwise exactly in original form (except for missing the cute pictures).

Hi John,


Feedback from teachers and students regarding the field trip was extremely positive. Thank you for providing this learning opportunity for our students. I had given one of our grade 5 teachers a check for the students' lunches, but she wasn't sure to whom it should be submitted. She returned it to me and I will mail it out as soon as I hear back from you regarding where to send it. Again, we are looking forward to future educational collaborations with WPI. (Two of my sisters and one of my brothers are WPI alumni!)

Sue Proulx
Principal
Belmont School

It was a very interesting week, and I must admit being "blown away" by how well the Moon Base unit could be integrated into a normally textbook-based curriculum. Kudos to Ruthann for her vision to allow it and to Fran for his willingness [to be the guinea pig class] and the skill that must have been there in implementing it.

Alfred "Dr. Fred" Bortz
Distinguished Lecturer for the Event

CORI Request Form

WORCESTER PUBLIC SCHOOLS		
	<small>Dr. John E. Dakin Administration Building 20 Irving Street Worcester, Massachusetts 01609-2893 Telephone: (508) 799-3121 Fax: (508) 799-8280</small>	
WORPS CH 385 G		
This request is submitted by: Department/ School/ Collaborative _____		
CORI REQUEST FORM		
<p>Worcester Public Schools has been certified by the Criminal History Systems Board for access to all criminal case data including conviction, non-conviction and pending. As an applicant/employee for the position of _____, I understand that a criminal record check will be conducted for convictions, non-convictions and pending criminal case information only and that it will not necessarily disqualify me. The information below is correct to the best of my knowledge.</p>		
_____ Applicant/Employee Signature		
<u>APPLICANT/EMPLOYEE INFORMATION (Please print)</u>		
_____ Last Name	_____ First Name	_____ Middle Name
_____ Maiden Name or Alias (If Applicable)		_____ Place of Birth
_____ Date of Birth	_____ Social Security Number	_____ Mother's Maiden Name
Current and Former Addresses: _____ _____		
Sex: _____	Height: ____ ft. ____ in.	Weight: _____ Eye Color: _____
State Driver's License Number: _____		
IN ORDER FOR THIS CORI TO BE PROCESSED, A COPY OF A MASSACHUSETTS ID MUST BE ATTACHED.		
_____ PLEASE DO NOT WRITE BELOW THIS LINE		
****The above information was verified by reviewing the following form of government issued photographic Identification: _____		
Requested by: _____ Signature of CORI AUTHORIZED EMPLOYEE		

WHY A CRIMINAL OFFENDER RECORDS INFORMATION (CORI) CHECK?

In order to protect the welfare of our students, and in accordance with the M.G.L. c.71 §.38R, all candidates for, and current occupants of, positions which have the potential for direct and unmonitored contact with WPS students, including, but not limited to teachers, teachers aides, school nurses, counselors, coaches or other extracurricular staff or supervisors, food service employees, custodians and transportation providers. This also includes volunteers, interns, student teachers or other persons regularly offering support to any school program or facility, whether paid or unpaid. This CORI check will be done every three (3) years.

HOW DO I GAIN ENTRY TO A SCHOOL?

In order to be in the schools, individuals (students, faculty, and administrators) from outside institutions must complete a registration process, as follows:

1. Fill out the CORI form on the reverse side of this page so that a CORI check can be done by the Criminal History Systems Board in Boston. Return the form to:

**Human Resource Manager
Worcester Public Schools
20 Irving Street
Worcester, MA 01609**

The Worcester Public Schools will maintain a current data base of all applicants who have been approved or whose approval is pending which can be accessed by each public school. An individual will be contacted **only** if there appears to be a problem with CORI approval. All information is held in strictest confidence by the Human Resource Manager.

2. On the first visit to the school, verify CORI clearance. You will then complete a brief Registration form which will be kept at the school. Orientation will be provided on-site at the individual school(s). A college ID must be worn at all times when in any Worcester public school.

IS INFORMATION KEPT CONFIDENTIAL?

The CORI process is covered under Massachusetts Law and the statute contains strict language regarding confidentiality: "...any willful, unauthorized dissemination of the CORI may subject the offending agency or individual to a fine of \$5,000 and/or up to one year in a House of Correction, in addition to Civil penalties." Within the Worcester Public Schools, CORI information is kept in a confidential file. The Worcester Public Schools is very diligent in not releasing CORI information to anyone other than the specific individual on whom the CORI was conducted.

The Worcester Public Schools is an Equal Opportunity/Affirmative Action Employer/Educational Institution and does not discriminate regardless of race, color, gender, age, religion, national origin, marital status, sexual orientation, disability, or homelessness. The Worcester Public Schools provides equal access to employment and the full range of general, occupational and vocational education programs. For more information relating to Equal Opportunity/Affirmative Action contact Stacey DeBoise Luster, Human Resource Manager, 20 Irving Street, Worcester, MA 01609. 508-799-3020. Please call the main office at the school if you would like this document translated into a language other than English.

Por favor, contate a secretaria central da escola caso deseje que este documento seja traduzido para o português.

Por favor, llame a la oficina central de la escuela si usted desea que este documento sea traducido al español.

Ju lutem telefononi zyren qendrore te shkolles ne se deshironi ta kini kete dokument te perkthyer ne nje gjuhe tjeter pervec Anglishtes

Xin gọi điện thoại cho văn phòng nhà trường nếu quý vị muốn tài liệu này được dịch ra một ngôn ngữ khác hơn tiếng Anh

Verizon Grant Application

Proposal

Our project is to teach science to a fifth grade class, while incorporating a lunar-base focus. While teaching the concepts in the textbook, we tie in to how the material is applicable in a lunar scenario, as well as on Earth, to give them a comparison. As part of our project, we are requesting \$4,000. This would allow us to do four different activities with the class, and evaluate which is best, so that in the future only the events with the most learning value would be kept, lowering future costs.

The first event would be to bring in Dr. Fred Bortz, a nationally acclaimed writer of science and technology for young students. It would cost us \$1500-\$1800 to have him here for three days – one day would be spent solely with the class we are teaching; one day would be at WPI in a large setting, open to other fifth grades classes in the city; and the other day would be spent with us and our advisor, to discuss how it went, and also to discuss the material in greater depth, hopefully leading to Dr. Bortz writing his next book on the subject of a lunar base.

We would also like \$500 to pay for buses to organize a trip to the McAuliffe Center in Framingham. This would be for 36 people maximum, meaning two fifth grade classes. The McAuliffe Center houses full-size mockups of both Houston's Mission Control and a space station interior, where students apply the principles of physical science to the real-time challenges of a simulated space flight. Before arriving, the students would learn about and be assigned different jobs to perform while they are there, such as life support, communications, and navigation.

Two years ago, a class went to the New England Air Museum, and really enjoyed it. It would cost \$1200 for transportation and admission for 40 people. While NEAM doesn't have the lunar focus, it does have many amazing planes that caught the interest of the students two years ago. There are flight simulators, guided tours, and an interactive exhibit for kids. This event would be designed to capture their imagination, and to increase their interest in math and science in general.

In January, we plan to hold an event at WPI, in which fifth grades classes other than our own could come to the school and see what engineers in a college setting get to play with. We'd show them our fire protection laboratory, our wind-tunnel, and the many robots built on campus. This event would also be one of the days when Dr. Bortz would visit, and he would speak to the students in an auditorium. For this event, all we need is \$500 for the buses to bring the students to WPI.

Conclusion

Verizon is a partner company for Elm Park Elementary School, meaning Elm Park can request grant money from them in the amount of a few thousand dollars. The last time they did so, however, was a few years ago. When we started the application, we had no idea what the process included or how involved it was. Before actually seeing the application, we wrote the above proposal for it. However, the application itself was over twenty-five pages long, and even if we had finished it and won, the money wouldn't have arrived until the following year. While this is definitely a resource that should be looked into for the future, we found out about it too late and didn't have the time to fully go into it ourselves.

5th grade MCAS review day, Plan and Schedule for Each Activity

	ELM 1	ELM 2	ELM 3	Belmont 1	Belmont 2	Belmont 3
900-930	PC Alden	Robots Alden	Robots Alden	BORTZ OH 107	BORTZ OH 107	BORTZ OH 107
930-1000	Plate SL 104	Plate SL 104	Plate SL 104	BORTZ OH 107	BORTZ OH 107	BORTZ OH 107
1000-1030	TOUR	TOUR	TOUR	Plate SL 104	Plate SL 104	Plate SL 104
1030-1100	TOUR	TOUR	TOUR	DR SL 115	DR SL 115	DR SL 115
LUNCH 1100-1200	Lunar Odeum	Lunar Odeum	Lunar Odeum	Lunar Odeum	Lunar Odeum	Lunar Odeum
1200-1230	Robots Alden	Grnhse Alden	Grnhse Alden	Exp Alden	Exp Alden	PC Alden
1230-100	DR SL 105	DR SL 105	DR SL 105	PC Alden	Grnhse Alden	Robots Alden

	Goddard 1	Goddard 2	Goddard 3	Vernon 1	Vernon 2	Vernon 3
900-930	Grnhse Alden	Grnhse Alden	Exp Alden	BORTZ OH 107	BORTZ OH 107	BORTZ OH 107
930-1000	Robots Alden	Mnrkr Alden	Grnhse Alden	BORTZ OH 107	BORTZ OH 107	BORTZ OH 107
1000-1030	DR SL 115	DR SL 115	DR SL 115	Grnhse Alden	Grnhse Alden	Mnrkr Alden
1030-1100	Plate SL 104	Plate SL 104	Plate SL 104	DR SL 115	DR SL 115	DR SL 115
LUNCH 1100-1200	Alden	Alden	Alden	Alden	Alden	Alden
1200-1230	BORTZ OH 107	BORTZ OH 107	BORTZ OH 107	Mnrkr Alden	Robots Alden	PC Alden
1230-100	BORTZ OH 107	BORTZ OH 107	BORTZ OH 107	PC Alden	Exp Alden	Exp Alden

	Clark 1	Clark 2	Tatnuck 1	Tatnuck 2	Wawecus
900-930	BORTZ OH 107	BORTZ OH 107	Mnrkr Alden	Mnrkr Alden	PC Alden
930-1000	BORTZ OH 107	BORTZ OH 107	DR SL 115	DR SL 115	DR SL 115
1000-1030	PC Alden	PC Alden	Exp Alden	Exp Alden	Mnrkr Alden
1030-1100	Exp Alden	Robots Alden	PC Alden	Grnhse Alden	Robots Alden
LUNCH 1100-1200	BORTZ OH 107	BORTZ OH 107	Alden	Alden	Alden
1200-1230	Mnrkr Alden	DR SL 105	BORTZ OH 107	BORTZ OH 107	BORTZ OH 107
1230-100	Grnhse Alden	Mnrkr Alden	BORTZ OH 107	BORTZ OH 107	BORTZ OH 107

Key:

- PC Physics Club station
- Plate Plate Tectonics station
- DR Design Review station
- Grnhse Greenhouse station
- Exp Expedition station
- Mnrkr Moonraker station
- Bortz Lecture from Dr. Bortz

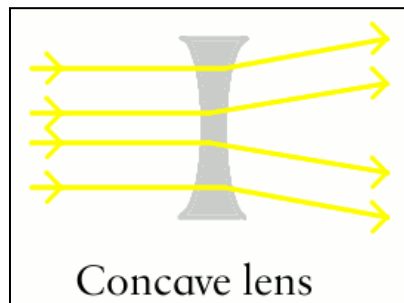
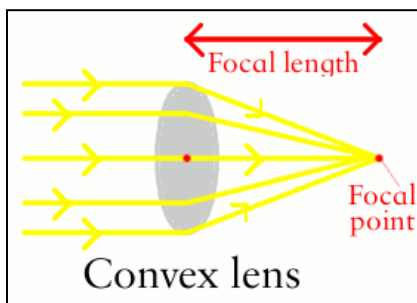
MCAS Review Day Comprehensive Study Sheet

Chapter 13: Earth, Moon, and Beyond

- The **sun** is the star at the center of our solar system.
- To **rotate** is when something spins on its axis.
 - It takes the Earth about 24 hours (1 day) to rotate completely on its axis.
- An **axis** is an imaginary line that passes through Earth's center and its North and South Poles.
 - Because the Earth's axis is tilted (at 23.5 degrees), we have seasons
- To **revolve** is to travel in a closed path.
 - The planets revolve around the sun.
 - It takes the Earth one year to revolve completely around the sun.
- An **orbit** is the path a body takes in space as it revolves around another body.
 - The moon orbits around the Earth.
- The **equator** is an imaginary line around Earth equally distant from the North and South Poles.
- A **moon** is any natural body that revolves around a planet.
 - Unlike the Earth, the Moon has no liquid water.
 - The moon is much smaller than Earth, only $\frac{1}{4}$ its diameter, leading to the moon having almost no atmosphere.
- A **crater** is a low, bowl-shaped area on the surface of a planet or moon.
 - The moon is covered in craters because it has no atmosphere to protect it.
- The **moon phases** are the shapes the moon appears to have as it orbits Earth
 - For example, full moon and new moon are two different phases of the moon.
- An **eclipse** is an event that occurs when one object in space passes through the shadow of another object in space.
 - When the Earth is between the sun and moon, it is a lunar eclipse.
 - When the moon is between the Earth and sun, it is a solar eclipse.
- **Refraction** is the bending of light as it moves from one material to another.
- A **star** is a huge ball of very hot gases in space.
- A **solar system** is a star and all of the planets and other objects that revolve around it.
 - Some solar systems have no planets – our solar system has 8.
 - In our solar system, the inner planets are rocky and dense, while the outer planets are big and gaseous, and much less dense.
- A **constellation** is a pattern of stars, named after a mythological or religious figure, an object, or an animal.
- A **planet** is a body that revolves around a star.
- The **universe** is everything that exists, including the stars, planets, dust, gas, and energy.
- A **galaxy** is a grouping of gas, dust, and many stars, plus any objects that orbit those stars.

Chapter 17: Sound and Light

- A **vibration** is a back-and-forth movement of matter.
- **Volume** is the loudness of a sound.
- **Pitch** is how high or low a sound is.
- **Frequency** is the number of vibrations per second.
- **Reflection** is the bouncing of heat or light off an object.
- An object is **opaque** if it does not allow light to pass through it.
 - The walls of buildings are opaque.
- An object is **translucent** if it allows some light to pass through it.
 - A dirty window is translucent.
- An object is **transparent** if it allows most or all light to pass through it.
 - Glasses are transparent.
- **Refraction** is the bending of light as it moves from one material to another.
- A **concave lens** is thicker at the edges than it is at the center.
- A **convex lens** is thicker at the center than it is at the edges.



Chapter 15: Energy

- Energy is the ability to cause a change in matter.
 - One type of change is movement
 - A car has energy when it is moving.
- The Law of conservation of mass states no energy can be made or destroyed.
- Kinetic Energy is energy in motion
 - The faster an object is moving the more kinetic energy it has
- Potential Energy is the energy an object has because of its condition or position.
 - The higher an object is the more potential energy it has
- Energy Transfer is the movement of energy from one place or object to another
- An activity or example of this is the moon shoes. When the person is standing still, they have potential energy. However, when they are bouncing around they have kinetic energy.
- Solar Energy is energy that comes from the sun.
 - This is the energy collected and used in the lunar base
- Energy stored in fuel is chemical energy
 - This energy can be released by a chemical reaction such as burning.

- Mechanical Energy is the combination of all the potential and kinetic energy of an object.
- Electric energy is energy that comes from an electric current
- Heat is the transfer of thermal energy between two objects of different temperature
 - Thermal energy is transferred in three ways:
 - Conduction: transfer of thermal energy directly from one object to another
 - Convection: transfer of thermal energy through the movement of a gas or a liquid
 - Radiation: transfer of thermal energy by waves that move through matter and space
- Resources is any material that can be used to satisfy a need
 - Nonrenewable resources are resources that cannot be replaced in a reasonable time such as coal and oil
 - Renewable resources can be replaced in a reasonable time such as solar or nuclear
 - These are the resources used in the lunar base

Chapter 16: Electricity

- Electricity is a form of energy produced by moving electrons

- Electromagnet is a magnet made by coiling a wire around a piece of iron and running electricity through the wire

- This was demonstrated in the Telegram Activity

- Static Electricity is the buildup of charges on an object

- This is what causes your hair to stick up when you rub a balloon through it

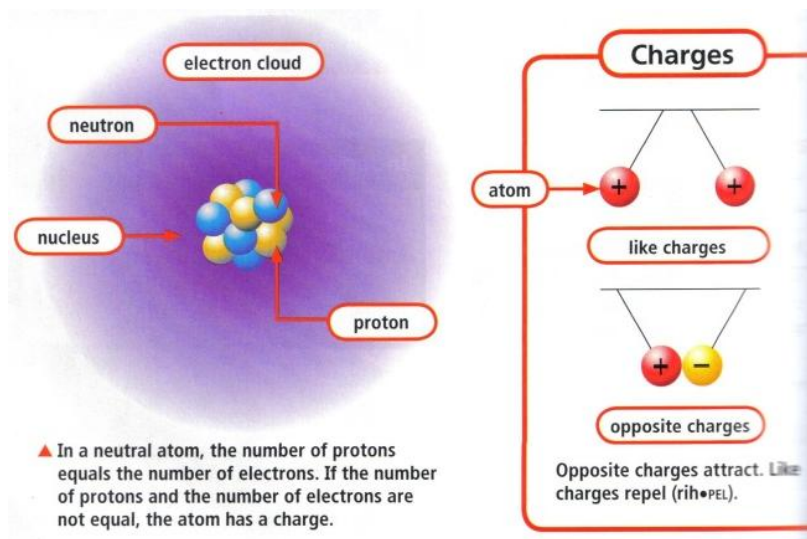
- Electric Current is the flow of charges

- Electricity that flows in this way is a kind of kinetic energy and called current electricity

- Electricity moves through certain materials better than others

- A material is a conductor if electricity moves well through it

- A material is an insulator if electricity moves poorly through it



Chapter 3: Plant Growth and Reproduction

- There are two basic types of plants: Nonvascular and Vascular Plants
 - Nonvascular Plants have no true roots, stems, or leaves. They also absorb water and nutrients from the surroundings. For example, moss
 - Vascular plants, which are much more complex. They contain many different parts, which include:
 - Vascular tissue, which carries water and food throughout the plant. There are two types of vascular tissue
 - Xylem: carries water and food from the roots to the rest of the plant
 - Phloem: carries water and food from the leaves to the rest of the plant
 - Roots: absorbs water and food from the soil and anchor the plant to the ground
 - Stems: carry the water and nutrients from root to leaf and the other way around. Stems also offer support for the plant and some plants even grow from stems
 - Leaves: make food for the plant through the process called photosynthesis
 - Photosynthesis takes place within the chloroplasts in the leaf cell
 - Photosynthesis uses light energy, carbon dioxide, and water to create sugar
- Plants reproduce in two main ways:
 - The first way is by spores, which are single reproductive cells that can grow into a new plants
 - The second is seed-bearing plants, which release seeds
 - Gymnosperm: plant that produce naked seeds
 - Angiosperm: plants that produce seeds that are protected by fruits
 - Seeds are adapted to sprout when conditions are best for growth and this is called germination
 - Remember when you put the plant seeds under the box and watched them grow? This activity demonstrated the growth of a plant.

Chapter 18: Forces

- **Force:** A push or pull that causes an object to move, stop, or change direction
EX) Pushing desk to start move.
- **Friction:** A force that opposes the motion.
EX) Friction between desk and ground oppose your push.
- **Gravitational force:** Force that pulls object in the universe on one another.
EX) Gravitational force pulls us to the ground.
- **Magnetic:** Having property that pulls iron toward magnet
- **Magnetic force:** The force produced by magnet
- Magnet can attract iron, but also push and pull another magnet. Every Magnet has two opposite end side. One side is north and another side is south. South end of magnet pulls magnet's north end and north end of magnet pulls magnet's south end. However south end push another magnet's south end. North end push another magnet's north end.
- **Balanced force:** Forces that act on an object but cancel out each other.
EX) Two people pushing each other but they do not move.

- **Unbalanced force:** Forces that act on an object and do not cancel out each other, this cause to change the motion.
Ex) pushing desk against friction force.
- **Buoyant force:** The upward force exerted on an object by water.

Chapter 10: Using Resources

- **Gravity:** Force that pulls towards matter or anything that has weight.
Ex) if you let the coins from the hand, it pulls towards earth due to gravity.
- **Inertia:** Tendency of a moving object to keep moving in straight line
Ex) If there is no gravity force around the matter (such as space), it will keep moving straight line.
- Day and Night occur due to rotation of the planets around the Sun. When half of the planet faces the sun, that half would be day and another half will be night.
- Earth's season occur due to that earth is tilted away from the Sun. During the summer, the place get direct ray from the Sun. During the winter, the sun ray comes with the angle from low sky.
- **Lithosphere:** Hard outer layer of Earth. The rocky surface that makes up the top of the lithosphere is called **Crust**.
- **Hydrosphere:** Earth Water, trillion of liters of water such as lake, river, and sea. Also this water keeps temperature of earth changing drastically.
- **Atmosphere:** Many layer of gases that surround earth.
- **Faults:** Cracks in the crust
- **Geologist:** Scientists who study earth
- **Mineral:** Solid materials of Earth crust such as gold and iron. Each mineral is unique they are made of different composition.
- **Luster:** Way that light bounces off the mineral
- **Streak:** Color of the powder left when a mineral is rubbed against a hard, rough surface.
Ex) In class, we rub the rocks against another rock to see the streak.
- **Hardness:** measure of how well a mineral can resist scratching.
- **Cleavage:** Tendency of a mineral to break along flat surface.
- **Density:** How heavy it is with same size (**volume**)
- **Ores:** Some of the most useful minerals. Ore is a mineral that contains a useful substance.
Ex) Mineral hematite contains Iron that makes building and ships.
- Many minerals are formed when hot liquid rock, or magma, cools and harden into solid. Each mineral are formed differently by pressure, heat, how long it takes to cool down from the heat. That is why some rare mineral exist deep underground. Also minerals can be formed when water dissolve into the rock.
- Minerals are used to make many products such as steel or light bulbs.
 - **Gems:** minerals that is valued for being rare and beautiful such as rubies and sapphires.

Chapter 9: Changes in the Earth's Surface (Plate Tectonics)

Landform: a natural land shape or feature

Topography: All the kinds of landforms in a certain place

Glacier: A large, thick sheet of ice

Sand dune: A hill of sand, made and shaped by wind

Plate: A section of Earth's crust and upper mantle that fits together with other sections

Earthquake: A shaking of the ground, caused by a sudden release of energy in Earth's crust

Magma: Molten rock beneath Earth's crust

Lava: Molten rock that reaches Earth's surface

Volcano: A mountain made of lava, ash, or other materials from eruptions that occur at an opening in Earth's crust

Epicenter: The point on Earth's surface directly above the focus of an earthquake

Fault: A break in Earth's crust

Other Concepts

Plate Tectonic Theory: The key principle of plate tectonics is that the lithosphere exists as separate and distinct *tectonic plates*, which ride on the fluid-like asthenosphere.

"Ring of Fire": the Ring of Fire is an area where large numbers of earthquakes and volcanic eruptions occur in the basin of the Pacific Ocean. The Ring of Fire is a direct result of plate tectonics and the movement and collisions of crustal plates.

Mantle: Two main zones are distinguished in the upper mantle: the inner asthenosphere composed of flowing rock, and the lowermost part of the lithosphere, composed of rigid rock. A thin crust, the upper part of the lithosphere, surrounds the mantle and is about 5 to 75 km thick.

Inner core: hottest part of the earth, composed of nickel-iron alloy

Outer core: liquid layer of the earth composed of iron and nickel, lies below the mantle and above the inner core

Lunar Regolith (simulated): a volcanic, basalt-based, powder similar to what is found on the surface of the moon (2-10 meters deep). Contains iron, oxygen, silicon, calcium, aluminum, titanium, and helium

Solar radiation: harmful energy given off by the sun that travels in all directions through space

Solar flare: an intense burst of solar radiation

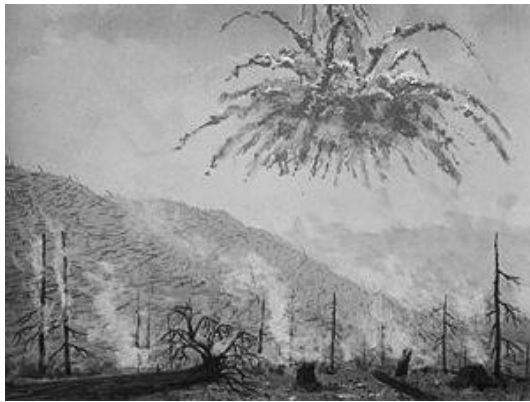
Nuclear Fission reactor: a reactor that operates by splitting atoms into smaller pieces to release energy

Nuclear Fusion reactor: a reactor that operates by combining small atoms into bigger ones, like the Sun

Impact of Asteroid - Handout

1908 Tunguska Event

This "Tunguska Event" refers that major explosion that occurred on 30 June 1908. This event was located in the Tunguska in Siberia. This caused destruction of over 2000 km² and globally detected pressure, waves, and bright night sky in Europe and Central Asia. This has happened because of impact with the Earth of an Asteroid that exploded around 5 to 10 km above the ground. This leads to release in energy around 10 to 15Mton of Energy. However, the parts of asteroids were never found. Lake Cheko which was inferred explosion epicenter has shape of funnel like bottom. Lake Cheko has formed because of secondary impact onto alluvial swampy ground. Size and shape of the crater would impact the nature of the ground which resulting melting and degassing the ground and making the lake.



Top Left picture describe asteroid bursting about 10km above the ground.

Top Right Picture describe woods lying down because of the impact of asteroid.

Bottom left picture describe area after the impacts after cleaning the woods.

Bottom right picture describe Lake Cheko which formed from asteroid impact.

Barringer Crater, Arizona

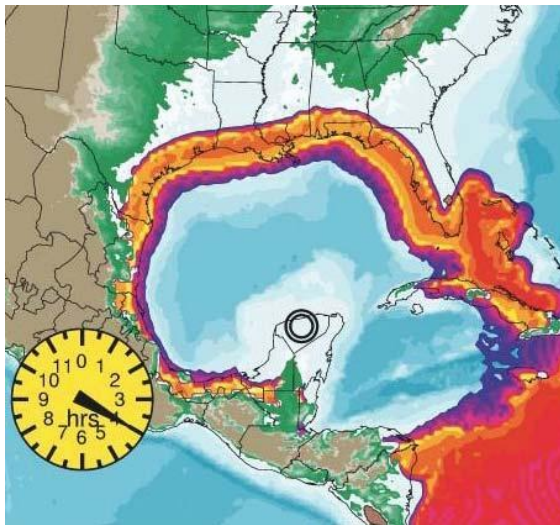
Around 49,000 years ago Meteor within 150ft across, weight about 300,000 tons, and traveling about 40,000 miles per hour, hit earth which result in this crater. This asteroid Impact had same energy of explosion 20 million tons of TNT and leaving the crater within size of 0.75 miles across, 575 ft deep and rim of 148 ft higher than surrounding plain.



Picture describe Barrington crater from Arizona

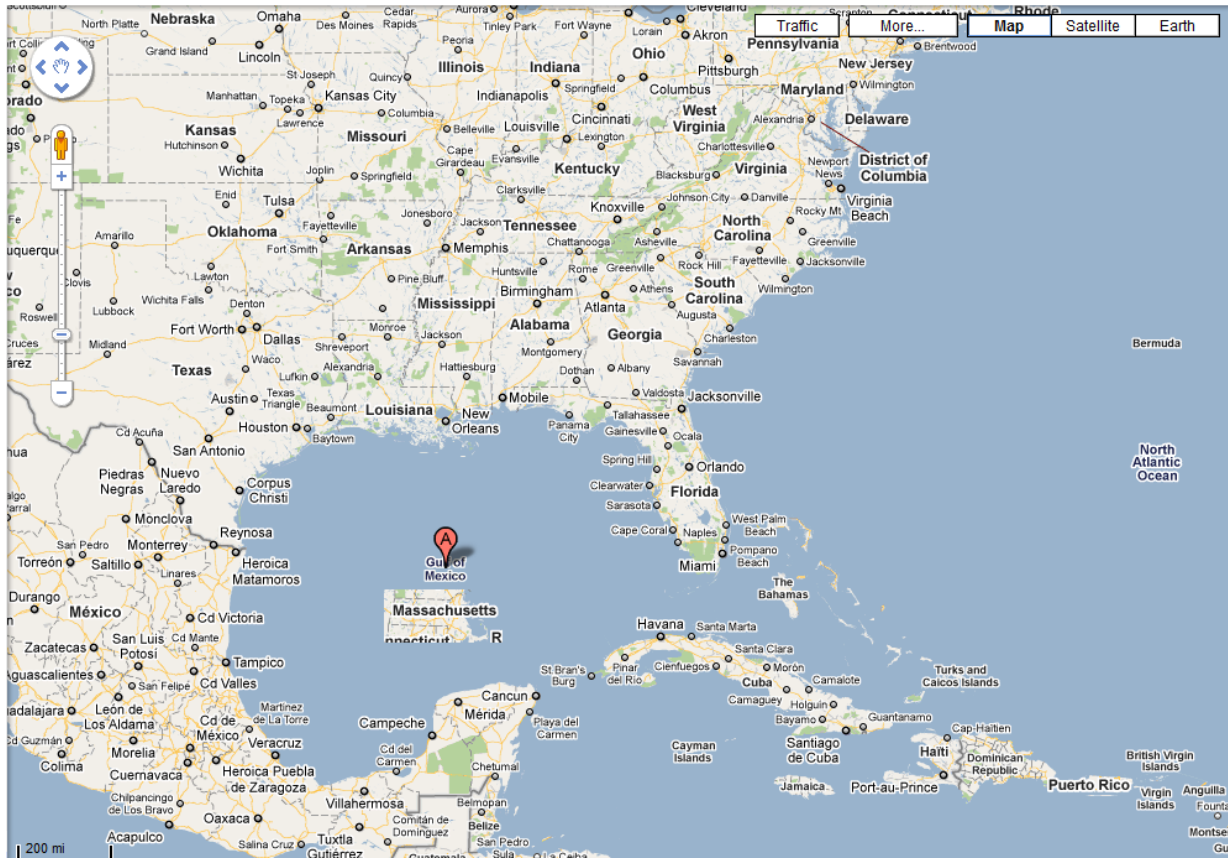
Gulf of Mexico

This crater is very huge that measured about 105 miles across. The impact would have happened about 65 million years ago. When a asteroid within the size of small size city crashed on earth it makes impact of energy about 100×10^{12} tons of TNT explosion which is simply 5,000,000 times of asteroid impact cause Barringer crater in Arizona. This would lead to mega tsunami, earthquake, and volcanic eruption around the globe. This is widely believed that this would led extinction of dinosaurs.



Top picture describe imaginary picture of asteroid make Gulf of Mexico

Bottom left picture describe Gulf of Mexico in map.



Size of Gulf of Mexico compare to Massachusetts

Elm Park's Standard Science Curriculum Schedule

	Term One	Term Two	Term Three	Term Four
Sixth Grade	<p>"Getting Ready For Science" textbook pages 2- 38.</p> <p>Life Science CH 4 Ecosystems CH 5 Resources in Ecosystems</p> <p>Engineering Design Project (not in the text – it will be presented at an "Intel Inquiry Science Workshop" for all grade 6 teachers (date TBD)</p> <p>If time permits,HSP CH 2 and then CH 1</p>	<p>Physical Science CH 12 Atoms, Elements, Periodic Table CH 13 Changes in Matter CH 14 Energy (Add Marble Madness and Catapults from last year's wkshp) CH 15 Heat / Electricity</p> <p>Engineering Project (not in the text – will be presented at an "Intel Inquiry Science Wkshp)</p>	<p><i>Science and Engineering Fair</i> : March 3 at EcoTarium</p> <p>CH 16 Forces and Motion (Add Cars and Ramps)</p> <p>Earth and Space CH 6 Changes to Earth's Surface</p> <p>Engineering Project (not in the text – will be presented at an "Intel Inquiry Science Wkshp)</p>	<p>Earth and Space CH 7 Rocks CH 8 Fossils CH 9 Water Planet CH 10 Weather CH 11 Universe</p> <p>Engineering Project (not in the text – will be presented at an "Intel Inquiry Science Wkshp)</p>

		<i>B Term Review</i>		
Fifth Grade	<p>"Getting Ready For Science" textbook pages 2- 38.</p> <p><i>Now</i> Earth and Space CH 7 Rock Cycle CH 9 Earth's Surface CH 11 Weather + Water CH 13 Earth and Moon</p> <p><i>Now 5th the must be done</i></p>	<p>Physical Science and Engineering CH 14 Properties of Matter <i>Do no</i> CH 15 Energy CH 16 Electricity CH 17 Sound and Light CH 18 Forces</p>	<p><i>Science and Engineering Fair</i> : March 3 at EcoTarium</p> <p>Engineering Design Project (not in the text – it will be presented at an "Intel Inquiry Science Workshop" for all grade 5 teachers (date TBD)</p> <p>Life Science CH 2 Classify CH 3 Plant Growth CH 4 Animal Growth</p>	<p>Life Science CH 5 Energy and Ecosystems CH 6 Ecosystems</p> <p><i>MCAS Review</i></p> <p>Science MCAS CH 1 Human Body (after the MCAS Test)</p>
Fourth Grade	<p>"Getting Ready For Science" textbook pages 2- 38.</p> <p>Life Science CH 1 Classify Living Things CH 2 Life Cycles</p>	<p>Life Science CH 3 Adaptations CH 4 Human Body CH 5 Ecosystems CH 6 Energy Transfer in Ecosystems</p>	<p>Earth Science CH 7 Rocks CH 8 Changes to Earth's Surface CH 9 Water Cycle</p> <p>Physical Science CH 11 Matter</p>	<p>Physical Science Ch 13 Sound CH 15 Electricity</p> <p>Engineering CH 17 Simple Machines</p>

Melting Points of Some Metals and Alloys

Metal	Melting Point	
	(°C)	(°F)
Admiralty Brass	900 - 940	1650 - 1720
Aluminum	660	1220
Aluminum Bronze	800 - 855	1190 - 1215
Antimony	630	1170
Beryllium	1285	2345
Beryllium Copper	865 - 955	1587 - 1750
Bismuth	271.4	520.5
Brass	930	1710
Cadmium	321	610
Cast Iron, gray	1175 - 1290	2150 - 2360
Chromium	1880	3380
Cobalt	1495	2723
Copper	1084	1983
Cupronickel	1170 - 1240	2140 - 2260
Gold	1063	1945
Hastelloy C	1320 - 1350	2410 - 2460
Inconel	1390 - 1425	2540 - 2600
Incoloy	1390 - 1425	2540 - 2600
Iridium	2450	4440
Iron	1538	2797
Lead	327.5	621
Magnesium	650	1200
Manganese	1244	2271
Manganese bronze	865 - 890	1590 - 1630
Mercury	-38.88	-37.95
Molybdenum	2620	4750
Monel	1300 - 1350	2370 - 2460
Nickel	1453	2647
Niobium (Columbium)	2470	4473
Osmium	3025	5477
Platinum	1770	3220
Plutonium	640	1180
Potassium	63.3	148
Red Brass	990 - 1025	1810 - 1880
Rhodium	1865	3569
Selenium	217	423
Silicon	1411	2572
Silver	961	1760
Sodium	97.83	208
Carbon Steel	1425 - 1540	2600 - 2800
Stainless Steel	1510	2750
Tantalum	2980	5400
Thorium	1750	3180
Tin	232	449.4
Titanium	1670	3040

AWARD-WINNING BOOKS + EXCITING SCIENCE =

A DAY WITH DR. FRED



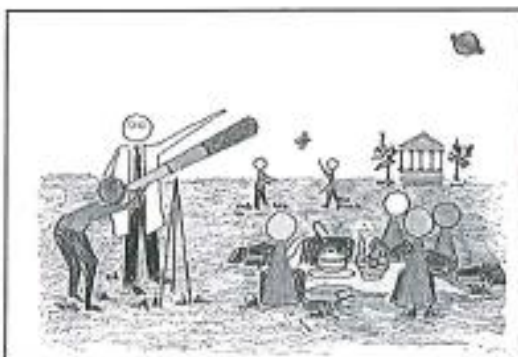
Who is "Dr. Fred"?

Fred Bortz is one of the nation's leading writers of science and technology for young people, winner of the prestigious American Institute of Physics Science Writing Award.



What does the "Day with Dr. Fred" program include?

- **Optional pre-visit "Meet Dr. Fred" e-mail exchange.** Dr. Fred answers one question per day in his distinctive, entertaining style and posts his responses on a web page that the community can follow. Questions can be about his books and other topics in science, or about being a writer and the writing process.
- **One or two assembly presentations.** School may choose either of Dr. Fred's unique talks, "The Truth About Space Aliens" or "Our Next Planet: Why, When and How People Will Settle Another World."
- **Up to six grade-level or classroom question-and-answer sessions.** These are always lively and informal and are usually the highlight of the day for the students and Dr. Fred himself.



What areas of the curriculum does this program support?

A Day with Dr. Fred reinforces inquiry-based science and cross-disciplinary learning. It also demonstrates that literature includes nonfiction and encourages reluctant readers to discover "true stories." Dr. Fred's books connect to specific curriculum objectives in the following areas:

- Earth Science • Meteorology • Life Sciences
- Environmental Science • Astronomy/Space
- Technology and Innovation • Sci/Tech Careers
- Writing Process • Using Reference Materials

Where can we find out more?

Discover Dr. Fred's books and much more at his website, www.fredbortz.com

How can we contact Dr. Fred?

Fred Bortz, 1312 Foxboro Dr., Monroeville, PA 15146
DrFred@att.net 412-856-1440



Discover these and other great books by Dr. Fred in your library today!

Photos

From the Video shown during lunch at the MCAS Review Day

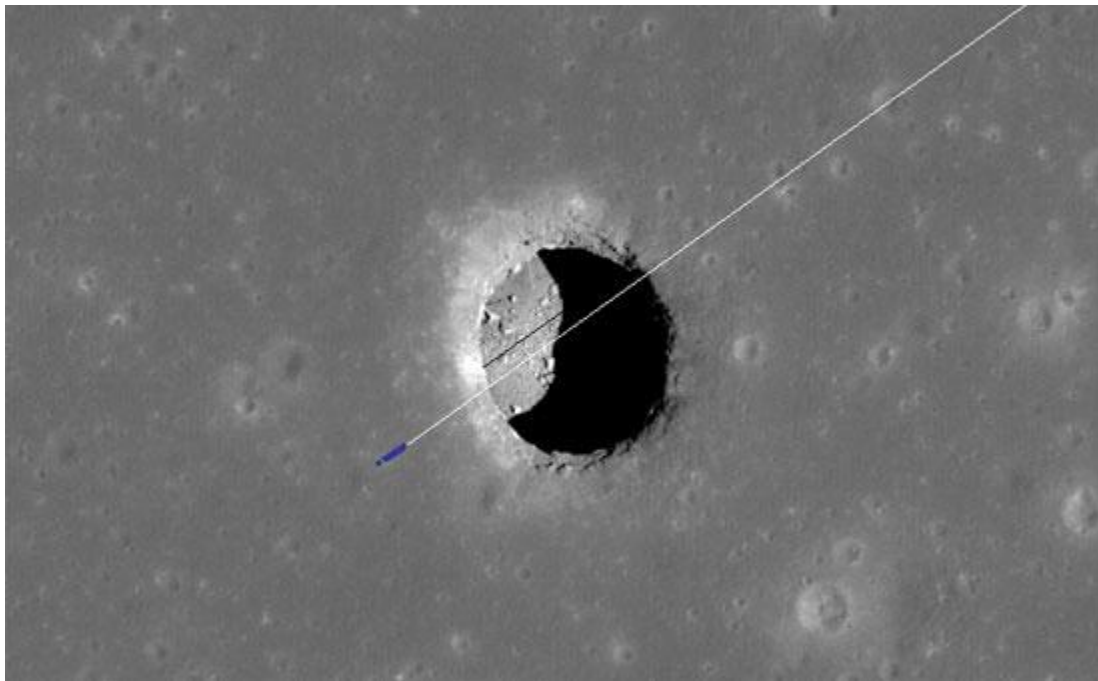


A Base Design from the Design Review Station at the MCAS Review Day



The Cave in the Marius Hills that inspired the “Expedition” Station to investigate it, as depicted by the Indian Space Research Organization

Discovered by the Chandrayaan-1 spacecraft, this chamber is more than one mile long and 393 feet wide. There would be lots of benefits of building a moon base in there, mainly for protection from the nastiness of the surface of the moon. It'd provide a nearly constant temperature of -4 degrees Fahrenheit, unlike the surface, which fluctuates between 266 degrees and -292 degrees. And it would provide protection from radiation, micro-meteor impacts and dust.



Bibliography

10 greatest Major-Impact Craters on Earth, Images, Author unknown, 2008

"Barringer Crater, Arizona, US." *Environmental Graffiti*. Web. 2 Mar 2011.
<<http://www.environmentalgraffiti.com/featured/10-greatest-major-impact-craters-on-earth/1403>>.

Impact Extinction, Impact that would cause extinction to certain kind, Author Karina Hall, 2006

"Last Piece of Asteroid WMPH Remnant Hits Earth." *Impact Extinction*. Web. 2 Mar 2011.
<<http://karinahall.txc.net.au/MoonExtinctionCycle/z6.html>>.

Tsunami risk of asteroid strikes revealed, Effect of Tsunami and Asteroid, Author Jeff Hecht, 2006

New Scientist. Web. 2 Mar 2011. <<http://www.newscientist.com/article/dn9160-tsunami-risk-of-asteroid-strikes-revealed.html>>.

Google maps- locating Gulf of Mexico, Size comparison with states

Google Maps. Web. 2 Mar 2011.

1900 Galveston hurricane, Basic information

"1900 Galveston hurricane." Wikipedia, 2011 . Web.
<http://en.wikipedia.org/wiki/1900_Galveston_hurricane>.

1900 Great Storm Theater, Detailed information, Galveston Historical Foundation's website

"1900 Great Storm Theater." *Galveston Historical Foundation*. N.p., n.d. Web. 2 Mar 2011.
<<http://www.galvestonhistory.org/>>.

Special report on the Galveston Hurricane, report of event, Author Isaac Cline, 1900

Wilson, James, and Willis Moore. "Galveston Storm of 1900." *NOAA History* (2004): n. pag.
Web. 2 Mar 2011. <http://www.history.noaa.gov/stories_tales/cline2.html>.