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Grade 5 Space Enhanced Science Education

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Grade 5 Space Enhanced Science Exploration

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Contents

Acknowledgement

I would like to thank everyone at Elm Park Community School and each prior team and advisor that has helped develop this project over the past few years. However, it is my own project partners that that I want to acknowledge the most since their names are not on the title page and I did not do this project alone. I am reporting first because my schedule requires it, but two thirds of the report is still a work in progress and Elise Margiolis and Zackary Couture will not be completing their sections on the rest of the descriptions and reports on the activity units to go with chapters and the parts lists of the activity kits until next term. Elise will also be offering a critique of both the text and some of the unit produced last year. She sees opportunities to link with science with math that are likely to be mentioned as well.

My other partner, Taymon Beal, was on special assignment much of the term, though he supported some classroom activities. His mission was to take up the idea of a service club to sustain the use of this kind of hands on science education in the future, when there is no IQP team doing curriculum development or evaluation in a given classroom. His concept of the club "Reach for the Stars" and its mission and organization interweave with my project at the point of the Essay contest we ran as a pilot project this year. I am to report on how it went at this one school and he is supposed to try to figure out how to run such an activity on a broader scale at 8-10 schools, without the job becoming overwhelming. We also never got to plan a field trip for the 5^{th} graders and he has an idea for one that still may be carried out in D term. I encourage Taymon to add his section to this report and resubmit the whole in his name. I do expect him to clearly note who the author of each section was.

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 essay 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 should see science as the fun course with amazing implications for the future since all their activities had a lunar theme based on solving the problems associated with living and working on the moon using what the 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 completely 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 it can be a reality.

Our team worked with the AIAA, which is an organization very interested in students and helping schools in any way they can. They allotted us $50 to enhance each kit, money for a field trip, and money to run the essay contest.

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 misfortune was the attempt but failure to start an essay contest and a service club aimed at being volunteers for the teachers when they are running activities.

Background

Last Year's Report

This project continues on what previous projects began, but expanded on key elements. The goal of the past few years has been to increase the student's interest in science and technology, and give them the confidence, experience, and knowledge they need. This will allow them to the opportunity to solve problems and design things to one day go into the science and engineering fields. The previous team went into the classroom of Fran Mahoney on a weekly basis because the science teacher has the same students for a week, then a different class the next. Our team had the challenge of a new schedule. Students now have science every other day, so this required us to be in the classroom twice a week, every other week.

The previous team created kits based off of the material in the book, and made sure to incorporate all of the key words and principles necessary to have an effective grasp of concepts. These activity kits 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. This is one way for them to have a fun hands-on way to experience science in a lively 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.

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

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 angle of the asteroid impact that created Shackleton crater at the South Pole of the moon. 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 regolith layer on top is about 3-10 meters deep of “sand”. 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 a 0.5 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 0.25 inches above the flour surface arriving at a specified angle 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 measured 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 length and width ratio, 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 and what happens when the marble is dropped in the flour, and it truly made learning fun as well as messy. 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 very 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 the 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 an activity that the teacher was committed to doing. 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.

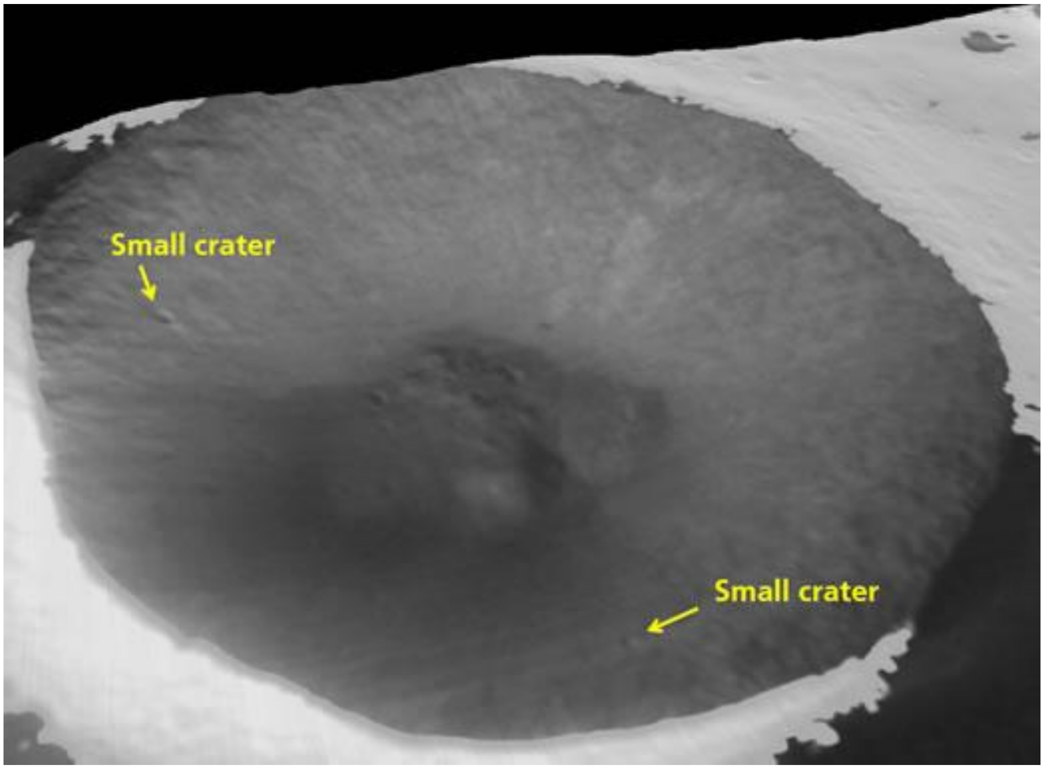
But to really do it right one should return to this question when talking about friction as a "force" and compare landing on Earth to landing on the moon, and the behavior of asteroids hitting each body as well. The fate of the Shuttle Columbia due to having lost a few of its heat shielding ceramic tiles is a case in point. Without protection, the aluminum alloy of the spacecraft structure beneath the shield reached the melting point upon reentry so that the wing fell off and the craft rolled. The side of the craft was without any protection and 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 moon as 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.

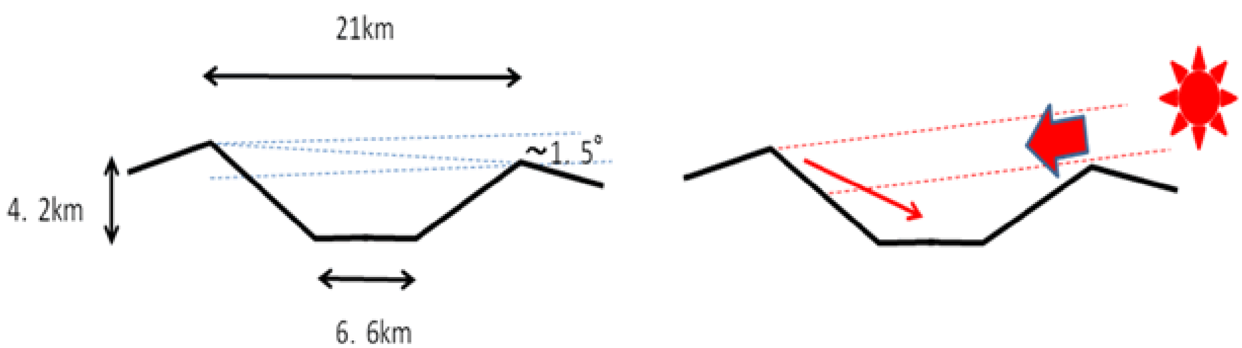
This activity simulates the surface of the moon. A marble that is dropped into the pan resembles an asteroid hitting the moon. Asteroids can hit at any angle, and the activity showed what a crater would look like from various angles. The goal was to estimate the angle of impact that formed a given crater, 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 the 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 were also surprised to see that it is the asteroid hitting slower and at a lower angle that 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 books. 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.


Small crater
Small crater


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 text book covers electricity. The activities we developed leaned heavily on the work of the prior team cover 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 1 and this topic was not developed at the time that the 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, so it may not be used in the activity.

The first station contains Christmas lights, a three 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 matching large six 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. The students are asked how the electricity gets from the positive to the negative pole and pass 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 the 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 wiring design when they note how the device they assembled will not work. By comparing this to an identical system that works, 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. 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 understand the concept, they will start to think of it as stored solar energy. Other sources like solar and nuclear are the promising sources of electricity to help 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.

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 intensity 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. Also to be mentioned is photovoltaic cells, - 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 between 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 Earth 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 everything in 10 minutes, but do go with the flow of student questions as you take them through a 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 they want. 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 came 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 the 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, except 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, 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 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 inserted 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 glass making up the wall- inserted 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
- Mirror
- Tape
- Protractor
- Concave / Convex lenses
- Kaleidoscopes
- Binoculars
- Telescopes
- Glasses with mirrors
- Prism
- Slinky
- Color wheel
- Handouts

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 into the lunar base theme. It is just having them handle a lot of musical instruments and figure out what is vibrating in each case. He was also given a toy that changes the sound of a voice spoken into it and they have to figure out if the sound wave is being shortened or lengthened electronically-like a distorted telephone. The team covered both, and 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 later 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 the different lenses 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 try 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 having 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 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 speed of travel. This is helpful to show how they work and what they do. A slinky can be used 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 turn white (more like beige) while in motion. Plants only respond to certain wavelengths of light for cooking CO2 and H2O into carbohydrates. 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 red or blue in color.

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 shielded by at least 10 feet 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. The plants must not die so it is essential to get rid of the dangerous light in space. 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 and 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 year we do not want the 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 South Pole.

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 and 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 to 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, with 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. They were 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 to 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 the technical minds 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 from the 6th grade curriculum 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 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 top essays at each grade level went into a final review by a team of judges that consisted of the 5th grade team, and they 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 grade 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 seemed 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 until 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 known 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 that 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 was 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 he finally owned a book, especially one about space exploration that she 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 first semester and the student writing has to be done by Christmas since the second semester, when they return after New Year's 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 time to do the ceremony, so moving it up two weeks next year is advised.

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 it 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 on 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). We had been expecting 48-50 out of 55. This was an assignment that was assigned and required of all students- a directive from the 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 was a general 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 this 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 the last time anyone had been to the moon by explaining that when we quit making Saturn 5 rockets in 1972, we 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. The 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 in the chapter provided, and the same information was used by about six essays. Others showed evidence of independent data 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 their 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 goal 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 showing up with laptops and helping 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, there is hope that the idea can be approved for the whole Doherty Quadrant 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 abilities for the whole class, after the winning 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 still being independent and 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 the top 10 % "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, and 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 snacks for 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 were 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 made us 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 those 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 realize 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 for 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" experiment was. It is a drawing of either Zack's or Amber's station (possibly a mix) in the electricity activity unit where bulbs would light up. There seems to have been something for everyone.

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 in the following years. 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 activities are busywork that assume access to no equipment. Worse in the space area there are misleading figures and it gives an inaccurate image of the moon which is resources rich, 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 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. It is time to shift to hands on science education in 5th grade while getting some science into English classes 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 to 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 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 with the IQP teams that are working from a text.

In the future the exhibit and curriculum teams should be running in parallel and talking to each other with 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 as 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 as build upon it. Feed to the next 5th grade teams 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 the club as much as possible. Teams should meet twice a week, with the first being on their own, and second by sending a representative to an all teams meeting. Everyone should gather in person monthly. 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. It was meant to have science curriculums with an emphasis on lunar themes. A well-developed curriculum guide is a very important piece of this project, and will help future teams as well as the club assist the teachers at the school in what they need done. Students like learning when there are fun activities to be done, and they may be learning without even realizing it.

Without a good guide, teachers will shy away from the lunar concepts and teach straight from the book, which isn't acceptable. The book is a bad example of a text book, and doesn't explain concepts well. It has a lot of problems, and we want students to learn the most they can with what they are given. Reach for the Stars will help run the activities, since a lot of them require multiple people to handle the equipment and make sure the children are paying attention to the concepts. Once off the ground, it will erase any need for a teacher to avoid the curriculum set before them. We are trying to create future scientists and engineers, and this curriculum does just that.

In the end, this project has been composed of a lot of work and proposes pieces of a curriculum guide, with a promise of more to come from fellow team mates soon. The success of this IQP is essential in order to help middle school students compete with the rest of the country. Being a master of science is an extra ordinary skill, and every student should get the opportunity.

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.)

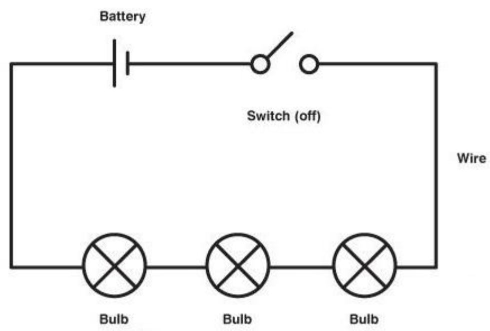
How to Use Electricity?

Electric circuit: The path an electric current follows

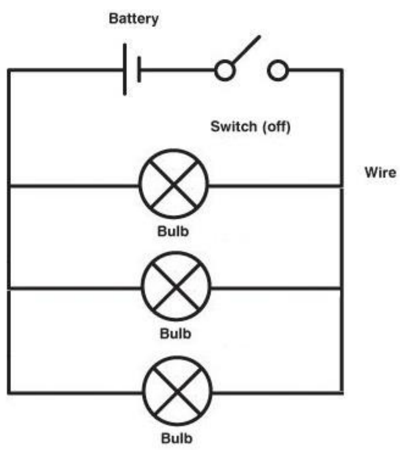
Series circuit: An electric circuit in which the current has only one path to follow.

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?

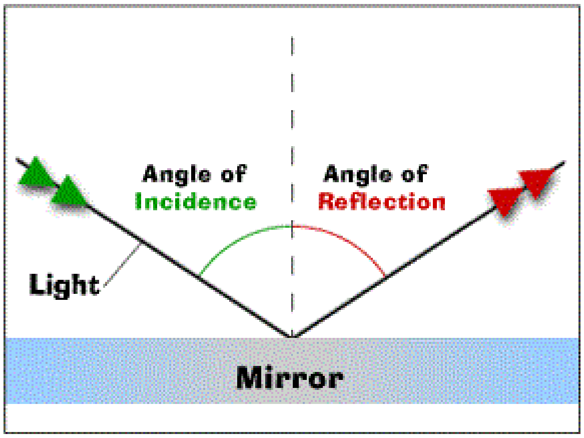
Visible Light is electromagnetic radiation that is visible to the human eye.

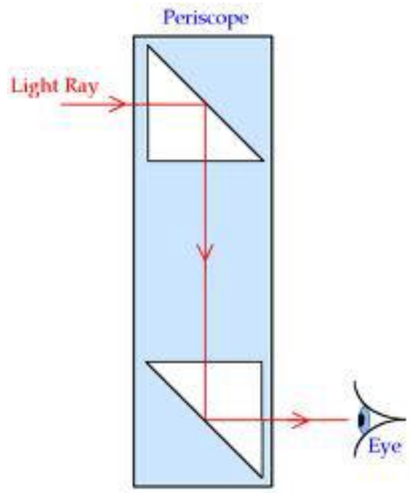
Opaque object: light cannot pass through

Translucent object: only some light can pass through

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

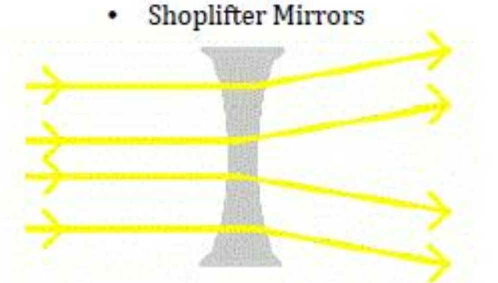
Reflection: the bouncing of light off an object.
Examples: mirror, periscope.

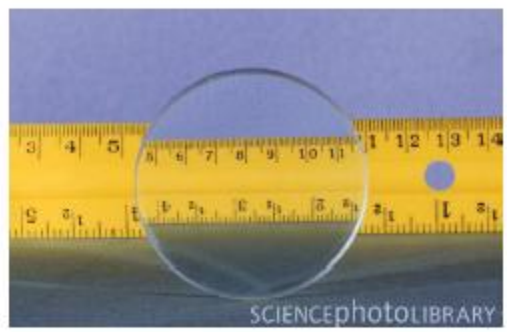




Refraction: The bending of light as it moves from one material to another.
Concave lens: A lens that is thicker at the edges than it is at the center
Uses of concave lens:

- Treat Nearsightedness
- On Door Holes
- Shoplifter Mirrors



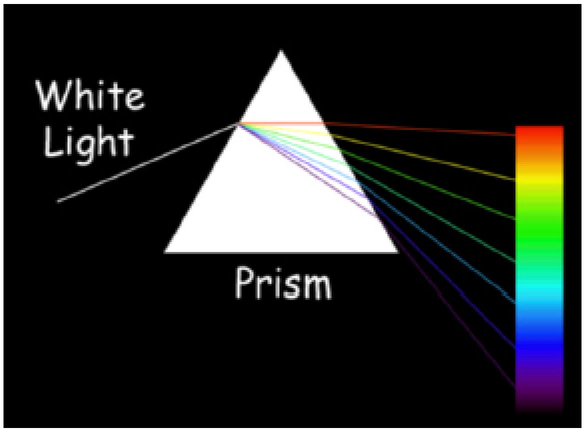


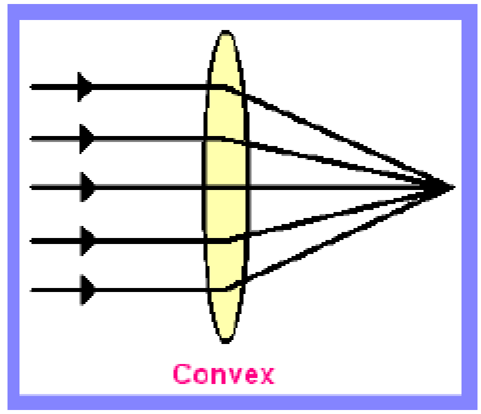
Concave lens

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.