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Grade 5 Space Enhanced Science Exploration

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Contents

Authorship

Taymon Beal wrote the text of the “Special Activities” section. Amber Desjardin wrote the text of the other sections. This report is based on the work done by the team of Taymon Beal, Zackary Couture, Amber Desjardin, and Elise Mariolis.

Acknowledgement

I would like to thank everyone at Elm Park Community School and each advisor that has helped this project over the past few years. The 5th and 6th grade science is getting better each year, and it wouldn't be possible without their willingness to depart from the standard curriculum and experiment with thematically integrated hand's on science education.. They truly know what they want, and that is a school that offers a consciousness raising experience in science as the fun subject and gets 10-11 year olds dreaming about technical careers and a better future as a possibility through the mastery of math and science.. Yes, there is also a state exam, and the students need to learn specified concepts, and the staff is there to help them over this hurdle every step of the way, but it goes so far beyond that. The team effort of English and Science teachers to do the Space Oriented Essay contest this year was a labor of love leading to brilliant success at the 6th grade level, and a success at the 5th grade level. as well.

We would also like to acknowledge the contributions of Martha Cyr and Shari Weaver from the WPI STEM Education Center, of Reach for the Stars volunteers Mark Lerret and Kerrin Beovich, and, of course, of our advisor, Dr. John Wilkes, without whom none of this would exist.

Abstract

The goal of the overall project was to elaborate moon based themes to augment the required 5th grade science curriculum as defined by the Harcourt School Publishers science text. Our team enhanced previous team's projects with better activities and piloted an essay contest conceived of by the prior team, but which they could not get approved and executed. We also worked toward creating a service club of WPI students to help teachers institute hands on education in 5th grade classrooms and started the process of planning a 5th grade field trip to WPI.

` The central project goal is to produce well documented kits for the classroom that contain materials necessary to have group activities and hands-on demonstrations in class For 6 text chapters, solar system, matter, energy, electricity, light and sound, forces, and possibly a plan for a 7th on motion. These activities happen on a bi-weekly basis and in the future are to be run by volunteers and the teacher as necessary. This paper outlines only a quarter of the complete project including some activities that were run in class and part of the essay contest, stressing the 6th grade easy contest on Mars Rovers, since the author was a judge in that activity. The rest of the team worked on the 5th grade contest dealing with the search for water on the moon. The rest of the project report is a work in progress that will probably be finished next term by the rest of the team. At the end of this project, 5th grade students should be able to understand and apply basic

science ideas from those chapters based on the activities we took into their classroom. In addition they came to see science as the fun course with amazing implications for the future since their activities all had a lunar theme. They were solving the problems associated with living and working on the moon using what they learned each week.

Introduction

As in the previous reports, this project is geared towards 5th graders because of their age. By the time they are astronaut age, they will be the generation in charge of building a base on the moon, which is expected to happen in less than 60 years from now. This base would allow for people to live on the moon and it would be largely self-sufficient. This is a big task, but it lies in the hands of our current 5th graders. Some parts of the task have already been completed, while others still have more work required before the base we envision can be a reality.

Our team worked with the AIAA New England chapter, which is an organization very interested in students and helping schools do a better job with science and math education and of course hope to encourage the use of aerospace examples of concepts.It is interesting that they sponsored an essay contest run by the English teacher in this project, but the topics were space oriented non fiction.. They allotted us $50 to enhance each of 6 chapter materials kits, $600 for a field trip, and about $300 more to run the essay contest. The awards ceremony cost them $175 just for the 7 prize books and there were royalties on the use of the book chapters copies and video by Dr. Bortz that was shown.

The last team developed activities for the chapters on Solar Systems, Matter, Energy, Electricity, Light, and Forces. However, the teacher’s reviews

of Energy and Friction were negative. He also made it clear that Buoyancy and Gravity were mediocre at best. The students didn’t even learn all of the concepts necessary when it came to Light. The chapter on motion was also skipped the previous year. Another lapse- or possibly failure to sell the idea, was the attemptto start an essay contest. They sold the idea of a service club aimed at being volunteers for the teachers when they are running activities but then ran out of time and stumbled on execution. We too would find that it is hard to do anything else hwen getting ready to work in the class room every week, and even every other week.

Background

Last Year's Report

This year's 5th grade curriculum development project continues on what previous projects began, but expanded on key elements. The goal over the past few years has been to increase the students' interest in science and technology, and give them the confidence, experience, and knowledge they need to be considered science literate. From the literate pool, about 10% will go on to become professional scientists and technologists. The seed of interest seems to have to be planted early and nurtured. The 5th grades space enriched science education unit we further developed was a exposure to role models and problem solving with the formation of a literate pool in mind. . The main goal is allow them the opportunity to solve problems and design things so tht they will know what it is like enough to be able to conceive of what it might be like to one day go into a science or engineering field.

The previous team went into the 5th grade classroom of Fran Mahoney (newly assign to do just math and science) on a weekly basis. There were 2 5th grade classes and he saw both of them every day for math, but science classes was held only half the time. The science teacher had the same students from one of the classes for a week while the other took social studies with a different teacher. Then they swapped, so he saw the other class the next week.Hence all the activities were repeated 2 weeks in a row

as the new units were developed. The problem was that the long gap allowed students to forget too much between class meetings. We did not like the schedule and were pleased tp hear that is was being changed to every other day with each class. Our team had the challenge of a new schedule which demanded repeating the activity not the next week on the same day, but rather two dys in the same week, back to back with all the differences between our own Wed and Thursday schedules involved. On the othe hand one would not have to do a unit every week. It was expected to be every other week. That did not work out though, since the class got behind and we still had to be done by the end of C term. WE ended up having to go in on Christmas break and sometimes every week to try to cover as many units as the last team, but faster. In principle though, it should have been that the students now had science every other day, so this would require us to be in the classroom twice a week, every other week. We were surprised to find it hard to keep up with the drumbeat of preparing a new unit every other week and delivering it twice the next week.

It would have been manageable if that were all we were doing, but we also had a club to create, field trips to plan, an essay contest to run and assessments to do.

The previous team created kits based off of the Cratersville lunar base theme but drawing on and illustrating material in the textbook. We tried to incorporate all of the key words and principles necessary to have an effective

grasp of concepts, but in practice we generally found the activities focused on one or two, and it was our job to figure out how to cover at least some of the rest. The prior team had made lists of them all for he students to take home. We liked this idea as a way to compensate for not being able to take the texts home, but did not think that that was adequate compensation for having skipped a major concept in class. . These activity kits were tied into a lunar base theme to both keep the students interested in what they were learning and so that the separate ideas came together around a common set of problems. Solving problems in an alien environment where things don't quite work as the y do on Earth is a good way to find out if you understand a concept or not. It was also one way for them to have a fun hands-on way to experience science in a lively imaginative environment. Last year an essay contest was proposed, but there were very few volunteers from the many students at Elm Park because the reading level of the school wasn't up to par as of yet. This was a big disappointment to all involved, but a goal was established for this year because of it. The book that the students were to read for the contest, has become an experiment over the past few years and is made possible by the author, Dr. Fred Bortz. He has made presentations at Elm Park, and furthered the student's excitement of learning. Field trips have also been arranged the past related to what was being taught in the classroom and were a success once implemented.

One thing that last year's team didn't accomplish was good documentation of the kits and procedures on how to recreate this activity

with a volunteer club instead of an IQP team. This was touched upon in this year's project so that the kits can continue and the new club, "Reach for the Stars" can pick up where the IQP teams over the years have left off.

Taymon -SEE IF THIS ONE IS THE SAME –IT IS THE ONE I SENT YOU BEFORE

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year’s project so that the kits can continue and the new club, “Reach for the Stars” can pick up where the IQP teams over the years have left off.

5th Grade Key Words from Text Book

The following key words and concepts are taken from the 5th grade text, by Le Yu to compensate for the fact that the students could not take their texts home . He wanted them to be able to study for the MCAS and be exposed to the things not covered in the demos and activities done by the team in class. The lunar theme made it difficult to teach all of the concepts. The following is what the previous team used to be sure that their kits and activities covered the necessary concepts from the text, but in a more engaging manner. It is split into chapters and covers most of the important material that 5th graders will see on the science portion of the MCAS but is just a list highlighted by the text itself. The lunar base was tied to these key concepts to the best of the team's ability. Last year had a few holes and some of the connections were improved this year. Our job was to assess, enhance, and fix some problems noted by the teacher and ourselves.

Chapter 13: Earth, Moon, and Beyond

Lesson 1:

Sun: The star at the center of our solar system

Rotate: To spin on an axis

Axis: An imaginary line that passes through Earth's center and its North and South Poles

Revolve: To travel in a closed path

Orbit: The path one body takes in space as it revolves around another

Equator: An imaginary line around Earth equally distant from the North and South Poles

Lesson 2:

Moon: Any natural body that revolves around a planet

Crater: A low, bowl--shaped area on the surface of a planet or moon

Moon phase: One of the shapes the moon seems to have as it orbits Earth

Eclipse: An event that occurs when one object in space passes through the shadow of another object in space

Refraction: the bending of light as it moves from one material to another

Lesson 3:

Star: A huge ball of very hot gases in space

Solar system: A star and all the planets and other objects that revolves around it

Universe: everything that exists, including such things as stars, planets, gas, dust, and energy

Galaxy: A grouping of gas, dust, and many stars, plus any objects that orbit those stars

Chapter 14: Properties of Matter

Lesson 1

Volume: The amount of space an object takes up

Atom: The smallest particle that still behaves like the original matter it came from

Molecule: Two or more atoms joined together

Nucleus: A dense area in the center of an atom that contains protons and neutrons

Element: Matter made up of only one kind of atom

Periodic table: A chart that scientists use to organize the elements

Lesson 2

Physical change: A change in which the form of a substance changes, but the substance still has the same chemical makeup

Density: The measure of how closely packed an object's atoms are

Mixture: A combination of two or more different substances

Solution: A mixture in which all the parts are mixed evenly

Lesson 3

Combustibility: A measure of how easily a substance will burn

Reactivity: The ability of a substance to go through a chemical change

Chapter 15: Energy

Lesson 1

Energy: The ability to cause changes in matter

Kinetic energy: The energy of motion

Potential energy: The energy an object has because of its condition or position

Lesson 2

Solar energy: Energy that comes from the sun

Light: Radiation that we can see

Chemical energy: Energy that can be released by a chemical reaction

Mechanical energy: The combination of all the kinetic and potential energy that something has

Electric energy: Energy that comes from an electric current

Lesson 3

Heat: The transfer of thermal energy between objects with different temperatures

System: A group of separate elements that work together to accomplish something

Conduction: The transfer of heat from one object directly to another

Convection: The transfer of heat through the movement of a gas or a liquid

Radiation: The transfer of energy by means of waves that move through mater and pace

Reflection: The bouncing of heat or light off an object

Lesson 4

Fossil: The remains or traces of past life, found in sedimentary rock

Resource: Any material that can be used to satisfy a need

Nonrenewable resource: A resource that, once used, cannot be replaced in a reasonable amount of time

Conservation: The use of less of a resource to make the supply last longer

Renewable resource: A resource that can be replaced within a reasonable amount of time

Pollution: A waste product that harms living things and damages an ecosystem

Chapter 16: Electricity

Lesson 1

Electricity: A form of energy produced by moving electrons

Electromagnet: A magnet made by coiling a wire around a piece of iron and running electric current through the wire

Lesson 2

Static electricity: The buildup of charges on an object

Electric current: The flow of electrons

Current electricity: A kind of kinetic energy that flows as an electric current

Conductor: A material that carries electricity well

Insulator: A material that does not conduct electricity well

Lesson 3

Electric circuit: The path an electric current follows

Series circuit: An electric circuit in which the current has only on path to follow

Parallel circuit: An electric circuit that has more than one path for the current to follow

Chapter 17: Sound and Light

Lesson 1

Vibration: A back--and--forth movement of matter

Volume: the loudness of a sound

Pitch: How high or low a sound is

Frequency: the number of vibration per second

Lesson 2

Reflection: The bouncing of heat or light off an object

Opaque: Not allowing light to pass through

Translucent: Allowing only some light to pass through

Refraction: The bending of light as it moves from one material to another

Concave lens: A lens that is thicker at the edges than it is at the center

Convex lens: A lens that is thicker at the center than it is at the edges

Chapter 18: Forces

Lesson 1

Force: A push or pull that causes an object to move, stop, or change direction

Friction: A force that opposes motion

Gravity: The force of attraction between objects

Gravitational force: The pull of all objects in the universe on one another

Magnetic: Having the property of attracting iron objects

Magnetic force: The force produced by a magnet

Lesson 2

Balanced forces: Forces that act on an object but cancel out each other

Unbalanced forces: Forces that act on an object and don’t cancel out each other; unbalanced forces cause a change in motion

Net force: The combination of all the forces acting on an object

Buoyant force: The upward force exerted on an object by water Lesson 3

Work: The use of a force to move an object through a distance

Simple machine: A device that makes a task easier by changing the size or direction of a force or the distance over which the force acts

Lever: A bar that makes it easier to move things

Fulcrum: The balance point on a lever that supports the arm but does not move

Wheel--and--axle: A wheel with a rod, or axle, in the center

Pulley: A wheel with a rope that lets you change the direction in which you move an object

Inclined plane: A ramp or another sloping surface

Chapter 19: Motion

Lesson 1

Position: The location of an object in space

Speed: The distance an object travels in a certain amount of time

Velocity: A measure of an object’s speed in a particular direction

Acceleration: The rate at which velocity changes

Lesson 2

Inertia: The property of matter that keeps it at rest or moving in a straight line

[Are you sure there were not more sections in Motion?]

Classroom Activities

Where do Craters come from?

Materials List:

- Flour (2 lbs.)
- Tupperware containers(5)
- Angled Ramps (4)
- Marbles (5)
- Playdough
- Black Sand (optional)
- Handout

Method:

This activity is part of Chapter 13, The Earth, Moon, and Beyond. It covered most of the concepts in the book, and the rest were covered or repeated in later activities. This was one of the first lunar themed activities to be done at the school, but not the first time the team met the teacher and the students since there was a prior unit on Buoyancy built around the Galveston “flood” which was actually a storm surge that engulfed the island. . In retrospect, a meeting with the teacher and observation of the classroom is recommended before entering the school for the first time. The

goal of this activity was to ascertain the angleof the asteroid impact that created Shackleton crater at the South pole of the moon..

The lunar activity involved ramps to deliver marble or ball bearing at angles of various degrees. They ranged from 15 to 90 degrees and each ramp stand was at a different station that was manned by a volunteer. The class was split up into 5 groups with about 7 minutes at each station to get the crucial information that they needed.

Preparation involves modeling the geologic layers of the moon as described by Marianne Dyson in her book Home on the Moon: Living On the Space Frontier. In effect, we approximated deep bedrock with play dough the original lunar surface with flour and the dark basalt volcanic layer on top with a dark sandy soil. The asteroids punch through the dark surface layer and expose the whitish layer below- but also pulverize the rock as the asteroid so that the reglolith layer on top is about 3-10 meters deep of “sand”. So you want a powdered surface, but it would really not be that deep. On the other hand at 50,000 mph impact speeds it does not matter if it was powder or rock before. It is powder after.

So, In metal pans is .5 inch deep layer of playdough that is rolled flat and covered in flour. A thin layer of the darker powder is spread over the top of that for the first trial, but that will not be renewed for each run of impact. Most trials will be into a flattened layer of flour 2-3 inches deep. A large shooter sized marble is at each station along with a ramp on a stand that

delivers it to .25 inches above the flour surface arriving at a specified angles measured in degrees.

The students were first required to use a protractor to measure the angle they were working with. They are labeled, but they should double check to reinforce math skills and know how to find out if it was not marked. The next step is to set the marble at the top of the ramp, and let it roll off the end of the ramp into the flour at the prescribed angle of impact—so you can’t let it fall off so high that the angle would change much before impact. . If they had the 90 degree angle, there was no ramp. The student simply dropped the marble into the pan from a given height and measures the depth, width and length of the impact “crater” noting if one side is higher than the others, as is the case for Shackleton crater. . It is best to use rulers that are short and have no extra wood or plastic on the edge where the first unit starts. You do not want the student digging into the flour to get to make their measurements, as that will skew the results. They then filled out a worksheet with measurements including the angle, length, depth, and width of the crater created, calculated the length or width ratio to get at elongation and and noted how elongated the crater looked overall as well as the relative heights of the side walls. The overall look is one of the most important pieces of information for figuring out what happened at Shackleton. The students need to be very descriptive to be able to solve the problem they are to be given.

Once everything (3 trials) for a ramp was completed, the volunteers would move the ramp to the following station so the students weren't required to move around but could get data on each of the angles. An example of the handout for data recording can be found in the appendix.

This was a very successful activity for the students, as it combined math on angles and science, which is something that one of the team members thought very crucial. The students enjoyed seeing the flour fly and splash what happens when the marble is dropped in the flour, and it truly made learning fun as well as messy, but there was as much concern about everyone getting a turn to release a marble as there was about measurement. Set up a system and make sure you know who's "turn" it is to release, record, measure and smooth the flour.

Background:

This activity was to get the students to move from the emphasis on volcanic activity and water as having shaped the Earth's surface to thinking about asteroid impacts as the dominant force shaping the moon. The black layer gives you a chance to talk about volcanic activity on the moon- but it leaves sheets of basalt rather than mountains behind. They should note that there were asteroid craters on Earth and they had important implications for life on Earth. We later found pictures of several nice craters on Earth with the best being in Arizona. Even though they were located after the lesson, we did

however make the point that there are impact craters on Earth even if the one we showed in class (crater lake) was not an example of one. The activity was inspired by a marble dropping activity that came from the book, that involved using a ruler to vary only the height of release. But how many real craters were formed by asteroids arriving at a 90 degree angle? Further, asteroid speeds do not vary as much as their angle of impact or composition. Composition would be key to understand an impact on Earth as size and composition more than affects whether it will reach the Earth and produce a crater or blow up above the surface of the planet, or just burn up completely. However, on the moon there is no atmosphere so they are all going to hit, large or small and whether made of metal, stone or ice.

Hence, as we see it,we enhanced a dull, boring and misleading activity and made it one that was designed to tell you something about a real lunar crater of interest- and about craters in general. . We would also return to this same crater many times in next few chapters as we were going to explain why NASA felt it was the best place for a lunar base.. The goal was to make this activity that the teacher was committed to doing a fun learning experience that set up the rest of the Lunar unit. The activity was improved for the class' benefit., but it came out of the text, was enhanced by Mariane Dyson's addition of the dark layer and our own ideas about angle of impact to explain the high and low side of Shackleton crater.

But to really do it right one should return to this question when talking about friction as a “force” and compare landing on Earth to landing on the moon, and the behavior of asteroids hitting each body as well. The fate of the Shuttle Columbia due to having lost a few of its heat shielding ceramic tiles is a case in point. Without protection , the aluminum alloy of the spacecraft structure beneath the shield reached the melting point son reentry so that the wing fell off the craft rolled so that the side of the craft without any protection was superheated and it just disintegrated in the sky over Texas while coming in for a landing in Florida. One could not have such an accident landing on the moonas not heat shields are needed. This is clear from one look at the Apollo lunar lander called the LEM. You want to do this activity after having done the unit on matter in which we introduce melting point of metals ranging from aluminum to titanium.

This activity simulates the surface of the moon. A marble that is dropped into the pan resembles an asteroid hitting the moon. Asteroids can hit at any angle, and the activity showed what a crater would look like from various angles. The goal was estimate the angle of impact that formed a given crater, so it is important for them to see a picture of Shackleton crater at the beginning and the end of class, and explain from what angle an asteroid hit to create that crater. After each station is completed, the students go back into their teams and work out the reasoning for what angle an asteroid hit Shackleton crater to create it since it had one side higher than the other. Although few of the teams did a meticulous job of data gathering

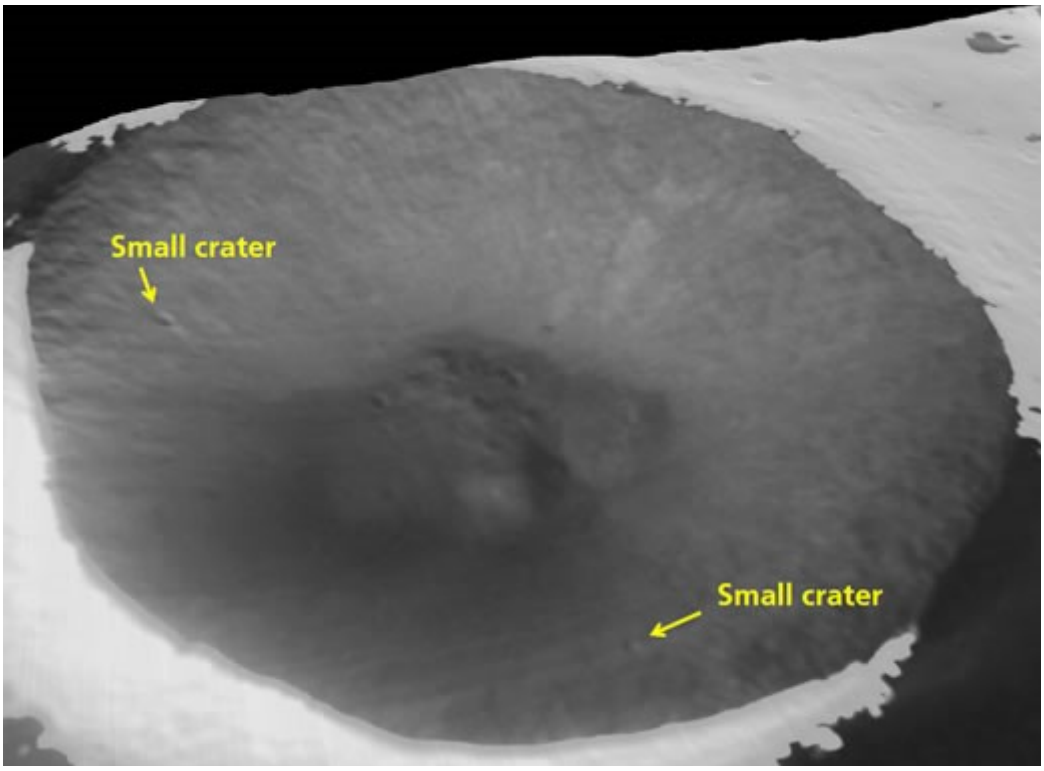
and recording, nearly all of the teams could figure out that the angle of impact was between 45 to 60 degrees by noticing the low side of the crater. And which way the flour “splashed” since it generally got on the shirt of one of the students standing on the far side of the pan from where the ramp was. They also are surprised to see that it is the asteroid hitting slower and at a low angle than make the biggest and longest, but not the deepest craters, They glance off the bedrock and plow a trench through the loose surface regolith. While a bit misleading since in the real case the asteroid would probably be going fast enough to pulverize the bedrock, the students really like seeing that unexpected affect, and it gets them thinking. Leave it in.

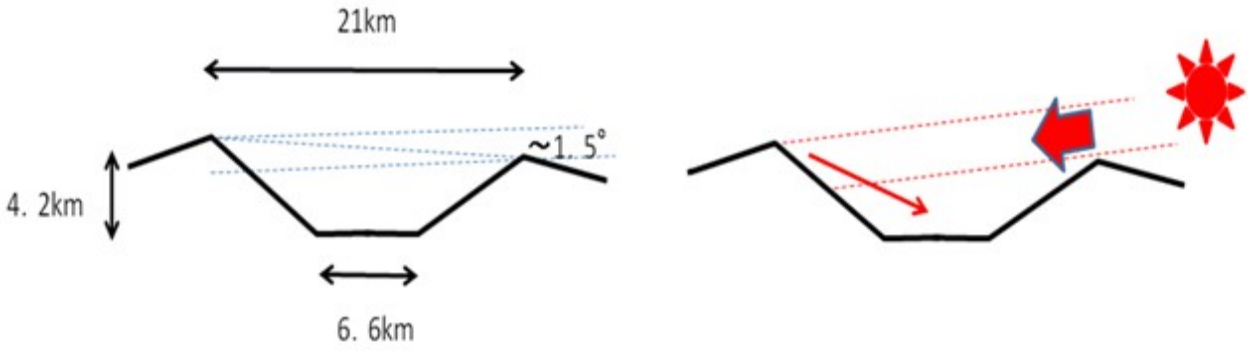
Below are the pictures that correspond to the activity and should be shown on a projector while the students are working. The first is of Shackleton crater and is an overall view. The second picture is a bit out of scale given the numbers shown, but it is published and not our work, yet it corresponds to the width and depth of the crater and shows angles. This picture is the defining measurement for how the students are going to solve the problem. Help should be given in the last few minutes of class as the teams discuss what angle they think was used, and their reasoning why. In the end, a volunteer should find out the answer from each team, then discuss the real answer and explain why each team was right or wrong.

A version of this activity by Marianne Dyson talks about the formation of the moon as a light colored bedrock coved by volcanic basaltic sheets of a darker color. Thus, an impact cut through the dark layer and exposed the original bedrock. This was important since it was the original bedrock that had most of the aluminum rather than iron on the moon. There were also rare and valuable things created by the impact heat and stress of the crater impact which she notes in her book. . While this was too much to go into all at once, we could at least cover the flour with a dark layer of another powder as recommended by Dyson. Our team tried out the idea of using black sand in a trial run, but decided it was too much for us to handle this year since the flour is useless after being used one since the black sand mixes in with it and is no longer on the top.

The previous team had problems with the aluminum baking pans they used to hold the flour . The ramps were not firmly attached to the stands, which of course varied in height. They had to cut V’s into the pans to hold the other end of the ramp in place to hold the unstable ramps. The pans didn’t have covers so the playdough had to be rolled out right before the activity to prevent it from drying out. We decided to move to low sided plastic covered trays and could not cut into them. Hence, a team member took it on himself to totally redesign the ramp holders trying to make them kid proof and stand alone. This involved a lot of hardening clay. The redesign also took care of the students having to hold the ramp, and gave more accurate data. However, the cost was not being able to use the ramps

for a later activity on energy where they all had to be set at 30 degrees. Store of the ramp holders and breakage became issues, so this system is not yet perfected. We are still improvising. What we need is a pan that holds the ramps in place and close to the surface of the flour and flanges on the high end of the ramp that hook into something on the stand.




21km
~1. 5°
4. 2km
6. 6km

Electricity

Materials List:

- Christmas Lights
- Flashlights
- Light bulb demo
- Batteries
- Forms of Metal
- Forms of Glass
- Small Light Bulbs
- Conductivity Apparatus
- Light and Battery demo
- Conductive Metals
- Handouts

Method:

Chapter 16 of the 5th grade student's textbook covers electricity. The activities we developed leaning heavily ofn the work of the prior team, covers the lessons from the text except for static electricity. However, the unit expanded by going over renewable resources and energy which is part of their Energy unit (chapter 15) and this topic was not developed at the time that chapter activity was carried out. thus, a loose end is covered now. The materials for this activity are contained within the Electricity Kit. For this activity, the students are split into four different groups by the teacher.

There are four stations around the classroom for the groups to each spend about ten minutes each, based on the time frame given. Preparation and a basic knowledge of electricity is necessary before running these activities. The goal of this activity is to teach the concepts needed to be able to complete a homework assignment in which one is asked to rewire a lunar habitation unit which consists of a suite of four rooms using only local materials found on the moon. No copper, plastic or rubber is available.

The first station contains Christmas lights, a 3 light bulb demo of series and parallel circuitry, flashlights, and a handout with the information that the students learn in the demonstration. The light bulb demo shows parallel and series circuit. It is very important to show the students that the electricity comes from the wall in two wires, not one as they will believe. The demonstrator shows how the light bulbs turn off and on and how well lit they are based on where in the circuit they are. They will learn the proper concepts to move onto the Christmas lights. They will think that when you unscrew a light bulb, that all of the lights will go out. This isn’t the case because it is made of two wires, something they will realize from the previous demonstration with the light bulbs. Lastly, there are multiple flashlights, and two matching yellow ones That use large 6 volt batteries with both contacts on top. On the inside of one, there are wires connecting the battery, but the other simply has metal contacts and the students are asked how the electiricity gets from the positive to negative pole passing through the bulb with no wires?. An explanation may be necessary with this piece but

most groups will figure it out. . Next, two smaller flashlights using D cells with the poles on opposite ends are compared; one having been taken apart, and one still intact. It is important that the students see the positive and negative poles in the different places as well as see the circuit design clearly of the light bulb demo. They should get the chance to put the batteries in backwards, and learn the hard way about things that also affect w ring designs.. When they note how the device they assembled will not work but another one with all the same parts does, they start to manipulate, experiment and observe more closely until the satisfying moment that it works.

The next activity station the students will rotate to is one involving the various forms of metal and glass. Later they will find out that there is no copper or plastic on the moon to make normal wire so they will need to find other conductors and insulators to work with. It is essential that the students can understand that they can make wire out of braided steel, and cover it with a textile or paper like glass. The idea is to stretch their concept of what metal and glass can look like.

This station will contain fiberglass insulation which is an insulator, filters that are paper like and patching material that looks like a textile as well as glass beads. All these silicon products are insulators. They will want to touch the glass that looks like cotton candy and that which looks like cloth, but it is very important that the students do not open the bag and touch it

for fear of tiny scratches and skin irritation. Melting points and the fact that electricity gives off heat come to play in this activity since they will ultimately have to choose between aluminum, titanium, or steel for the conductor. In essence, a mini power plant needs to be created on the moon before people can get electricity. The posters will come into play for this part, as they show what proposed moon base will look like. This part of the activity shows pictures and examples for what the homework assignment is, which will be discussed in length at the end of class in the last ten minutes.

The third station consists of ways to generate electricity. They are told out right that we have to get a generator turning and normally do that by boiling water to get steam, but falling water and wind have also been used on Earth. Fossil fuels and wind, for example, is of course out of the question on the moon- but the students do not start out thinking of coals and oil as the remains of ancient plants and animals and just think of coal as another kind of rock you dig up. When they get it- they come to think of it as stored solar energy. . Other sources like solar and nuclear are the promising sources of electricity for the future moon base to be self-sufficient in terms of energy fuel imports. .Using a small hand held parabolic mirror and test tube the students can see how concentrated solar energy could heat and boil water- even on Earth with only 70 degree sunlight. On the moon where surface temperatures can hit 212 degrees the potential is far greater. You can note that the best

Then we show the direct conversion of light into electricity-by photovoltaic means- in this case using a device that plays a song. In order to be sure they know the light is the power source, they note how much faster the music is as the light increases- and we massively increase it with a hand held electric clear glass 100 watt bulb. By having the cells turn, away from the light – though the light is still there, we mimic the impact of the moon's rotation. They see how the energy input declines to zero- a problem at the equator but not the poles of the moon where one can rotate the cells to stay in sync with the sun as it seems to go around you on a 28 day cycle. . We note two ways to solve this problem of solar power loss at the equator, one by putting the solar collector in orbit and beaming down the energy to the dark side of the moon and the other by using sunlight to charge a battery when the sun is out and using the stored power when the 14 earth day lunar night hits the equatorial region.

They seemed to know something about photovoltaics,- though it fascinated them- but fuel cells, and power satellites are new ideas and illustrations would be valuable.

. This activity should turn into a debate that engages the students about the pros and cons of each source., but you will have to explain nuclear to them as they associate atom energy with bombs rather than power plants- but the idea of fission is something 10% of them have down in very general terms. There are different ways to generate electricity, like steam, and these ways

should be discussed by the students. They should learn by the end of this activity that the sun is actually a fusion reactor. Most students won't know this at first, so it is important to explain with enough detail that they distinguish fission and fusion, and know that you release energy both ways and most power plants on Erath are fission plants. Europe the USA and Japan at least(ITER project) , and probably Russia as well, are working on how to create the conditions that exist on the sun so that we can have fusion plants too- and it would be a very big deal if we succeed. The best source of the fusion reactor fuel used by the Sun is the moon. It is carried there by the solar wind and there is no atmosphere or magnetosphere to deflect it as there is on Earth. . This activity also needs some research to be done before the activity occurs to make sure the key concepts are taught correctly. You will not cover everthing in 10 minutes do go with the flow of student questions as you take them through ha list of courses we use on earth and talk about each as it comes up.

The last station is about conductivity. A demonstration is to be given first to show what happens in the station. Students will be given pre-made set-ups that include a light bulb and will light up if the item they test is conductive. They are to go through the materials found in the lunar regolith, not including sodium or calcium. Ceramic tile, glass, aluminum, titanium, iron and steel should all be present but we missed on the iron, which is a frying pan currently in storage for the first group and got another one temporarily to use for the second group that is too big, but serves the

purpose. . Since they have already done the matter unit they will have a melting point list to refer too. It is all compared to copper, which is the Earth standard for wire– so let them test copper too if the ywant. They will actually want to test everything in sight. . There will be a myriad of different items scattered at the station to try out. The students will eventually want to try anything they can get a hold of and they will truly get into this activity while learning what is conductive and not. At the end, a battery and light are used to show how to wire a circuit in series. The light needs a certain amount of current and voltage to turn on, so that is demonstrated through having a series circuit. Parallel can be demonstrated, and it shouldn't work. Since you want everyone to have something to test circuits with and we had only two light bulbs we also used to telegraph keys by turning on the electromagnets.

AS an add on, one day we added making a battery to this station, using vinegar and salt copper and zinc. Getting enough power to turn something on is a challenge, but an LED light can be used for this purpose. In our case the equipment can out of a kit. We suggest that the next group use something larger of their own design and more vinegar. This Energy activity kit also had a way to extract hydrogen and demonstrate a fuel cell that would have been a better fit for he unit- but the teacher wanted to have them see a battery made as it was more likely to come up on the MCAS.

Background:

The homework for this unit combines what they learned at all of the stations that the students went to excepting the battery experiment, so it is essential that they learn and pay attention at each one. In the last ten minutes of class, a handout will go out to each student that shows how lunar bases on the moon may look in years to come. Cartersville living space is basically made out of fiberglass wrapped cylinders inserted into round holes excavated into the side of Shackleton crater. In order to help them see the pictures before them as a 3d object Also going around is a cardboard tube wrapped in fiberglass that simulates a small scale model of the base space where people will live.

There are 4 units in a cylinder a scale model of the picture which indicates cylinders about 8 meters in diameter and 12 meters long. They are stacked one on top of the other and are half the length of the cylinder. A person 6 feet tall as a stick figure is added for perspective. Their problem is to rewire the base. This seems simple, but how do you do that without copper, plastic, or rubber? In this illustration all the wires are in the round wall inseted in the middle of the cylinder and they tie into metal bars running the length on at least one side. They are wrapped in the fiber galss making up the wall- insert ed there half way through the construction process.

The students also need to figure out how to even get electricity in the first place. They then need to change the wiring of their room in the base which contains wall plugs, lights, heaters, and computers. It is currently in

series with expensive wire imported from Earth, but if it is changed to parallel, other items will still work if one goes out but each will get less power. The lunar residents want to use more power and more wire, but to make their case they have to show how you can wire the base without using imported wire and generate ample electricity to be able to afford parallel circuits. Since parallel circuits use more wire, the students should be able to explain why parallel is better enough to be worth it in a few sentences they attach to their handout once they complete it. This should be collected by the team and graded for the teachers use to measure how well they understood the concepts. Parallel and series circuits are on the MCAS every year, so it is a crucial concept to master. Rewiring involves drawing on a paper where you want the metal wire or rods and indicating what they are made out of. and how they are insulated.

The best answer is to use the braided steel wire wrapped in fiberglass- but aluminum would work and one should show aluminum wire too., pointing out the higher failure rate that is likely given the lower melting point of that metal. On the other hand you could use it as a fuse mechanism to be sure you know where the circuit will break if it starts to overheat, and that it is easy to get to and fix.

We are also teaching about how to interpret a diagram with different perspectives and what the drawings represent as a 3-D object. The key is to practice drawing circuits and predicting what will happen if a device failure

breaks the circuit at any given point. In series, that would leave them in a dark cold hole without communication system at the South Pole of the moon. In addition, not only their unit would be affected. There are 3 others that are tied into the same circuit. The exercise could be elaborated to figure out how to make sure only one unit is knocked out in case of a serious break in one that cannot be repaired by a simple blub replacement. For an enhancement, there should be fuses in the kit that are either burned out or overloaded to make the points to the students.

Light

Materials List:

- Christmas Lights
- Flashlights
- ETC ADD MORE

Method:

Chapter 17 covers light and sound. The previous team provided equipment for both, but did not do anything with sound. Mr Mahoney handled that without trying to tie in tinot the lunar base theme. It is just having them handle a lot of mscial instruments and figure our what is vibrating in each case. He wa also given a toy that changes the sound of a

voice spoken into it and they have to figure out in the sound wave is being shortened or lengthened electronically- like a distorted telephone. The team left the sound equipment with Mr. Mahoney and we never even saw it. . This team upgraded the Light portion of the activity and sound was again covered separately by the teacher.

The light activity we again did in stations set up around the room. Four stations are set up with volunteers manning each one. Each station is also around ten minutes, depending on the time frame. All of the materials for this activity are included in the kits provided from the previous team. Each lesson should be researched before implementation to allow background knowledge. The chapter from the 5th grade text should also be read so as to properly use the key concepts and words.

The first station in this activity is one involving mirrors and 45 degree binoculars. The mirrors are to teach the concept of reflection. The mirror, while small, is taped to the classroom white board and a piece of tape is put on the floor perpendicular to it. The students are then lined up on the tape. The purpose of this activity is for the students to learn about angles. A student that is at a certain angle from the mirror should see a student at the same but opposite angle when looking at the mirror. This takes some adjustment, but when everyone is lined up correctly, the activity works. Protractors let other students do the measurements while two are currently seeing each other.

The next activity is about convex and concave lenses. This is a demonstration that is good with a piece of paper on hand– and indeed the last team had a handout on this concept as the students struggled with which was which.. The different lenses are drawn, and thoroughly explained. Diffraction and diffusion through the lenses are explained with each type of lens. How to concentrate and diffuse light is also explained at this station. After the mini lesson, lenses are brought out and shown to the students. Pass one of each kind around and ask what type of lens they are. Once they properly identify them and explain why, more lenses can be passed around. The students should look through the lenses and describe what they see until time is up.

The next station is the favorite of the students. It puts reflection and lenses together. There are kaleidoscopes, binoculars with a side door to shift from seeing straight ahead to seeing sideways., and other toys like telescopes and eye glasses with a rear view mirror that are found in the kit. These toys bounce light around corners, which is a crucial part of this activity. The students will play with these devices and use them to see around corners and get the idea that they can make light turn corners in a predictable way. They will try to explain how many mirrors are in each of the toys they use.

The volunteer for this station should be well versed in what is in these toys and the methodology of how these toys work because the students will

ask many questions. Background information can be given while this activity is happening, but most likely the students will be too involved in the station to absorb more information. Everyone will want to handle every device so have 3 or 4 of each is a good idea,.

The last station covers light wavelengths and colors. . A prism is included in the kit, and the volunteer must explain how the white light is really made up of colored lights running from red to blue and the wave lengths we can't see as well ultraviolet and Infrared that are still there. You want to have a table of the ranges handy and a long slinky (put a few together if necessary) to illustrate differences in wave length and sped of travel. This is helpful to explain how waves work in the light spectrum. A color wheel can be spun with a basic motor, and this mix of colors will will turn white (more like beige) while in motion. Plants require only certain wavelengths of light for cooking CO_2 and H_2O into carbohydrates.and if they look green it is because they are reflecting back the blue and yellow and absorbing the red—but plants do not all look like the same kind of green and some actually look reddish or blueish.

Successfully growing plants is critical to a sustainable lunar base. The radiation levels on the surface would kill them, so they must be grown underground in a greenhouse sheiled by at least 10 ft, of regolith to block 90% of the dangerous cosmic radiation. Also the sun is too hot without atmosphere to block and reflect some of it, and would evaporate the water

and wilt and burn the plants. So to grow plants on the moon you have to be able to separate the radiation from the light and get it to go underground and then diffuse it to the ambient levels on Earth. The key to separating radiation from light is that the gamma rays will go right through a reflector (like an X-ray) but the light will change direction. You need to make it turn a few corners and you have just the light. This is also a new station that was developed this year, from what was in the past just a slinky demo so further fine tuning is appropriate to make this color oriented activity fruitful and tightly tied to the needs of growing plants.

As 6th graders they will be focusing on the greenhouse problem, what to grow and why, so this activity sets the stage for the whole 6th grade lunar base curriculum and the color section is part of the transition. There is also a greenhouse design problem coming up and the decision about whether to use grow-lights underground, or make the whole roof glass and water 8 meters deep or see if they can use a small opening and get the light to concentrate, then turn a 90 degree corner and zoom down a hole and then turn another corner before spreading in all directions. This yer we do nto wantthe details, just the general concept. In 6th grade they will visit Tower Hill, see a massive greenhouse and then redesign it as it would look if it were to be part of a lunar base 10 meters underground at the lunar couth pole.

The Problem in the Background:

As for the relation to the lunar theme, at the beginning of the lesson, the students are faced with the challenge of getting light into a greenhouse. This greenhouse is located in a base dug into the side of Shackleton crater, something the students should be familiar with as they have worked with it before on previous activities. This greenhouse is situated ten meters underground, and a picture of the crater is necessary for the students to understand the situation completely. The solution we are looking for is for the students to take what they have learned in the activities and apply them to delivering enough, and not too much light to the plants. They should first concentrate the light, bend it into the crater, and then diffuse it into the lighthouse. If any parts of this are done incorrectly, there is a high chance that the plants either won't get light, or they will burn because of too much light. A piece of paper should be handed out to each team. In the remaining class time, they are to draw a picture together of how they would come up with their solution of getting light to the plants. Another tricky situation is where the students have the light come into the greenhouse. If it comes from a reflector on the floor or the lower half of the chamber, the plants would have to be on the ceiling and walls since plants will grow towards the light. They also respond to gravity-but that is a much smaller force on the moon than on the Earth- and we are not going to get into the water delivery problem this year. . This is something to keep in mind while the volunteers go around and check on each group's progress.

So far no team has announced that they do not need any light underground as they will be growing mushrooms. However, some day a Smart Alec will do that and we can respond with questions about what temperature the mushrooms will need and since they do produce their own food, but live off of other plants like animals do, what the feed stock will be if it is not going to be rotting trees? If they come up with human feces as the answer you just shake their hands as the rest of the class is grossed out.

Essay Contest

Background

The 5th grade Space Enhanced Science Education team (4 WPI students) offered to run a special pilot project for at least the Elm Park School 5th and 6th graders, and possibly a larger group of schools that want to participate. It was the launch event of a proposed WPI student service club, now called Reach for the Stars. In this case we saw ourselves as addressing the problems of public understanding of science and technological literacy This all occurs while improving science education trying to carry out phase one of a talent search. The mission of reach for the stars is in part to find the students in the next generation with a knack for science and who should be encouraged to pursue it.

Three years ago an IQP team working at Elm Park pioneered this idea with a smaller scale essay contest, which they called a book report contest.

Only 5-6 students from the 5th grade and about the same number of 6th graders from Elm Park participated. The reading level of the chapter from the book selected as a prompt was considered too challenging for most of the 5th and even the 6th graders that year. However, Elm Park has worked hard on English reading levels over the last 2 years and Principal Paula Proctor seemed to think the bulk of the class was probably ready to tackle the same reading used in the prior contest this year. She at least wanted them to try and stretch a bit if necessary.

The book used before was, Seven Wonders of Space Technology. The author, Fred Bortz, said that it could be used again under the same terms to support both the 5th and 6th grade contests using chapters 4 " Moon bases and Moon Water" and 5 "Mars Rovers" as prompts for the two grades respectively. Dr Bortz allowed the last team to distribute copies of chapter 4 to students entering the essay contest. He was even more excited about the proposed event for 110 students , since the prize was to be copies of his book that had to be bought for the winners at his special price of $25.00 (rather than $30.00 each from the publisher) , and he agreed tp inscribe them personally as book awards. A $1.00 royalty fee was also established for each student that entered the contest so that they could have a copy of the text to read and bring home and even mark up. It cost about another dollar to make the photocopies, but WPI contributed to cover that cost.

Chapter 4 fits the theme of the curriculum unit for 5th grade very well. Just reading the chapter about the discovery of water on the moon that changed everything and makes lunar bases feasible was challenging enough for most students. In essence, this was a glorified book report built around an MCAS like essay prompt. More was required at the 6th grade level, especially since these 6th graders had a space enriched 5th grade science unit last year, focusing on the moon, and the biology part of their 6th grade class will pick up on this theme again. They were ready to move on to another subject.

Chapter 5 talks about the Mars rovers and even mentions “Curiosity” before it went into space, and everything that went into making it. It goes into a few details about its purpose, and why it is important for space exploration and even explains how it was named. . However, it could not go into what happened next, so the 6th graders weren’t doing just a “book report”. In order to finish the story they had to do some independent current events research for their essays.

It is a very inspirational and detailed chapter of the book that has a lot of potential for an essay. The latest Mars rover has landed on the Mars in a very dramatic way this past summer, and it is still just at the beginning of its long journey. This was a great opportunity where students were able to read what has happened in the chapter, and then go on and do their own research about what the rover is doing now. Students were supposed to use

newspapers, the media, and any other form of news source, including those on line, since it is still such a new topic. There were endless possibilities that students were able to write an essay about based on what articles they read in addition to the book chapter offered. They were able to go in whatever direction they find the most interesting. There was to be a myriad of different topics to focus on, and that is what helped make this a great essay contest.

The Principal was enthusiastic to the point of wanting us to let all the students do the Mars essay, and predicted that her 6th grade team would do a lot with this idea, the English teacher taking the lead and the science teacher covering necessary background materials. She was right, but the teachers were worried about the vocabulary and the length of essay anticipated, and terrified about the need to support 60 students all wanting outside materials at once, with no librarian to help and only 3 computers in each classroom. Hence , they changed to prompt so one that was on a prior rover mission covered entirely by the distributed materials . Then, when they saw how the students did with that, they selected the top 3 students and supported them in adding a section responding to the original prompt about Curiosity. They also had those 3 papers typed as they figured they were going into the external competition with the other schools. However, there was not outside competition this year as it was not approved by the district. We asked to see all the essays, and took the opportunity to see if we agreed with the teachers as to what were the top 3 essays. This would determine if we could delegate the task of producing the short list to English

teachers in the future. Would they see the same things in the essays as Techies from WPI –or the author of the book, Fred Bortz?

The leaders of “ Reach for the Stars” chaired the two review committees and the 6th grade committee dealing with this complication was Alec and Danny fro mthe 6th grade currilcum team, mark, President of the Club and Amber from the5th grade team. In the end, it was their job to identify the top 20% and send off to author Fred Bortz the top 10% for his review. He would select the winner and they would rank order the next two for book awards, finalist certificates and honorable mentions.

The 5th grade essay review team was to be the rest of the 5th grade team, Taymon, Elise and Zack headed by Kerrin the VP of the Club. the 5th grade team, faced a different problem. The prompt had not been changed but was sometimes all but part one (the descriptive part that could come directly from the text) was ignored. The English teacher got sick for a week and in the end only about 32 students out of 55 completed the essay even with her collecting 8 more after she got back- some completely new as the originals were lost. The results were less polished as the students got less feedback. Some lost their prompts and copies of the chapter before she returned.

Hence the review started late and Elise and Zack were involved in other things by then and never fully participated. An outside reader was recruited who had worked with this age level before and could handle the

challenging hand writing. So, Taymon, Kerrin, Professor Wilkes and outsider Sandra Ansaldi finally did the judging- Ansaldi focusing on how much of the assignment each student had done, and commenting on what the handwriting revealed, providing a very different voice in the committee. . The best 6th rade essays were sent to Dr. Fred Bortz for final review 2 weeks before the best 5th grades essays. . He looked over the essays, and decided which three are the best and which captured the story he was trying to portray at the 5th grade level and how imaginative the response was at the 6th grade level.

. His decisions were a surprise as he was willing to overlook substantial factual errors to reward the most imaginative reactions to his work. At the 6th grade level he went for an essay that seemd to ignore the comment in the prompt that a minimum trip to Mars would take 2 years, 6 months to get there and year on the ground unlit the planets were realigned for return and 6 months back. This student said that was not good enough and the trip would have to be cut down to 6 days to reach Mars, not 6 months. Bortz responded that many technical people agreed with that assessment and were working on a drive that would cut it to 6 weeks from 6 months and this was the right attitude. At the 5th grade level he overlooked a .substantial reading error that was surprisingly common that the students thought we had been back to the moon for new sample in 2009 when he really meant the Apollo samples had be reanalyzed, blaming that on the teachers, who should have know we had not been back and coached on the point. He then

went on to reward an essay that was unusually complete in thinking about the implications of the discovery of water on the moon. This student author had clearly picked up on the idea of what agriculture on the moon would mean in terms of making a lunar base feasible.

In the end the assessments of the teachers, WPI students and the author were so different t hat we dropped the idea of giving first, second and third prize and gave out an Author's award with a small trophy as well as a book, a WPI book award and a Teacher's choice award, representing the radically different criteria in play. The WPI students were looking for the students who "got it" technically whatever their mastery of the English language, the authors wanted imagination and the teachers were looking for essay composition, completeness and presentation taking into account how challenging the assignment was for an individual. Honorable mentions were supported by a specific phrase from the essay that was notable or revealing.

Those students identified as best by any of the three criteria would become the overall winners of the essay contest and they would get an inscribed book. However, in the case of the 6th grade contest there was an essay on everyone's list- but always in second place. This wa arguable the best essay produced, and so a 4th award- and First Runner Up award was created to cover this situation. In the past, the author has signed and delivered his book for the winner to own and bring home. The student that won 3 years ago at the 5th grade level was ecstatic that hhe finally owned a book, especially one

about space exploration that he won by his own efforts. It was a very special book indeed. The 6th grade winner was also noticeably moved to be singled out by the author of the book. He read from her essay and she identified herself as author. This was not her first book ever- but rather her new favorite.

The timeline we used demands a start in the firs semester and the student writing has be done by Christmas since the second semester, when they return after New Years is dominated by preparation for testing and the testing itself. There is time later only for an awards ceremony. Given the constraints, the activity worked out well, and the schedule must be followed in order to complete the task and allow for the WPI and Elm Park Community School's break schedule. It has to start in early November, where students are given a prompt. They then have 3 weeks to work on their essay and submit it to the teachers. The teachers had until mid-December to review the essays, so as to add it to the curriculum and make it count for a grade. The team then received the essay, read each one, and met in person or electronically to create a short list. Then the best must be sent to Dr. Fred Bortz. An awards ceremony is scheduled in the last week of February, which is right after the students come back from spring break And just before the WPI students leave on theirs. Finals week is a hard tome to do the ceremony, so moving it up two weeks next year is advised.

Discussion of the Outcome

This was the first time this was done at such a large scale and it was a great learning experience for everyone, but not everyone was involved. The prompts, shown in the appendix, were changed greatly by the teachers. For lower level reading classes, pieces of the prompt were taken out all together, and the students weren't required to answer each one. The higher level reading classes wrote more and answered more questions. The top students, as the teachers saw it, were given extra help typing their essay and with outside research. This would help the stars in external competition. That did not happen this year but it is revealing that is was on the minds of the teachers when it was a possibility. . This made the contest a bit unfair for some of the students that really had great ideas, but couldn't execute them in the way they wanted to because they didn't have outside help.

It is also revealing how much things unraveled at the 5th grade level when the teacher got sick for a week during draft process. Some papers were lost altogether and - two students rewrote from scratch at the encouragement of the teacher- but she feels the second version was not as good as the first. Still, she had to move onto other things. Some 6 students out of 55 are in an IEP and she really never expected more than a paragraph from these students so they were not contenders and she let it go and did not push them. In the end we got 33,(9 late, after the teacher returned) WEehad been expecting 48-50 out of 55. This was an assignment that was

assigned and required of all students a directive fro m th Principal, but still didn't work out in practice..

The 6th grade English teacher started out believing that the reading was too challenging for their class, and was struck by how completely the class engaged the material and stretched to master it. They needed some help on the level 3 words that are rare and some had not seen before, but the science teacher was on board to help. The class was supposed to be doing more non-fiction- and this fit the bill so the 6th grade team of teachers went for it and the students rose to the challenge. Soon we heard that 6 boys in the 6th grade class were determined to build a model of Curiosity out of LEGOs and had found instructions on line. The teachers supported this effort- and soon found that rare and expensive parts were needed to get past instruction 23 out of 36. We were asked to help out, but delegated the problem to the 6th grade team of Alec and Danny with support for Martha Cyr's collection of LEGOs at WPI. Dr. Cyr once worked for the LEGO company and her collection is worth over $1000, but is not normally allowed to leave the WPI campus. In this case a few parts were allowed to go to Elm Park.

The 5th grade team did not have a chance to work on this project like the 6th grade team due to the illness of the lead teacher on the effort. Substitutes were not up to the challenge. And did not even manage to collect all the first drafts. When we asked for the essays before the teacher had returned she had not read them and there wa a genera reading

comprehension problem affecting even the top essays. The mistake came from reading the chapter incorrectly and a lot of the 5th graders believed that we had been to the moon recently, as in Americans landing on the moon in the 1990 or as late as 2009. This is in fact not true, and made it difficult to judge a lot of the essays when they had incorrectly understood key information. Were we to reward avoiding error or overlook a factual error and look for the ideas? Dr. Fred Bortz decided he would not fault the students for his one and awarded books based on ingenuity and originality since as the line between awarding a good essay that was in one place incorrect and a descriptive essay that got the facts right but had little else to offer was in the end a matter of educational philosophy on which he was willing to take a stand. .

So, we followed his lead, though one student got an honorable mention for getting all the facts right, when so many of her classmates did not.

At the awards ceremony, Professor Wilkes decided to clarify the question of when was the last time anyone had been to the moon by explaining that when we quit making Saturn 5 rockets in 1972 the no longer had the means to get people to the moon, and the Russians had never gotten their moon mission rocket the N-1 to work. Since then, one could only get lunar samples with unmanned missions, like the Russians did after the Apollo landings, but so far the USA had not done so.

The last problem came from the 6th graders. They didn't do independent research as we had hoped. It was made clear after the contest was over that in order for them to have completed the outside research part of the paper, we would have had to provide them with the means and the materials to do so. Their new library isn't equipped for such things as of yet, and each classroom has few computers. The teachers instead gave the students a source or two they found on the sojourner mission, which was also covered I n the chapter provided . , and the same information was used by about 6 essays. Others showed evidence of independent dta gathering but they were few, about 2-3.out of 90. This wasn't the intention. We hoped that the students would each go separate ways in the outside research on Curiosity , and have an essay based on what they themselves found interesting in their research and their own independent thinking about what the next mission to mars should try to learn if the long term gola was to prepare for a manned mission.. Giving the 6th graders more freedom proved to be something that needs to be handled at a much closer level in the future possibly by having a library tour at WPI or students show up with laptops and help the students through the process.

To fix these problems, the IQP team must work more closely with the 5th and 6th grade teachers. A volunteer should go into the classroom on the first day of the contest to explain the prompt to each class, and answer any questions that may arise. Weekly check-ins should occur, and progress reports should be obtained from teachers so the team running the contests

knows whether they need to provide more information to the students or not. By working with the teachers closer, we would have known that the prompt had been changed, and we could have prevented it or changed the overall criteria for everyone so the essays weren't all so different. Collaboration is key for this to be a complete success in coming years.

For the future, it is time to up the stakes, and get more children involved in non-fiction reading, space exploration, and to give them all a chance to write about something they are likely to find interesting. If we are able to get more classes involved, it would be a good thing, but so far the concept is approved only at Elm park school. There the idea is popular because it combined science and English all in one essay effort.hence, with an Elm Pak endorsement, ther is hope that the idea can be approved for the whole Doherty Quarant of 8 elementary schools and there is a book by Bortz (A biography of a female astrophysicist) suitable for use at the 7th or 8th grade level as well where all the quadrant students come together at Forest Grove Middle school before going to Doherty high schools as 9th graders. . In future years , the essay prompt should be fine-tuned for the 5th and 6th grade. A book of past winners, needs to be compiled for placement in the school libraries. Then students would be able to look at the winners' essays from past years to get a grasp for what a good essay consists of. This assumes that the chapter background and prompts would change from year to year.

To work on overall writing ability for the whole class, after the winners of the essay are announced, students should be sent home with another packet. It would consist of a good essay, a mediocre essay, and an essay that could use some more work and thought. Students would read all three as homework and then describe which the best was and which needed work and what they would add to make the weaker essay as good as the best one.- but different. This would help the students understand the different writing levels and get to critique something they worked on themselves. It would be a good way to end the project within the classroom and contribute as a capstone to the essay contest and give a real learning value. MCAS preparation takes a lot of practice runs, and this could be one of them. The more experience the students can get, the better. With the correct timing, funds, and knowledge, this contest has the potential to become a great opportunity and learning experience for everyone involved and the AIAA NEC should be thinking in terms of some sort of token gift to all participants, possibly a special pencil. Hence, we would like to see this activity taken to a larger scale– inviting all of the 5th grade students in the Doherty Quadrant of Worcester to participate, so long as the faculty is willing to do the first round of review. In short, an IQP team devoted to running this one event and setting up a field trip to follow at WPI can handle about 5-6 strong essays from each participating 5th grade class, up to 20 classes. The service club at WPI Reach for the Stars can help out with both the field trip and working with top 10 %, the “stars” identified as the finalists in the contest. A critical

thinking afterschool club for these students has been requested by the Elm Park school. That is likely to be a popular idea elsewhere as well if WPI student mentors can be found in sufficient numbers.

The 6th graders of the Quadrant should be offered a field trip to Tower Hill Botanical Garden and also allowed to join the club, but use the time to prepare projects for the district wide science fair.

Awards Ceremony and Feedback on the Project

The award's ceremony was part party, part display of the Curiosity model, part the showing of a videotape of a presentation by Fred Bortz, the author of the book, partly a presentation by Professor Wilkes on the space race and moon missions, a a special opportunity for Principal Paula Proctor to have Martha Cyr, be a role model to all the students. She would be giving out the prizes on behalf of President Berkey of WPI while Carol Puskas called up the students and Amber Desjardin of WPI read the citation and Professor Wilkes handed the appropriate prize to Martha, as each book had the name of a specific student written into it.

The students cheered, there were snack sfor all, a few parents got there and we understand that the children were blown away and the 5th graders can't wait for a

chance to be a winner next year.in the 6th grade contest. Fran Mahoney says they want to start now on a Mars project.

The Thanks you notes we were given by the 5th and 6th graders mention Tower Hill repeatedly and include comments like " wonderful lessons, amazing projects", "sharing your amazing talents", "bringing fun to science", " science got much funner with you guys around", " one day I hope to be able to go to Tower Hill again", " thank you for all the cool trips and we get to learn a lot of new stuff and Mars and moon research", "activities that wer fun and exciting", " We learned many fascinating and interesting things like the plant botanical gardens and many more facts that I don't know where to start. I still have the plant. It's so big now…" " all the fantastic things and experiments you showed us", " thank you for helping us increase our knowledge", " my class appreciates what you have done for us and we loved when we got to plant plants with the staff at Tower Hill, " thank you for helping us understand our science", You..taught us students things about plants and space I never knew and the trip to Tower Hill as a blast", " the biggest thanks for paying for the trip to Tower Hill Botanical Garden. I had a wonderful time there looking at all those fascinating interesting plants..it was so big. I so wanted to eat all those fruit I found there- Ha Ha. Another huge thank you.", "You are a great group WPI, Flowers bloom because of WPI.", " thank you for everything…you really mad eus learn so many facts about the moon, Mars and from Tower Hill Botanic garden , plants. Without your help we will never had learned, explore and discover thous amazing facts and things that we saw…", "thank you WPI for taking the time to talk about science related things like thermal energy experiment or the time of talking to us about Mars and letting us learn about outer space." thank you for your time and part in helping me relize how fascinating space can be. Also thank you for taking time to look at my writing." " Space is Amazing", " thanks for all the guidance you told us about science, because some of us get stuck on science, even me, but when you are here everything is just right.", " The trip was the greatest thing ever".

Principal Paula Proctor added the following" Dear Professor Wilkes, My sincerest thanks fo the work that you and your WPI students with the AIAA NEC funding provided for use at Elm Park. You have truly made a difference." So, the space enriched science education initiative is showing great promise and it is hard to separate out the impact of the work in the classroom, the field trip and the Essay contest, but in combination they "made a difference" and made science "funner" and "amazing". The picture on the card that just says "thank you for the experiment", leaves no question what "THE" experiments was. It is a drawing of either Zack's or Amber's station (possibly a mix) inn the electricity activity unit where bulbs would light up. There seems to have been something for everyone.

Special Activities

There is another dimension to the 5th grade curriculum project besides building kits and running science class activities. There should also be special events and extracurricular activities designed to augment the curriculum. These activities are designed to further inspire and excite students and bring them to the next level of understanding and enthusiasm. The scope of this aspect of the project is large, and covers many different areas of the curriculum. We believe that it offers great promise for enhancing students' science education.

On Special Assignment

My role in this project was different from that of my teammates. I did not develop the classroom science activities, build kits for them, or take charge of running the activities in the classroom. Instead, I worked to develop special curricular and extracurricular activities designed to enrich students' understanding of and interest in science. For this year, the major activity that was implemented was the book award essay contest. Numerous possibilities have been investigated for other events to run in the future, including field trips, science fair support, and after-school clubs. We have also investigated opportunities to collaborate with other organizations in order to make these activities possible and provide financial support for them.

Although my work was not focused on classroom lessons, I did frequently go into the classroom due to the need for manpower to facilitate

the activities. My role was as a largely untrained volunteer. Most of the activities were structured in stations; the class would be divided up into groups which would rotate into different parts of the activity. I would be assigned to a station and would figure out the activity on the fly while guiding students through it. (There were a few activities, such as a demonstration of the nature of light, which I developed myself.) From my experience, it is apparent that future teams will need to develop activities in a way that more directly supports outside volunteers in the classroom. At a minimum, there needs to be established documentation of each classroom activity and how it works; this alone will greatly help volunteers if they are given the opportunity to read it in advance. Naturally, this documentation is more likely to be helpful for well-established activities than for new ones. While the curriculum continues to be developed by IQP teams, if it is going to continue to be used, as intended, in small group activities, the teachers will need assistants. A pool of outside volunteers organized as a student service club should be briefed in advance by members of the curriculum development team about newly developed or adjusted activities that are not yet fully documented.

The Coordination Role

Much of my work on this project was devoted to finding opportunities for cooperation between the existing teams working on space-enhanced science education and other groups. On multiple occasions, I met with Principal Proctor of Elm Park School in order to gain a better understanding of

what Elm Park's needs were and how WPI's supplementary education projects could best meet them. This is how it became apparent that more support was needed for the students who have shown the most promise and interest in the areas of science and technology. Principal Proctor gave us much-needed direction for our development of curricular and extracurricular activities with her concept of a "critical thinking" club. She also endorsed my idea of trying to do a re-run of the field trip to WPI called "Field Trip to the Moon- at WPI" that was organized by an IQP team at Elm Park 2 years ago.

I also met multiple times with Martha Cyr and Shari Weaver of the WPI STEM Education Center, which we hope will be a partner in the work of creating a student service club to support hands on science education that I want to call "Reach for the Stars" going forward. In February, I attended an event sponsored by the Colleges of Worcester Consortium, "Dessert & Discourse on Science, Technology and Engineering Curriculum Initiatives", during which educators in Worcester area schools met with faculty from Consortium colleges to discuss the future of STEM curricula. While there, I made the acquaintance of Kathy Berube, Curriculum Liaison of the Science and Technology/Engineering program of the Worcester Public Schools. She expressed interest in the activities that we were planning for the Club (including the essay contest and a potential field trip) and had heard of the Elm Park lUnar themed curriculum initiative. Coordinating with her program will be important, especially to the extent that we wish to expand activities beyond Elm Park to the rest of the district.

One possibility that we attempted to pursue was working with the WPI Great Problems Seminar “Educate the World”. This first-year seminar is devoted to contemporary problems in the field of education, and the instructors wished for their students to go into local elementary schools and work with students there to gain a better understanding of the issues involved. The instructors were aware of our work and were interested in coordinating with us; their students would gain classroom experience, and we would benefit from the newly available personnel power enough to be able to run another field trip to WPI. . Unfortunately, “Educate the World” was not held this year due to a lack of enrollment. Future teams should bear in mind the possibility of collaboration with future offerings of the seminar.

Another potential strategic partner going forward is the Worcester Education Collaborative, a nonprofit organization supported by local businesses, foundations, and Consortium colleges, including WPI. Dr. Jennifer Carey is the founding- Executive Director of the Worcester Education Collaborative and she seems politically well connected. Jennifer received her Master’s and Doctoral degrees from the Harvard Graduate School of Education and her Bachelor’s degree from Harvard and Radcliffe Colleges. In 1998 she served as Special Assistant to Governor Paul Cellucci of Massachusetts, and a year later she became Director of the Office of Consumer Affairs and Business Regulations under Governor Jane Swift. Before joining Massachusetts state government, Dr. Carey worked at Ohio University, Harvard University and at Bancroft School, an independent K-12

school in Worcester. Martha Cyr seemed to think that she could arrange an introduction to meet her.

This year, the WEC came to my attention when it started the Blackstone Fellowship, an initiative through which college students would support students at Elm Park and other schools in creating science fair projects for the Worcester Science Fair. This is likely to play an important role in the future of extracurricular science education at Elm Park. However, the main reason for wanting to meet her is that the organization has traditionally been more interested in literacy than in science. they have done essay contests, and we have one that might interest them in that it is full of science content but gives practice in writing non fiction prose. As a team effort of the English and science teachers at Elm Park it was very successful this year, but we were not able to afford to bring the author of the book used to Worcester for the awards ceremony. Instead we showed a video recording of him speaking at WPI two years ago. It seems possible that the WEC could afford to do so. It would cost about $2000.

Reach for the Stars

While the groups that we worked with should be considered as important strategic partners in the future, the previous IQP team concluded that in order for the curriculum and associated activities to be developed as well as they can be by an IQP team, and to survive after the IQP teams are no longer working on them, it is necessary for a dedicated corps of volunteers from WPI to exist who can provide the necessary manpower to

run activities in class at the request of a teacher who wants to do hand's on activities with modest equipment needs. On that team's recommendation, we began the work to assemble activity kits and make this "club" a reality. The group has been named Reach for the Stars, and the proposed President and I are currently working to have it become become an official WPI-recognized student organization. We wanted to have it do something before it went into recruitment mode, so officially "Reach for the Stars" ran the pilot version of the 5t hand 6th grade essay contest, this year meaning that they helped do the judging.

The mission of Reach for the Stars is to promote STEM (science, technology, engineering, and mathematics) education at the K-12 level in Worcester. In its unofficial capacity wherein it consisted of the project team and a few other students, Reach for the Stars has already worked to assist in the administration of the essay contest and and a few classroom activities.

We have begun work drafting a governance structure for Reach for the Stars. Under the proposed constitution in progress, the organization will be governed by a board of officers, including a President who will oversee the membership of the organization, and a General Initiatives Coordinator who will coordinate all the initiatives that the organization will undertake. Students will be free to propose new initiatives in accordance with the organization's mission; each initiative has a coordinator who oversees it and the volunteers working on it. This will allow the group to have a broad mission while still remaining focused in its activities.

Reach for the Stars will have an especially important role to play in the classroom; when the activities have been documented, and evaluated, there is no longer a case for recruiting teams to work on them other than to disseminate the units to new sites. At that point the activities will have to be run by volunteers who are trained in workshops run by that organization and scheduled to go where they are needed.. One hoped-for benefit of this is to push the teacher to become more involved in the activities, since the IQP teams that designed them will no longer be directly available. When activities are in development, a single team member could be sent for research purposes, leaving the rest of the team free to work on other things instead of becoming bogged down running the class day to day.

The Pilot Essay Contest

The major special activity that was conducted this year was, of course, the essay contest. We learned much from this, and it changed form several times during the process. Originally, the plan was to invite multiple schools in the district to participate. Each school would have been required to buy one copy of *Seven Wonders of Space Technology,* by Dr Alfred Bortz, per participating classroom, in order to satisfy the royalty requirements for duplication of the chapters so that each student can take their own copy home. There was still a $1.00/ copy charge for this as well as the copy of photocopying. Each school would then select the best two essays from each classroom and send these to us. (The method of selection would have been left to the discretion of the individual teachers.) The project teams and

volunteers from Reach for the Stars would then have selected the single best essay from each school at the fifth-grade level and at the sixth-grade level. These essays would then have been sent to Dr. Bortz, and their authors would have received autographed copies of *Seven Wonders of Space Technology* and been invited to an award ceremony at WPI. Dr. Bortz would select first-, second-, and third-place winners for the entire district at each grade level, and these would be announced at the award ceremony.

Running the contest district-wide proved impossible this year due to scheduling difficulties; the standardized test schedule meant that we would have had to wrap up in January, and this did not leave us with enough time to coordinate and run the contest at a district-wide level. We narrowed our focus to Elm Park, which resulted in some alterations to the purpose of the contest. With only a single school involved, we could read all the papers and evaluate the reading level of the students. In addition, the essay contest now served as an opportunity for us to identify the most promising 10% of students in science suitable to have that interest be nurtured by a club like Reach for the Stars. .

When all was said and done, the students and educators at Elm Park were quite happy with the essay contest (especially the awards ceremony that involved students getting autographed books inscribed by the author as prizes which were paid for by AIAA NEC. However, I believe that there are changes and improvements that need to be made if it is to be done again next year. In order for the contest to have as wide an impact as possible, it

should again be attempted at the district level. It is important to recognize, however, that not everything that was done at Elm Park will scale to that level. Reading all the essays, for instance, will not be possible, and if the teachers change the prompt to avoid having to support outside research by so many students, (as they did in this case) our ability to adapt will be more limited. We will need to recognize this when adapting the contest for a wider audience and stay in touch so that the teachers will not feel they are being left to their own devices. If the prompt must change, we need to make the change ourselves and it must apply to everyone.

For a district-wide contest with competition between schools, it is especially important that the schools and their students know in advance how they will be judged. Therefore, much attention must be paid to the construction of the prompt and the judging criteria. A good prompt should ask a single overarching question that is specific enough to be directly answerable, while at the same time broad enough to support an entire essay. It must be open-ended enough to allow students the freedom to answer creatively, but also settled enough to serve as a filter between students who understand the material and those who do not. The judging criteria must be written for multiple audiences; they must be understandable by students and teachers, but also usable by the judges as their sole guide to judging the submissions, in order to give everyone a fair chance at writing a winning essay.

Crafting a prompt and judging criteria like these is not easy, and the ones for this year’s contest were put together in a fairly rapid and haphazard fashion but still went through several revisions.

Two sets of criteria were drafted up; the first was a good description of the pedagogical goals of the contest, but was too full of educational jargon to be of much use to students. The second set of criteria was written more directly for students, but was too vague for teachers; there was also uncertainty about the relative importance of creativity versus technical accuracy. With the time drawing near for the contest to begin, the two sets were combined in a way that did not quite meet any of the goals. Meanwhile, the essay prompts were expanded to incorporate multiple questions in order to allow students who had potentially novel ideas about space exploration to be able to incorporate them. The result, unfortunately, was that the prompts were unfocused and consisted of multiple different questions bolted end-to-end, with some teachers splitting them up into separate writing assignments, and some students being told not to attempt all of them. . A final issue was the minimum and maximum word counts, which were arrived at by guessing; the teachers will have a better idea of what their students can actually write and there should probably be several categories of entry based on reading ability.

In order for this contest to work in the future, the team will need to lay out the requirements for what the prompt and judging criteria need to be, then allow time for them to be crafted properly. It is probably a good idea for

them to receive input from teachers while they are doing this. When they send out the prompt, it needs to be definitive; switching things around because the teachers aren't happy with them will not work at the scale of multiple schools.

Another important question is the role of outside research in the contest. The decision was made in this contest to include a research component in the sixth-grade prompt, in order to add an extra dimension of educational value. This was largely inspired by the obvious research potential in the topic matter; the book made reference to *Curiosity*, which had since landed on Mars and resulted in much media coverage. Furthermore, a major purpose of the contest is to promote student interest in space exploration; this necessitates tying it in with current events whenever possible. While there are clear benefits to this research component, there are downsides as well. From the school's perspective, the contest is already a project of immense scope if everyone is going to enter and be stretched by the vocabulary. In the case of Elm Park this was the first time a need for citation of sources had come up, and that needed to be explained as well. Adding a component that requires external research only increases this pressure, and a case can be made for having that be optional, but worth "extra credit".

Furthermore, in the absence of a well-stocked school library, outside research for students is possible only with external support; we had hoped that we would be able to provide this in cooperation with the library team,

but this effort fell through as they were occupied with a book drive. These factors combined resulted in the teachers changing the prompt.

Another question is the extent to which the prompt should resemble an MCAS essay prompt, in order to justify the contest in an environment where test scores are given the highest importance. The contest bears less resemblance to the MCAS prompt when outside research is included. All told, the outside research component must be carefully considered when this contest is conducted again. If outside research is again included, it must be determined how this will be supported in a multi-school setting. One possibility is to make each school responsible for the provision of its own outside research material. Another is to provide support for all participating schools, perhaps by sending a representative from Reach for the Stars to each school for a day with research materials.

Finally, it will need to be decided how the award ceremony will be conducted. The one held at Elm Park this year, though quite well received, was nothing like what was originally planned. It had the benefit of allowing students to be recognized in front of their entire body of peers, and inspiring all the students in the fifth and sixth grades. However, aside from the planning issues that cropped up this year (that resulted in the students not seeing most of the Dr. Bortz video), this style of award ceremony has the problem that, once again, it doesn't readily scale to multiple schools. One possibility would be to send a representative from Reach for the Stars to each school to present that school's finalists and semifinalists with awards.

Such a ceremony would not have everything that this year's ceremony had; not all of the representatives from WPI would be present, and there would be fewer awards presented. Furthermore, other schools might not be interested in such a ceremony. Still, it is worth considering. Meanwhile, the inter-school award ceremony has its own benefits; it could be made into an event allowing Reach for the Stars to get to know the winning students and encourage them to continue their endeavors in science.

One important proposal regarding the essay contest is the possibility of expanding it outside of Worcester. The McAuliffe-Shepard Discovery Center in Concord, NH is interested in participating in the contest. Reach for the Stars would be in a position to provide guidance to them as an activity is developed there that runs in parallel with ours. This could be important in giving broader reach to the themes of space exploration that we wish to promote.

The essay contest unexpectedly gave rise to another activity. While I was working with the lunar base model at Elm Park, a sixth-grade English/Language Arts teacher came up to me and said that, after her students learned about Mars rovers from the essay contest, she wanted her class to work with a Lego model of *Curiosity*. They found instructions online for building such a model. The class worked with these instructions, but soon found that they were missing parts. We made arrangements with the WPI STEM Education Center to allow the students to use their Legos to finish the model. As the teacher herself said when asking for the model, many students

learn better with a tactile learning device; consequently, such a model has educational value.

In addition to the essay contest and Lego model, another activity is currently in the works: a field trip. This is being modeled on a field trip that occurred on the WPI campus in 2011. At that time, students from several elementary schools were brought to WPI for a variety of activities, in what was officially called an “MCAS Review Day “On the Moon” at WPI ” (largely out of necessity to justify taking a whole day for science). They were invited to hear Dr. Bortz speak and deliver his talk, “Our Next Planet...”, about the long-term future of Earth and the necessity of human space colonization. There was a computer based plate tectonics activity. In Alden Memorial, there were several different lunar-themed activity stations set up for rotation, including “expedition” a convoy of vehicles designed to go to the lunar pole to the equator made out of Legos, Moon Shoes, remote-controllable robots, an explanation of lunar agriculture, and an explanation of the *Moonraker* robot. (The Society of Physics Students explained Fusion Energy reactors and also had a demonstration of a Van de Graaff generator, (which did not particularly have anything to do with lunar science, but was naturally enjoyed by the students nevertheless.) Students were also shown 6 proposed designs for a lunar base and asked to evaluate them. (For fun the WPI students running the design review included a design for a wind-powered base and most of the 5th graders realized why this design was not workable). Some of the students also ate a “lunar lunch”, consisting only of foods that

could be grown in a lunar base. The event was a major success and was praised by the students, teachers, and principals. I was a volunteer for that event, and gave the Elm Park students a tour of Gordon Library.

We are now trying to conduct an event similar in spirit for the current Elm Park students. As Reach for the Stars is not yet a mature organization, the event needs to be reduced in scope to a single school for the time being. Due to scheduling difficulties, this year's event will have to be held at Elm Park, rather than at WPI. The stations that appeared at the 2011 event will be brought back if possible, and new stations will be introduced; for instance, the West Boylston Apparatus, a device that uses counterweights to allow a person to experience simulated 1/6th Earth (lunar) gravity, will hopefully be brought to Elm Park. This event will allow Reach for the Stars to learn more about what kinds of activities successfully contribute to students' understanding and enthusiasm, which will allow it to improve the events that it runs in future, and hopefully begin running larger-scale events at WPI again the following year. We believe that holding the 2011 event at WPI had important inspirational value for students who may not necessarily have considered college as an option for them, and that this should continue to be done.

Another important aspect of the 2011 event was the presence of Dr. Bortz. In addition to his talk that he gave to all the students, he also came to Elm Park and held question-and-answer sessions with students in the classrooms. We would like to bring him back to Worcester to talk to students;

unfortunately, this could not be done this year as there was no source of funding. One possibility for future years would be to connect it to the essay contest; participating schools would be given the option to contribute towards the cost of bringing him to Worcester, in return for which he would visit that school for half a day. With multiple schools contributing, the option becomes economical. Another possibility would be to arrange for Dr. Bortz to go to events in other cities in New England at AIAA expense and then come to Worcester for a day.

Science fairs are another important extracurricular activity; they provide a unique opportunity to learn the scientific method through actual practice, and to develop projects that encourage them to ask the right kinds of questions. The Worcester Public Schools encourages all schools to have their students complete science fair projects for the Worcester Science Fair; however, Elm Park initially decided not to include science fair projects in the main curriculum due to lack of room. Science fair projects ultimately were done at the sixth-grade level; a different IQP team worked with that class, and it seems to have been a success. Meanwhile, initiatives such as the Blackstone Fellowship support science fair projects on an extracurricular basis. It will be important to consider the role of science fairs in the work going forward. In particular, it may be worthwhile to reach out to the WEC for collaboration on the Blackstone Fellowship.

One further event has also been proposed. In order to encourage interest in space exploration, both among Elm Park students and at WPI, a

proposal has been floated that Reach for the Stars should sponsor a celebration of Yuri's Night: the April 12 anniversary of the first human spaceflight in 1961. Reach for the Stars could reach out to Student Pugwash and/or the WPI chapter of the American Institute of Aeronautics and Astronautics for assistance with this. Yuri's Night has long been a focal point of space advocacy, and could serve as a recruiting opportunity for Reach for the Stars. WPI as an institution can also play an important role in space advocacy, given the important role of alumnus Robert Goddard in the history of rocket science. In addition, an attempt is currently being made to bring a speaker from the Jet Propulsion Laboratory to Worcester to speak about *Curiosity* for audiences of elementary school students, WPI students, and aerospace professionals. No doubt, such a speaker would be received with enthusiasm.

A critical-thinking after school club

One of the most important priorities that Principal Proctor expressed at the beginning of the year was ensuring that these enriching extracurricular activities provided options for students at all levels of achievement. Remedial after-school activities already exist, and auxiliary science support for average students is being provided by another group of volunteers from some of whom come from WPI but the leader of the program is paid by Elm Park.. What she now wants to do is create a Critical Thinking Club for the high-achieving students. One initial step is to identify these students; this year's essay contest served that role by allowing us to see all the students'

thought processes in action and determine which were the most promising. MCAS scores and techer grades and nomination have also been proposed as ways to identify the “stars”. (How this will work if the essay contest is scaled up to multiple schools is, once again, an open question.) Once the students are identified, an after-school club run by Reach for the Stars volunteers can provide them with an opportunity to improve their critical thinking skills. This could also potentially be an opportunity to nurture their interest in space science and technology.

There are many possible directions that such an after-school club initiative could take. The purest critical reasoning exercises are likely to be based in mathematics; the students could be introduced to applications of math different than those they have seen in school, and how to use them to solve problems. If the club wanted to focus more on developing skills of empirical reasoning, it could set up science labs and use them to teach students to make predictions and apply the scientific method. Other possibilities focus on different areas of STEM; continuing with the lunar theme, for instance, students could be given engineering challenges related to the construction of a lunar base. They could do research projects, which might or might not be directly related to STEM. They could learn about something entirely separate from the normal school curriculum, such as computer science. They could do something in the spirit of the growing-in-popularity STEM-to-STEAM initiatives, which integrate the arts into STEM

activities. In short, many things are possible, and Reach for the Stars will have to determine what best meets the school's needs.

Overall, we made significant strides over the course of this project in the development of special activities. We executed a successful essay contest at Elm Park that will serve as a pilot for a future contest with a wider scope. We made valuable connections with a wide variety of organizations whose interests intersect with our own, which are in a position to potentially help with activities. We set up the base of an organization which will ensure that these activities continue to be organized. Most importantly, we made an impact on the students we worked with, and worked to ensure that this impact continues to be made for years to come.

In my role on special assignment I was not only planning the special activities but also finding out what would be involved if volunteers from the proposed club were to take them on next year.

Recommendations for the Future

Future IQP

For the future, the next IQP team should be given the main task of evaluation broken down to the level of what concepts we adequately conveyed and failed to convey. Thus the 6th grade year should start with a test of the concepts that were to have been taught in 5th grade through the activities presented in MCAS style. We have upgraded and documented the activities enough for a volunteer or club member to assist the teacher with the activity for the week. The club, along with volunteers, should teach each activity to those who are interested, in order to streamline the process and get the program to more schools so students have the advantage when it comes to science and technology.

Parts of larger initiative with goal of curriculum with a lunar theme integrated with an exhibit, a field trip, and activities still need work . Eventually a good paperback book about space for the students to learn from and enjoy reading Would be a major asset. The textbook has serious problems. It is disjointed and scattered in general and the activites are busywork that assume access to no equipment. Worse in the space area there are misleading figures and it gives in inaccurate image of the moon which is resources rick, rather than desolate and forbidding. Teachers need a curriculum, that builds toward a field trip as a capstone experience and they need engaging reading that they can do at home as class preparation. Our job was to look at a proposed curriculum theme and set of activities, assess them and replace or improve those we found wanting. We also filled gaps and improved the documentation overall. We also launched the essay

contest-to look into the outside preparation problem and assess the skill level of the class as a whole. Overall, the students are not in a good place. One has to start where they are at and where they are at indicated either that science education was not a priority in grades 1-4, since no teacher specializes in it, or that reading comprehension is standing in the way, so it is time to shift to hand's on science education in 5th grade while getting some science into English class so the vocabulary becomes less forbidding.

Clearly progress was made and the Principal thinks the whole case was made for this approach. On the other hand, she already believed in it philosophically and just needed to have someone field a working example and provide the necessary materials, which we did. In a way, the person who had to be convinced was the 5th grade teacher, who wanted to stick to the text as much as possible but who could hardly miss the joy in the faces of the students when we showed up for "activity" day. Science was not going to be based on the text that day and everyone knew it. The question in everyone's mind is whether he can do it our way after we leave without support beyond what volunteers from a club coming int o do something very specific can provide? They will not have an overview or plan of their own. They will be there to help him execute his plan and make small group activities or stations possible.

It is surprising to us that another IQP team has been working on what the exhibit for a lunar base field trip would look like and only at the last

minute came to us for advice. We found that they had not read the text, used in Worcester, but rather have been working off of the state guidelines. Yet it is the classroom teacher who will decide if the field trip is “time on task” or not and worth the time and money. They may use the state rhetoric to justify a trip once they have decided they want to do it, but to decide, they will refer to the concepts in the test that have to be mastered and reviewed for the test. These teams should have read not only the Worcester text- but those in use in other nearby school districts. Alternatively they have to be working a lot more closely wit h the IQP teams that areworking from a text. .

In the future the exhibit and curriculum teams should be running in parallel and talking to each other and monthly meetings of all the teams structured into the plan so they can update one another and critique each other’s plans. . We never worked out a plan for a field trip, we were too busy. The team planning the ultimate exhibit would have been in a better position to do that for us and try out some of their ideas if we worked together and they knew what the students were learning to plan the exhibit

Advice to future curriculum team: 6th grade, come find out from us what they did in 5th grade , and critique as well a build upon it. Feed to the next 5th grade team what concepts the 6th graders haven’t mastered so they know where to focus their attention to fix the 5th grade curriculum and focus for the students to learn better. Intergroup communications are the next challenge in getting a coordinated effort.. Work with volunteers in club.

Teams should meet twice a week. Once on their own, and once by sending a representative to an all teams meeting. Everyone should gather in person monthly. together. Cross meeting will help keep people on task and help get a report written since there will be regular progress reports to refer to in doing your own report and the group of reports will be better connected and have cross references.

Conclusion

In conclusion, this project was one of real importance and value for both the students at the school and those of WPI. More words to come….

Appendix

The following pages contain worksheets and visuals necessary to run the aforementioned activities. These are to be used as a guide when running activities for students to use for their own personal learning and background information.

Crater Handout

	Angle of Impact	Length of Crater	Width of Crater	Ratio (L/W)	Other Observations
Station 1					
Station 2					
Station 3					
Station 4					
Station5					

Electricity Handouts

Take-Home Reading & Study Sheet for Electricity Chapter

What is Electricity?

Electricity is a form of energy produced by moving electrons (aka. Electric current)

Recall from energy chapter, **Electrical energy** is the energy that comes from an **electric current.**

Moving electrons produces electricity we use in everyday life. There is also another form of electricity, **static electricity** that involves no moving electrons.

Static electricity is the buildup of charges on an object. (Note: charges are electrons)

Current electricity is a kind of kinetic energy that flows as an electric current.

How does Electricity Work?

Conductor: A type of material that carries electricity well. (The electrons can move freely through the material)

Insulator: A type of material that does not conduct electricity well. (The moving of electrons is constrained through the material, in other words, no electrons can pass through.)

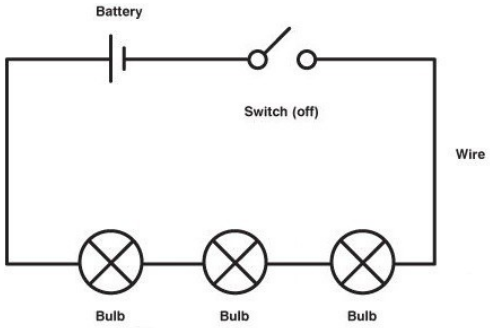
How to Use Electricity?

Electric circuit: The path an electric current follows

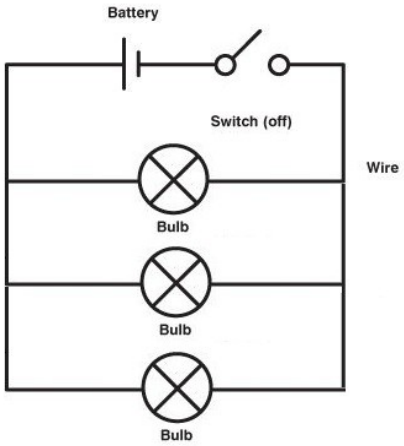
Series circuit: An electric circuit in which the current has only one path to follow.

Parallel circuit: An electric circuit that has more than one path for the current to follow.

Example of series circuit:



Example of parallel circuit:



Disadvantages and advantages of both series and parallel circuit:

Connecting three bulbs in series circuit uses less wire than in parallel circuit

If any one of the three bulbs in series circuit breaks, other two bulbs will not be working simply because there is one way the electric current can flow and the only way is broken.

If any one of the three bulbs in parallel circuit breaks, the other two bulbs will still be working because the electric current has three ways to go in parallel circuit. One bulb breaks meaning only one of the ways in which the electric current can follow breaks and the other two ways are still working.

What does Electricity do?

Turning electricity into magnetism

Electromagnet: A magnet made by coiling a wire around a piece of iron and running electric current through the wire.

Note: The piece of iron itself is not magnetic, but by coiling a wire around it and running electric current through it will make it magnetic.

Light Handouts

What is Light?

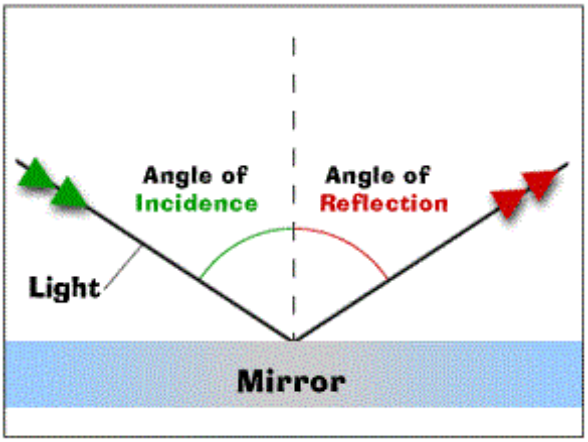
Visible Light is electromagnetic radiation that is visible to the human eye.

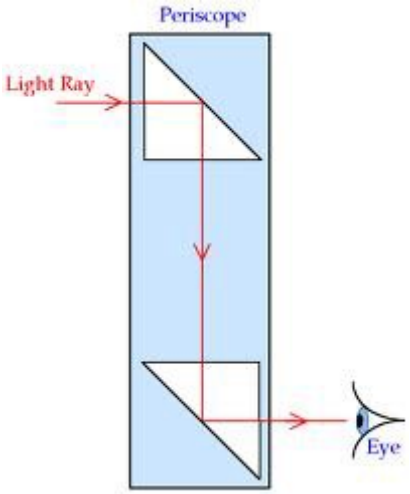
Opaque object: light cannot pass through

Translucent object: only some light can pass through

Transparent object: all light can pass through
Light can be redirected through **reflection** or **refraction**.

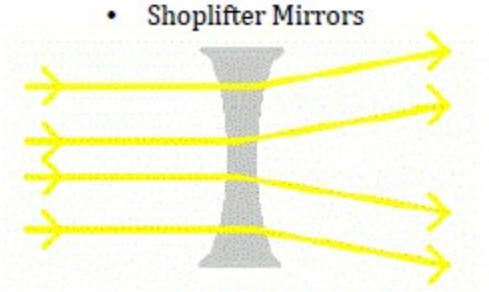
Reflection: the bouncing of light off an object.
Examples: mirror, periscope.

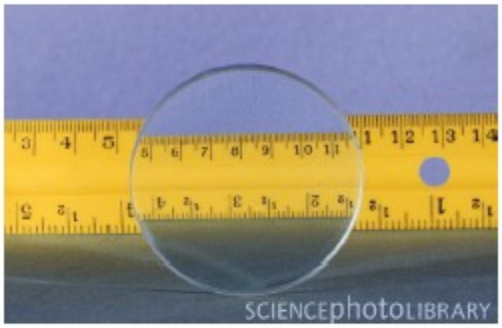




Refraction: The bending of light as it moves from one material to another.
Concave lens: A lens that is thicker at the edges than it is at the center
Uses of concave lens:

- Treat Nearsightedness
- On Door Holes
- Shoplifter Mirrors



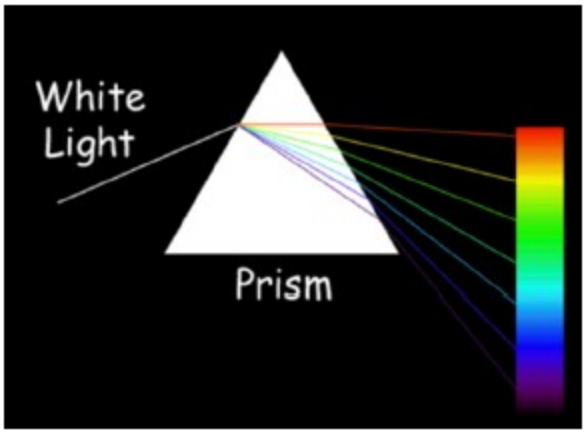


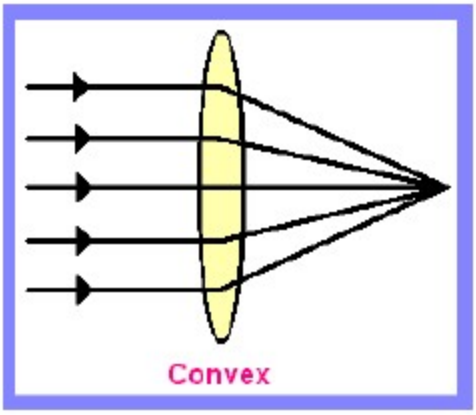
Concave lens

Convex lens: A lens that is thicker at the center than it is at the edges
Uses of convex lens:

- Magnifier
- Treat farsightedness
- Used on microscope to see tiny objects
- Used on cameras
- Human eyes are double convex lens

Prism: (Requires color printer for this)
Usually it's a triangular prism with a triangular base and rectangular sides. It can be used to produce rainbow light.





5th Grade Prompt

FIFTH-GRADE SPACE EXPLORATION ESSAY CONTEST

The New England chapter of the American Institute of Aeronautics and Astronautics and Reach for the Stars, a student club from Worcester Polytechnic Institute, are sponsoring an essay contest, based around the book *Seven Wonders of Space Technology* by Dr. Fred Bortz.

You will receive a photocopy of the book's fourth chapter, "Moon Bases and Moon Water". Read the chapter, then write an essay that answers the following prompt:

> Scientists have discovered that there is a significant amount of water on the Moon, even though the astronauts who visited the Moon between 1969 and 1972 didn't find any. This discovery could be very important for your generation. If Dr. Bortz is right, your generation could be the first to live and work on the Moon.
>
> When did scientists go looking for water on the Moon, and how did they prove that it's there? What does Dr. Bortz think will happen because of this discovery? Do you agree with him? Why or why not? Can you imagine any other exciting possibilities resulting from the discovery of water on the Moon not mentioned by Dr. Bortz?

Your essay must be between 500 and 800 words. You may use other sources beyond the chapter if you wish, but you must cite them.

You should aim to write an essay that answers the questions in the prompt, is well-organized, correctly describes the factual information in the chapter, shows your understanding of it, makes a point, and backs it up. You are encouraged to go beyond the facts in the reading when exploring new possibilities. Your essay will be judged by these criteria. The contest judging is separate from your teacher's grading of your essay.

Remember to:

- Read the prompt carefully.
- Explain your answer.
- Add supporting details.
- Proofread your work.

You must turn your essay in to your teacher before the end of the school day on Monday, December 10. The essays will then be judged by Dr. Bortz and a committee of WPI students from Reach for the Stars. The authors of the three best essays in the fifth grade will each receive a copy of *Seven Wonders of Space Technology*, autographed by Dr. Bortz. These will be presented at an assembly in January, where you will get to meet Dr. Bortz through videoconferencing and see his presentation, "Our Next Planet ...".

If you have any questions about the contest, talk to your teacher or send an email to Reach for the Stars at spacecontest@wpi.edu.

6th Grade Prompt

SIXTH-GRADE SPACE EXPLORATION ESSAY CONTEST

The New England chapter of the American Institute of Aeronautics and Astronautics and Reach for the Stars, a student club from Worcester Polytechnic Institute, are sponsoring an essay contest, based around the book *Seven Wonders of Space Technology* by Dr. Fred Bortz.

You will receive a photocopy of the book's fifth chapter, "Mars Rovers". Read the chapter, then write an essay that answers the following prompt:

> The rover *Curiosity* has now landed on Mars. It is the next step towards humans eventually visiting Mars. A short manned mission would take at least two years: six months to get there when Mars is closest to Earth, a year to stay on Mars until it is getting close again, and six months to return.
>
> How did the landing of *Curiosity* go, and what is it doing now? What do scientists hope to learn from it? What should we know before sending humans to Mars? What do you think the next rover should do? Can you imagine other ways to explore Mars than with a rover?

Because the book was published before *Curiosity* was launched, it does not tell you about the landing or what happened next. You will have to research these topics and use other sources beyond the chapter, such as newspaper articles and websites. You must cite these sources.

Your essay must be between 500 and 1,000 words.

You should aim to write an essay that answers the questions in the prompt, is well-organized, correctly describes the factual information in the chapter, shows your understanding of it, makes good use of outside sources, makes a point, and backs it up. You are encouraged to go beyond the facts in the reading when exploring new possibilities. Your essay will be judged by these criteria. The contest judging is separate from your teacher's grading of your essay.

Remember to:

- Read the prompt carefully.
- Explain your answer.
- Add supporting details.
- Proofread your work.
- Cite your sources.

You must turn your essay in to your teacher before the end of the school day on Monday, December 10. The essays will then be judged by Dr. Bortz and a committee of WPI students from Reach for the Stars. The authors of the three best essays in the sixth grade will each receive a copy of *Seven Wonders of Space Technology*, autographed by Dr. Bortz. These will be presented at an assembly in January, where you will get to meet Dr. Bortz through videoconferencing and see his presentation, "Our Next Planet...".

If you have any questions about the contest, talk to your teacher or send an email to Reach for the Stars at spacecontest@wpi.edu.