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MBJ IQP 1301

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Worcester Memorial Auditorium Lunar Base Exhibit and Activity Center

An Interactive Qualifying Project

Submitted to the Faculty of

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Submitted to:

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Introduction

Abstract

The Lunar Base Exhibit Project is an Interactive Qualifying Project which hopes to educate students of fifth grade to ninth grade based on the Massachusetts math and science curriculum. At the same time, it is a project of designing the exhibit program[1] to create a unique entertainment environment that will stimulate the students' curiosity and interest. The project will discuss the history of the moon related to mankind, resources, risk and purpose of living on the moon. Some background on the auditorium where the exhibit will be located will be provided, together with the general purpose of the project and information about the contest. The major point of the project will discuss the school curriculum of Massachusetts that sets the expectations of what students will learn from the exhibit. Also, the activities will be explained to demonstrate how the school framework will be applied to activities as part of our educational strategy. Additional information will be provided in the appendix to support the ideas.

Project group members

Inhwan Kim

Inhwan is a major in Civil Engineering, specializing in structural engineering. He uses his expertise to design the interior of the exhibits. His interest in this project is to design an exhibit of a lunar base that will complement the school education system. His main goal was to provide an educational program that combines science and entertainment.

[1] Appendix A

Erik Scott

Erik is an Aerospace Engineering major who is interested in and passionate about bringing about a renewed interest in space travel and exploration. In addition to his engineering interests, Erik is also a self-taught 3D artist who enjoys using his skills for the purposes of visualization.

Moon history

The Moon has been “the only Earth’s brother planet” for billions of years. However, the history of direct human exploration of the Moon goes back less than fifty years[2]. In this short time, spacecraft have discovered many physical facts about the Moon.

The dream of putting a human on the Moon became reality when Neil Armstrong stepped off the Apollo 11 spacecraft and onto the lunar surface in 1969. While Soviet and U.S. lunar missions have returned with samples, picture and data, the Moon is still filled with mysteries that needs to be explored. Less than a quarter of its surface has been mapped in detail, and very little is known about how it formed, what it is made of, and how it has evolved over time. There is no way to fully understand the past of the Moon just by studying it from Earth. Now, scientists are hoping the first lunar base will be constructed on the Moon in the 2060s.

Living on the Moon

After years of investigation, scientists have determined that the Earth and Moon have many similar characteristics. The Moon contains water, volcanic activity and a central nucleus just like Earth. It also offers valuable resources. Therefore, if we can find the right place for a settlement, it may be feasible to live on the Moon and make it the first step into further exploration of space.

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[2] http://lunar.ksc.nasa.gov/history/moonh.html

Our design for a lunar base is based on the winning design from a prior contest, which described an underground habitat containing laboratories for research, a greenhouse for oxygen and food, and living areas such as bedrooms and a cafeteria.

Resources

There are two important benefits that people are expected to get from the moon: natural resources and astronomical opportunities.

Although scientists have found evidence of ice on the Moon, it is still uncertain if we can collect enough water to support a base. Even though people can bring water from Earth, a local water source is necessary for a base to sustain itself economically. However, water is not the only Moon's only valuable resource. The soil of the Moon is a mixture of many materials. Some can be used for base construction. Without construction resources, it will be difficult to maintain a lunar base, because it is too expensive to ship construction materials from Earth.

Helium 3 is a potential future energy resource that is difficult to obtain on Earth. Although Helium 3 is present in the lunar soil only in low concentrations, the energy industry on the Moon has significant economic potential[3].

The Moon has a lot to offer future astronomers, who will be able to view space without the problems of atmosphere and radio interference. A lunar settlement will also serve as a platform for the colonization of the planets.

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[3] Schrunk, David G., Burton Sharpe, Bonnie L. Cooper, and Madhu Thangavelu. The Moon: Resources, Future Development, and Settlement. Second ed. Berlin: Springer, 2008. Print.

Risks

Although a lot of resources and information can be found on the Moon, it is still a great risk. It costs about ten thousand dollars to send one kilogram to the Moon[4]. If a project fails, large amounts of energy and money are wasted. We will not get far into space unless we find a way to reduce this economic risk.

Also, building up a base on a planet without air, different geographic characteristics and low gravity is not going to be an easy job. The architects have to precisely design a construction for conditions that are nothing like Earth. Even though the first man landed on the Moon in the 1960s, no one has visited in this century. There is no guarantee that people will successfully set up a base on the Moon. NASA and many aerospace scientists are studying ways to reduce the possible risks.

Contest overview

The debate about how to carry out space-enriched science education on a city or regional level has reached an interesting point. People are asking what kind of exhibit is needed to go with the 5th to 9th grade spiral curriculum in Worcester, MA. An architectural contest for students was planned during A term through C term to produce compelling images and explore the possibilities.

The contest sponsors, SHIFTboston and AIAA New England, see this contest as a spin-off of a previous lunar base architectural contest held May-Sept. 2010. This contest produced two exceptional designs for a lunar base in 2069 that were also judged to be technically feasible. The teams of

[4] Schrunk, David G., Burton Sharpe, Bonnie L. Cooper, and Madhu Thangavelu. The Moon: Resources, Future Development, and Settlement. Second ed. Berlin: Springer, 2008. Print.

architectural, engineering, and education students were asked to translate these winning designs into an educational exhibit. The winning design will hopefully become the model for lunar base exhibit

Purpose of IQP

The main purpose of the proposed exhibit is to educate fifth grade to ninth grade students to space science and the Moon using the existing Massachusetts Science and Technology Framework as a foundation. Our program design and suggested activities are designed based directly upon the 5th to 9th grade curriculum so that the students will experience essential material in a new, exciting environment.

The design must also appeal to school administrators and teachers, who will ultimately make the decision to visit the facility. This program therefore provides a list of suggested learning exhibits and activities, along with a preliminary visit schedule constrained to the length of a typical class trip. By offering activities based directly upon the topics students are expected to learn in class, decision-makers will be able to justify a lunar base visit as “time on task.”

An important secondary focus of the facility is to encourage interest in space exploration among the nation’s youth. While space exploration has appeared to have taken a backseat to more pressing domestic and international issues here on Earth, the case for a lunar base remains. However, it will be the next generation’s task to realize this dream. The activity-based, hand-on learning experience of the proposed lunar base exhibit will entertain and encourage students to choose college majors and future careers related to science, aerospace and related engineering disciplines.

Worcester Memorial Auditorium

The exhibit is designed to be located in the basement of the Worcester Memorial Auditorium at Lincoln Square, Worcester Massachusetts. The Auditorium was originally built in 1933 as a WWI

Memorial. It was designed by Lucius W. Briggs as a multi-purpose arena and auditorium. Through the years, it has served as an entertainment venue, public gathering space, legal document storage facility and juvenile court.

The original Auditorium had a seating capacity of 3,000 people in the main auditorium. If the floor seats are removed, an activity area of 18,212 square feet becomes available. The main stage is one of the largest in New England, 44 feet deep and 116 feet wide,. The proscenium arch is 68 feet wide and 44 feet high. There are 67 sets of lines for curtains, scrims, backdrops, etc. A ramp allows trunks to be driven onto the stage directly from the street. The main stage is equipped with removable seating that will accommodate a chorus of 630.

The Kimball organ in the main auditorium is one of the finest instruments of its kind ever built, with 6,719 pipes, 186 stops and 58 couplers. It is mounted on its own elevator, separate from the orchestra elevator. The celebrity "green room" suite has a private street entrance. The backstage area also has a musician's room, two chorus rooms, a set assembly area and a kitchen.

The Little Theater in the west end of the building seats 704. It shares the stage with the main auditorium. A soundproof curtain can be lowered to allow simultaneous usage. Both the Little Theater and main auditorium are equipped with film projection booths.

Education

The education component of the exhibit will be based on the Massachusetts Science and Technology/Engineering Curriculum Frameworks, with extensions in different topics for additional activities. The Appendix contains a summary of the frameworks for 2001 and 2006. Also, an example of middle school science curriculum will be provided.

There are four main subjects in the Massachusetts standards: Earth and space science, life science or biology, chemistry, physics and technology. The exhibit will contain activities based on each of these subject, tailored to different grade levels.

The material for biology will explore the human body, plants and ecology by comparing the environments of the Earth and Moon. Students will learn how to plan experiments, make observations and follow laboratory procedures.

The Earth science exhibits will cover topics such as mapping, size, mass, gravity, location, heat transfer, radiation, convection and conduction. Students will also learn about the phases of the Moon, and lunar and solar eclipses and the physics of the Earth-Moon system. Air, water, rocks, soils and geologic processes will be studied in the context of the lunar base environment, comparing and contrasting them with the environment of Earth.

Similar to biology, chemistry will be also taught through lab experiments. Topics will include elements, compounds and mixtures, atoms and molecules, elements and compounds, mixtures and pure substances, melting point and boiling point, and physical and chemical changes. Students will learn how to obtain certain elements using chemical reactions, and brainstorm how to obtain helium, an important lunar resource.

Physics exhibits will examine the laws of motion, velocity and acceleration and basic mechanics, using simulated vehicle launches and landings and remote control of robots.

Exhibit layout

The exhibit will be divided into several areas. Some of these areas will be used as congregation areas for the entire group of students, while others will be intended for smaller groups to partake in interactive activities. All these areas will be decorated so as to not only appear exciting and engaging to the students, but also to resemble what a real lunar base might look like.

Briefing room

The main briefing room is the first area the students will visit, and must leave a lasting first impression. This room will serve as the location of the introduction to the lunar base. Students will be show an introductory movie, setting the scene as if they have just arrived on the Moon from Earth. Live performers will also be present on stage to continue to introduction in a more personal manner.

This will require a fairly sizable area the size of a small theater complete with stage, movie screen and projector. As this is the first room and will serve as the location for the introduction for the entire group of students, it must be able to hold the 128 students we anticipate attending at one time, along with all accompanying teachers and chaperones.

Sectors

The areas where the students will conduct their activities and spend the majority of their time will be in six themed sectors, designed to simulate different areas and responsibilities on a real lunar base. With the exception of “Sector Zero” (the solar flare bunker), each sector is designed to handle approximately 32 students (One quarter of the entire intended group of 128) which will likely be further broken down into small teams of 2 to 3 students each. Throughout this paper, the terms “Sector” and “Activity Area” are synonymous.

During their time at the lunar base, students will only have time to visit four activity areas plus the solar flare bunker. While arranging their trip with the facility, the school will select the activities they would like their students to experience. This will better help the facility and school tailor the experience to the proper age level and relevant material the students are learning at the time.

Sector 1: Biology and Life Science

Sector 1 will take theme of a greenhouse and bio-research facility. The activities students partake in will directly address the biology requirements of the Massachusetts Science and Technology/Engineering Curriculum Framework. While the framework does have human and animal biology sections, the activities in Sector 1 will focus on plant life in a greenhouse. Students will be expected to learn about the water, carbon and nitrogen cycles, cell biology, effects of lunar gravity on plant life, and ecology. The sector will be equipped to help facilitate learning these topics in a hands-on manner using pH testing and balancing equipment, microscopes and other similar equipment.

The centerpiece of this area will be the model greenhouse which, on a real lunar base, would provide food and oxygen to the inhabitants. Depending on the selected activity, this may be used either directly or indirectly during the students time here.

Sector 2: Chemistry and Chemical Engineering

The Chemical engineering sector should concern itself mostly with how to extract valuable materials from the lunar soil, or regolith. Activities in this area will focus on taking measurements and simulating chemical reactions. Because chemical experiments require a lot of explanation, a computer-simulated approach would likely be a better approach when considering time and safety constraints. As such, the room could be lined with computer monitors for the students to work at. A table and chemistry equipment could be made available to an exhibit employee who could conduct pre-planned experiments to demonstrate certain concepts to the students in an interactive and visual manner.

Sector 3: Physics

The physics section of the facility must be able to serve activities in a variety of areas, including forces and motion, electricity and magnetism, light and waves, and energy conservation. Activities might include making electronic circuits, analyzing mirrors and lenses of different shapes, or performing experiments on various objects in motion. Equipment would include various types of springs, pulleys and sensors for analyzing motion; convex and concave mirrors and lenses, along with various light sources including lasers for activities involving optics; batteries, wires, switches and other electronics for experiments involving electricity and magnetism. Computers should be available to groups to perform simulated activities or parts of activities that would not be feasible in real life.

Sector 4: Earth and Space Science Studies

The Massachusetts Science and Technology/Engineering Curriculum Framework dedicates an entire section to Earth and space science. While a lunar base environment obviously lends itself to space science, Earth science topics can and will be covered as well. Most notable would be the topic of gravitational attraction and the basics of orbital mechanics. Much of this would be best explained using computer simulations. An interactive program like *Universe Sandbox* would be ideal for this task, as it accurately simulates the orbits of planets and other celestial bodies.

Another important part of this sector would be monitoring the sun for solar flare activity. This task would lead directly into the events and activities intended for sector zero (detailed later).

Sector 5: Manufacturing, Repair and Maintenance

Sector 4 will take the brunt of the engineering and technology side of the Massachusetts Science and Engineering/Technology Framework. Activities here are intended to be hands-on, with little or no use of computer simulation. Students will be working within the steps of the engineering design process in which they will have to identify a problem and design a solution using the resources available to them. Activities would involve designing subassemblies of a more complex prototype to perform a simple task. Simple robotics would be an ideal topic to use in this area. A simple, ready-made solution for this area would be to use the existing LEGO Mindstorms® educational robotics sets designed for elementary, middle, and high school students. This would offer a modular approach to robotics in which all students could use standardized parts to more easily work together while at the same time take advantage of the range of possibilities LEGO offers with its more advanced sets. This will also allow the students to learn programming skills, as they have to use the included software to make their creations perform simple tasks. The room may feature a model lunar landscape that the students must navigate successfully.

Sector 6: Electricity and Power

Electricity and power will take and expand upon several areas of the framework. These would be primarily in the areas of physics having to do with heat and energy transfer, electricity and magnetism, but could also be branched out into the space science areas having to do with solar and lunar eclipses, lunar phases and other events that would affect solar power collection on the Moon. Chemistry topics could also be involved, as helium-3 extracted from the lunar regolith is useful for nuclear fusion that could also be used to power the base.

The room should be equipped with wires, resistors and other electronics for electricity related activities. Solar power will be a large component of this area, so small solar panels should be included. Discussions of nuclear power will also take place, and thus various visuals associated with this topic should also be included. Examples would include a model reactor and model helium atoms.

Sector Zero: Solar Flare Bunker

Between the 3rd and 4th activity sessions, it will be revealed to the students that a solar flare is predicted to hit the moon and that all personnel must take cover in an underground bunker, which will be named Sector Zero. Here, students will learn about the adverse effects of solar radiation on humans (a biology component) and the science behind how and why they occur (space science and physics component). These explanations will be explained by detailed, yet understandable visuals on displays in the room.

The underground bunker, like the main briefing room, must be able to contain the entire group of visitors (approx. 150 people total, including teachers and chaperones). Unlike the briefing room, however, the room will be dimly lit and more rudimentary, as this is intended to look like a place people don't normally spend much time. Instead of theater life seating, the room should be arranged radially, with students sitting in tiered rows around the perimeter with a center area where staff will explain the dangers of the approaching flare to students. The aforementioned screens will also be situated high in the middle of the room to allow a view for all students.

Usage of the Auditorium

The lunar base exhibit is intended to use the majority of the auditorium's basement in addition to the Little Theater in the back of the building. The Little Theater, able to seat about 700 people, would be ideal for the briefing room.

The basement of the facility was until recently used as a juvenile court and is in relatively good condition (Figure 1). Renovation of this area is likely to cost significantly less than the renovation of the rest of the building, which has been abandoned for a longer period of time. The lunar base exhibit is intended to fill the entire basement, with space not taken up by activity areas dedicated to "behind the scenes" areas such as office space, conference rooms, prep rooms and maintenance areas.

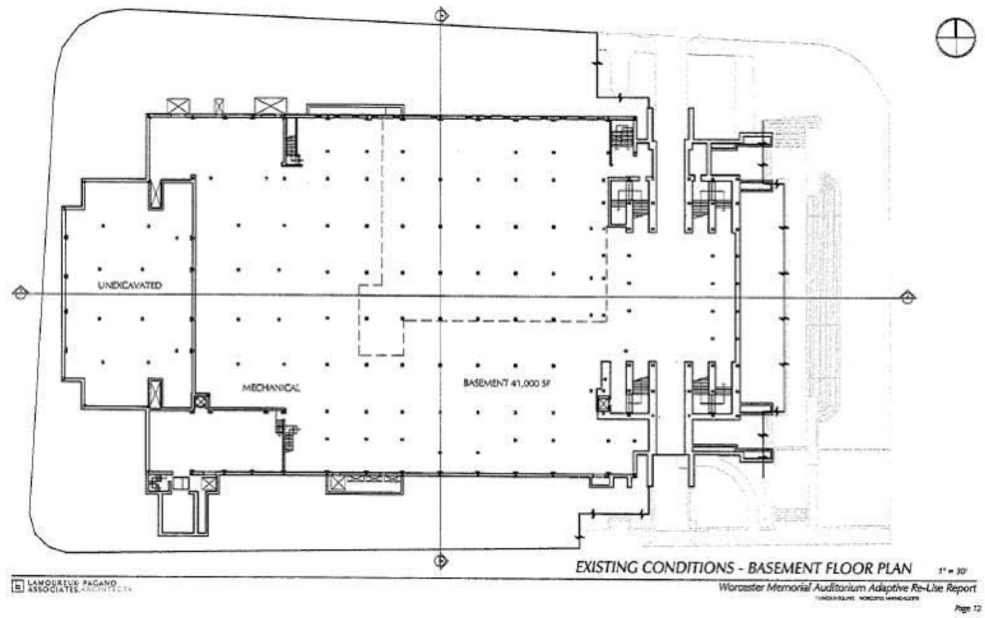


Figure 1: Worcester Memorial Auditorium Basement

The Experience

The exhibit design is intended to serve a minimum of four groups of 32 students (approximately 4 bus loads) at one time, including accompanying chaperones and teachers. However, the Worcester Auditorium facility is physically large enough to accommodate larger groups if needed, taking advantage of economies of scale. This could include 2 school groups being run through the facility in parallel.

Students arrive at the Little Theater entrance at the rear of the Auditorium at around 9:00 am. From the moment students leave their buses, the experience is designed to convey the feeling of having actually arrived on an actual lunar base set 50 years in the future. In addition to the physical setting, all employees interacting with the students are dressed in realistic space outfits, with headsets and other props to reinforce the illusion of visiting the future and being in a lunar environment.

After depositing their coats and lunches on robotic transport racks and bins, the students and chaperones proceed directly into the Little Theater, which is styled as a briefing area for passengers arriving from Earth. They are welcomed to the Moon and watch a short introductory presentation, including a 3D digital video that explains the layout of the base and the kinds of activities they will experience during their visit.

Upon completing the initial briefing, students divide into four groups and are guided to one of four themed activity areas, or sectors. Each sector is equipped with activity stations for up to 32 students. The stations provide opportunities for teams of 2-4 students to participate in a planned sequence of experiments and observations requiring about 40 minutes to complete. Each station encourages students to apply their classroom knowledge of science and technology in new and exciting ways, while encouraging teamwork. At the end of the first 40-minute period, each group of students rotates to a different sector featuring new activities and objectives.

After the second activity period, all four groups assemble in the cafeteria, where the robotic transports have delivered their lunches. After a lunch break of about 30 minutes, students form back into groups and proceed to their third exhibit area.

At the end of the third activity period, a scripted “base alert” signals the approach of a solar flare. All students are directed into a special underground chamber designed to look like a protective bunker. The lighting will be dim and warmer; screens and flashing lights will convey a sense of urgency. Here, students view a briefing on the dangers of space weather, solar flares and radiation, and how the Earth’s magnetosphere protects life “back on Earth.” Throughout this activity, screens display the current position of the approaching solar flare so that students can monitor its progress. Luckily, the dangerous flare “just misses” the Moon, allowing the students leave the bunker after a short period of time (less than 15 minutes) for their fourth and final activity period.

Upon completion of the final activity, students return to the theater for a short debriefing before their journey back to Earth. The visit concludes with an opportunity to visit a technology-oriented gift shop, an important revenue source for the facility.

The lunar base experience is scripted to last approximately 3 1/2 to 4 hours, providing enough time for students to return to their schools and ride their regular buses home.

Schedule:

- Arrival, Initial briefing and movie: 9:00 to 9:15
- Activity 1: 9:20 to 10:00
- Activity 2: 10:10 to 10:50
- Lunch: 11:00 to 11:30
- Activity 3: 11:34 to 12:20
- Solar Flare Emergency: 12:30 to 12:45
- Activity 4: 12:50 to 1:30
- Debriefing: 1:40 to 1:50
- Remaining time at Gift shop
- Get belongings and depart

Activities

The activities the students partake in while at the facility are the heart of the the experience and must be carefully crafted to be both engaging for students while also being considered “time on task” by teachers and education officials. Activities will be designed not only to present material learned in the classroom in a new and engaging way, but must also promote teamwork and cooperation between students. This can be done in several ways. The most obvious is requiring the smaller groups of 2 to 4 students in an activity area to rely upon each other for measurements and observations. Each group should be working on small, independent pieces of a problem that will ultimately come together as a single solution.

However, this is another, even more engaging way of enhancing this feeling of accomplishment: teamwork between activities. This can be accomplished in one of two ways. The first is to make all 4 periods of an activity area work towards a single solution, where the results of the students working in one sector during activity period 1 will directly affect the students in activity period 2. Period 2’s progress will then affect period 3’s and so on. The second is to enable interaction between different sectors in real time. For instance, the biology sector might have to request certain chemicals from the chemistry sector to be sent over on a small rack-mounted robot, or the students working in the power and utilities sector must request the correct part from the maintenance sector.

The specific activities will not be outlined as it is outside the scope of this report. Activities will have to be carefully crafted and tailored for each age group and combination of activity areas chosen by the visiting school. Activities will also have to be periodically and regularly updated to reflect changes not only in the Massachusetts Science and Technology/Engineering Curriculum Framework but also new discoveries in science. Activities should reflect the newest, most exciting aspects modern science has to offer if it is to inspire the next generation of students to pursue careers in science and technology. So, while specifics will require a much closer look, some examples of activities are listed below.

Biology Activities:

Upon entering sector 1, students will be informed that some of the plants in the greenhouse are dying and that they must be saved if people on the base are to live. Students will be presented some brief information to jog their memories and provide hints as to the correct way to proceed. Students will then divide up into teams and perform various tests to determine the problem.

The problem may be different for each group of 32 students that comes through the activity area. However, each solution must reflect a specific objective detailed in the Massachusetts Science and Technology/Engineering Curriculum Framework. For instance, students might determine that certain plants do not receive enough sunlight for photosynthesis in their current positions and must be relocated. Students will have to understand and apply concepts of photosynthesis in determining an optimum arrangement of plants based on their specific needs (Massachusetts Department of Education, 49). Other potential solutions could include changing the soil as the old soil can no longer sustain plant life. This would require knowledge of the carbon and nitrogen cycles (Massachusetts Department of Education, 33). Students may also find that a lack of biodiversity has led to an unsustainable ecosystem and they must introduce other plants or other members of the food chain (Massachusetts Department of Education, 47).

Students may instead be presented with the task of breeding new plants with traits more suited to the lunar environment. This will convey concepts of heredity and reproduction. Students will learn that traits are passed from living things to their offspring through chromosomes and that in the case of sexual reproduction, each parent contributes half the chromosomes (Massachusetts Department of Education, 47).

Chemistry and Chemical Engineering activities

When students enter sector 2, they may be asked to extract certain chemicals from samples of lunar regolith or identify potential pollutants in the water supply. To do this, students will require basic knowledge of chemical reactions and the differences between physical and chemical changes, and understand melting and boiling points to conceive of different ways of identifying and extracting compounds from various other mixtures (Massachusetts Department of Education, 61). Students should also be able to label and differentiate between pure substances, solutions, and mixtures, both homogeneous and heterogeneous.

Another problem may be the topic of adjusting the pH of the base's water supply. Students will have to identify if a substance is an acid or a base with a pH test, and then correct it using certain available chemicals (Massachusetts Department of Education, 65). This activity would be more appropriate for an older age group as the topic is more complicated.

Physics activities

The laws of motion become very interesting in the context of the Moon. Student activities could be based around the difference and similarities of how things move on Earth, on the Moon, and in the vacuum of space. Students should analyze how objects of different sizes fall in a gravity field and explain the transfer of energy from potential to kinetic and back again. Activities could include measuring how long a ball takes to fall and calculating its velocity when it hits. The students could then use this information to determine the acceleration due to gravity on Earth and the Moon. Methods of simulating the Moon's gravity should be present, whether practical or virtual. These results should then be carried over into the space and Earth science activity session to determine the size and mass of the Earth and Moon.

Another topic of interest in physics is light and how it behaves. Students might have to design a system of mirrors and lenses to natural sunlight into the lunar base without letting in deadly radiation.

In the vacuum of space, sound is another interesting topic. Students could analyze how sound moves differently through different mediums. This could be done using sensitive equipment and/or through computer simulation.

Earth and Space Science Activities

While space science may appear more suited for a lunar base, many Earth science skills can also be learned in this context. One activity students should be familiar with is the topic of geologic features and contour maps. Students may be given a model lunar landscape and should be able to map it. Students could then plot an effective course through the mountains and valleys of the moon to allow a robot to successfully navigate. This route could then potentially be sent to the repair and manufacturing sector for an actual robot to follow, perhaps in the next activity.

Students could also be tasked with accurately recreating the Earth-Moon system in a piece of software similar to *The Universe Sandbox* by Giant Army. Students will have to work together to determine the different parameters of the orbits. Once this is created, students will be asked to recreate a solar and lunar eclipse and discuss what each of them are and how and when they occur.

One important activity that could be tied in with the emergency between activities 3 and 4 is the tracking of the solar flare. Students in activity 1 could be tasked with tracking the sun and making notes of the location and sizes of sunspots. These students will, towards the end of the 40 minute period, encounter a rather large spot and make note of it for the group coming in for activity 2. They will notice the spot erupts and task the students from activity session 3 to track the incoming solar flare. These students will in turn determine that the flare is heading towards the Moon and recommends the people in the base take shelter. This leads directly to the scripted solar flare emergency between activities 3 and 4.

Manufacturing and Repair Activities

The activities in the manufacturing and repair sector will be more free and open ended, while at the same time emphasizing the engineering process:

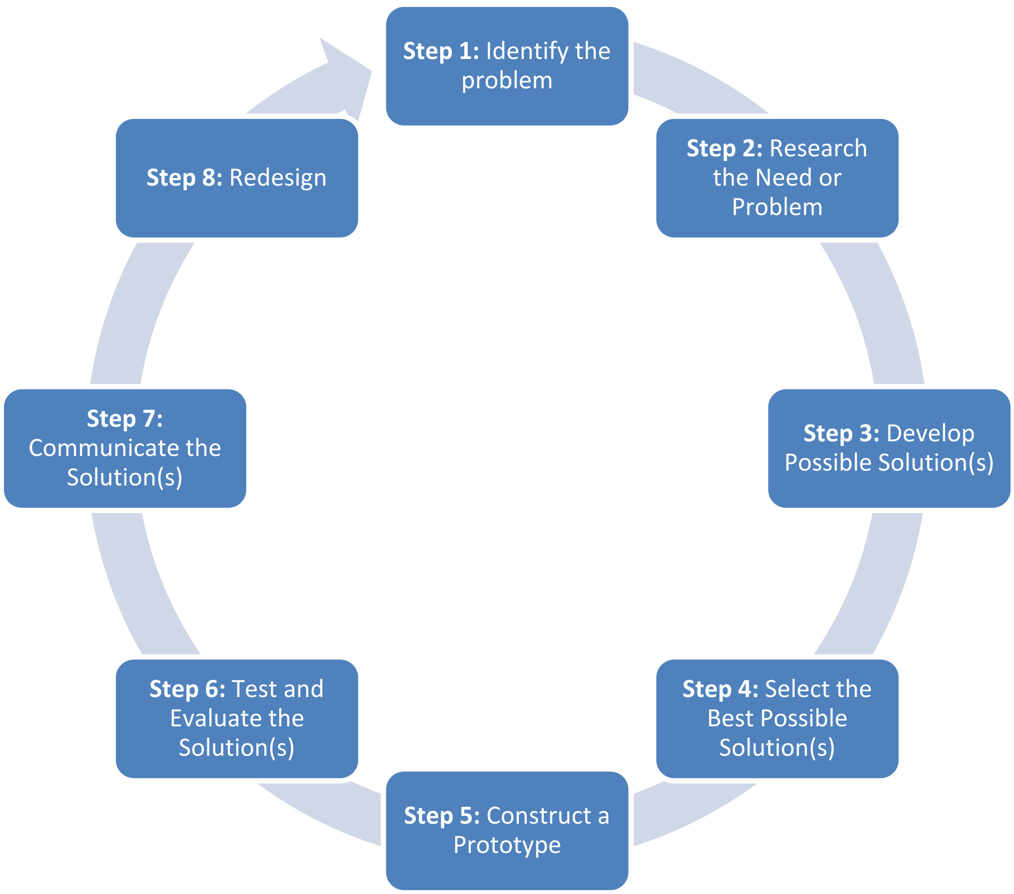


Figure 2: Engineering Design Process (*Massachusetts Science and Technology/Engineering Curriculum Framework*)

This process will likely have to take place over the course of all four activity sessions and groups as a single 40-minute session will only be able to accomplish one or two of these steps (Figure 2).

Because much of a lunar base will be operated by robots, the task of building a new robot, whether for the purpose of exploration, rescue or some other reason, would be an ideal activity. Once such practical solution for the facility would be to use the existing Lego Mindstorms® educational sets. Most students will already be familiar with the ways Lego sets function and work together and will reduce the time spent on explanations. Lego are also fairly robust and can take a fair amount of abuse. Students may be tasked with designing a solution to a simple problem, and each group may be in charge of building a small sub-assembly. The next group during the second activity session will then assemble the final robot. The third group will then program it and the fourth group will have it execute its mission. Students will then be asked to discuss what they did right and wrong and propose possible solutions for a redesign, completing the engineering design process cycle. Success or failure is less important than the students actually experiencing working through this process.

Power, Electricity and Utilities

Activities in sector 6 will be applications of topics learned in physics, chemistry and engineering as applied to generating electricity for the base. Students may be asked to identify what is wrong with a nuclear reactor and to do so must understand different types of energy and how it is transformed. For Instance, students could analyze how heat is transferred through conduction, convection and radiation.

Students may also be expected to design new circuits to re-wire the base more efficiently and securely. They will learn the difference between parallel and series circuits and the advantages and disadvantages of each. Topics of electricity and magnetism could be worked in. Students may have to test which substances obtained from the lunar soil or regolith are conductive of electricity and which are insulators. This information would then have to be used by others groups for the purpose of wiring a circuit or protecting people from exposed wires.

One interesting feature of the lunar base may be a large "field" of solar panels and this would give students an ideal opportunity to learn about solar power and photovoltaic cells.

Behind the Scenes

The Worcester Auditorium is a very large facility. Although only the basement of building will be used, there is still plenty of room to support more than 128 students. If financially feasible, the exhibit can be expanded to run two or more 128 student groups in parallel.

The building is currently not compliant with ADA and fire safety requirements, a major reason it is currently abandoned. Many certifications and structural requirements will need to be addressed in order to start the exhibit program. Restrooms are an obvious consideration, and a small medical infirmary will be necessary to handle minor sickness and emergencies. For the employees, a changing room must be available for each gender and must be able to hold 5 to 10 people at the same time.

It is likely that students will damage equipment during normal use. Maintenance workshops with mechanical and electronic repair facilities will be required.

Ideally, the facility will be open for professional development during the summer months. The benefits of this are threefold. First, it will provide greater occupancy and return on the investment in the facility. Second, it will offer teachers a valuable and unique opportunity to discover new and engaging methods of teaching their students. Third, assuming the facility is state-sponsored, the money from these professional development sessions that might otherwise go to private entities would instead be reinvested.

Several conference rooms should be available, both for professional development and internal needs of facility staff.

None of these areas will be seen by students and so will not require the futuristic décor of the main facility. This will be more financially feasible and also promote a sense of professionalism for teacher development sessions and other conferences or meetings where students are not directly involved.

Summary of findings

Many lessons were learned during this project, relevant to both aerospace science and architectural design. The lessons related to our goal included knowledge of the Moon, the state math and science curriculum, technologies to support activities and improvement in presentation skills.

One of the major findings is knowledge of the Moon. As we studied the lunar base project, we learned about issues related to settlement, resources, environment and benefits of a lunar base project. These factors helped in designing the activities and interior of the exhibit.

School websites and references from other IQP teams helped us understand how the schools teach students. An understanding of school curriculum contributed in designing activities as well, helping us create exhibits which seemed most efficient and entertaining. Practical and safety issues also helped inform our design choices.

There were also two formal presentations, one given by each member of the team.

The first presentation[5] was given by Inhwan Kim at Johns Hopkins University in Maryland on November 2, 2012. The audience consisted of student and professional members of the AIAA (American Institute of Aeronautics and Astronautics). Three different groups from WPI gave 15-minute presentations about the lunar base exhibit. Each group offered a different focus. Our focus was to explain the proposed program schedule and discuss the strategy of education, including the relationship

[5] Appendix B

between activities and school curriculum. We also discussed which materials should be included in activities.

A second brief 10 minute presentation was given by Erik Scott in the chairman's room at the WPI Campus Center on February 11, 2013. The presentation focused on the type of experience students could expect from the lunar base exhibit, including the day's general schedule and examples of activities students might encounter. The audience included several representatives from various other scientific educational facilities such as the *Christa McAuliffe Center* and the Worcester *EcoTarium*. The purpose of the gathering was to discuss various way in which existing STEM education facilities around New England could collaborate and share resources digitally using modern high-speed internet.

While the vision was bold, the presentation appeared to be well received. Erik took a couple questions regarding technical feasibility, as that was not discussed in detail in the presentation slides. Among these was the question of what would be done with the facility during “off-hours” when students would not be partaking in activities, such as during evening hours, weekends, and the summer months. Erik responded with the discussion of potential to bring other organized groups, such as scout troops, through on weekends, renting out the theater for local movie showings in the evenings in the theater/briefing room, and professional development sessions during the summer.

Both presentations were rehearsed among ourselves. These dry runs were very helpful in deciding what information to present. Also, we improved many of our exhibit designs as a result of preparing for the presentations.

Contribution

Our main contribution from this project is our strategy for educating students. All of the activities we designed offer valuable teaching in an entertaining “hands-on” context, while encouraging students to get interested in science.

The students who are in now middle school are the generation who must plan and initiate a lunar base project for the 2060s, which means they will need to become scientists and engineers.

If our lunar base exhibit is someday constructed, it will become a central facility for educating both students and teachers for the challenges of 21st century space exploration.

Appendix

Appendix A: SHIFTboston Contest Program Submission

Worcester Lunar Base Experience and Exhibit

By Erik Scott and Inhwan Kim

Contest Overview

The lunar base science exhibit contest is an architectural contest that promotes the idea of educating students through practical examples. The contest calls for a design of a simulated lunar base to be potentially installed in the basement of the currently abandoned Worcester Memorial Auditorium, located in Lincoln Square, Worcester, Massachusetts, or a similarly sized venue approved by a managing committee.

Project Overview

The primary purpose of the proposed exhibit is to provide late elementary and middle school students a different approach to learning science and technology topics under the overarching theme of a future lunar base. The state of Massachusetts has a specific set of science and technology requirements every student must meet. These are detailed in the Massachusetts Science and Technology/Engineering Curriculum Framework. Our program design and suggested activities are based directly upon the 5th to 9th grade curriculum so that the students will be presented with essential material in a new, exciting environment.

The design must also appeal to school administrators, curriculum development counselors, and science and technology teachers who will ultimately make the decision to visit the facility. This program therefore provides a list of suggested learning exhibits and activities, along with a preliminary visit schedule constrained to the length of a typical class trip. By offering activities based directly upon the topics students are expected to learn in class, decision-makers will be able to justify a lunar base visit as “time on task.”

A secondary focus of the facility is to encourage interest in space exploration among the nation’s youth. While space exploration has appeared to have taken a backseat to more pressing domestic and international issues here on Earth, the case for a Moon base remains and is indeed growing stronger. However, it will be the next generation’s task to realize this dream. The activity-based, hand-on learning experience of the lunar base will encourage students to choose college majors and future careers related to science, including aerospace and related engineering disciplines.

About the Base

The exhibit is to be based upon one of the two entries in the 2010 SHIFTBoston lunar base design competition that were considered “technically feasible.” Our program draws inspiration from the Cratersville submission by Team Goddard, a modular design which is highly versatile. It could be used not only for the intended crater-side location, but also adapted for construction in existing, yet-to-be-discovered lava tubes which would provide inherent protection from hostile environment of the lunar surface without a significant amount of excavation.

An important function of the actual lunar base will be to mine the lunar regolith for frozen water, hydrogen, oxygen or helium 3. These can be used to supply the lunar base itself, or exported back to Earth.

The initial construction of the base will be performed by robots. Because the cost of sending materials into space is so high, most of the initial building materials will have to be extracted from the lunar regolith. A fully autonomous fleet of construction robots is unlikely, as it’s difficult to predict complications beneath the lunar surface. Barring a sudden advance in artificial intelligence, the robots will have to be primarily controlled from Earth.

Once a suitable base has been constructed, humans will be able to travel to and live on the Moon. Their primary responsibility aside from basic monitoring of the station would be maintaining and improving the robots. Due to a limited number of people at the lunar base itself, however, most robot operations will still be controlled from Earth. The base will be continually expanded, and able to handle increasingly large shifts of people traveling to and from Earth on one-year deployments.

The engineering, construction and maintenance of the base will require extensive knowledge of technology, biology, physics and chemistry. In designing our simulated lunar base, we tackle each of these areas in separate activities, all in the context of living and working on the hostile environment of the Moon. Space weather is an especially important topic, both for future lunar exploration and in contemporary 5th to 9th grade curriculum. A real lunar base will need to be constructed at least partially underground for protection against continuous cosmic radiation and periodic solar flares.

Each exhibit area will contain several hands-on activities directly addressing these topics, tailored to the grade levels of the students visiting the facility.

Education

The exhibit designs are based on the Federal and Massachusetts middle-school science curriculum frameworks.

In the current frameworks, sixth grade students are introduced to ecology, human biology, chemistry and physics. These topics will be explored by comparing and contrasting the Earth and Moon environments, using simple experiments to make observations and draw conclusions.

Seventh grade is focused on the life sciences. Students will learn about human biology, introduction to plant cells and activities related to the observation lab. During the major activities, students will compare and contrast the effect on the body when they are on Earth and on the Moon. Students will learn how to observe during the experimental activities while becoming familiar with laboratory procedures. In minor activities, students will study basic Earth science topics such as gravity, measurements and distance between Earth and Moon.

For eighth grade and above students, five focus areas are covered: Earth science, biology, chemistry and physics. The Earth science activities include mapping, size and mass measurements, heat transfer (including radiation, convection and conductance), and the effects of gravity on bodies and on construction. Students will learn about lunar phases, and lunar and solar eclipses. They will be given opportunities to compare and contrast the Earth and Moon, and understand the technological challenges of space travel.

Biology activities will consider the human body, plants, ecosystems and environments, using the greenhouse and laboratory facilities of the lunar base exhibit. Chemistry will be also taught through lab experiments, with topics focused on the Worcester public school curriculum: elements, compounds and mixtures, atoms vs. molecules, mixtures and pure substances, melting and boiling points, and physical and chemical changes. Many activities will relate to the mixture of elements and temperature, and the process of chemical reactions. Students will be challenged to devise methods of obtaining helium and liquid oxygen (LOX), important lunar export resources.

Physics activities will allow students to explore the law of motion and basic principles of mechanics (such as velocity and acceleration) with experiments involving rocket propulsion, landing simulations and robotic control.

The Experience

The exhibit design is intended to serve a minimum of four groups of 32 students (approximately 4 bus loads) at one time, including chaperones. However, the Worcester Auditorium facility is physically large enough to accommodate larger groups if needed, taking advantage of economies of scale.

Students arrive at the Little Theater entrance at the rear of the Auditorium at around 9:00 am. From the moment students leave their buses, the experience is designed to convey the feeling of an actual lunar base. In addition to the physical setting, all employees interacting with the students are dressed in realistic space outfits, with headsets and other props to reinforce the illusion of visiting the future and being in a lunar environment.

After depositing their coats and lunches on robotic transport racks, the students and chaperones proceed directly into the theater, which is styled as a briefing area for passengers arriving from Earth. They are welcomed to the Moon and watch a short introductory presentation, including a 3D digital video that explains the layout of the base and the kinds of activities they will experience during their visit.

Upon completing the initial briefing, students divide into four groups and are guided to one of four themed exhibit areas. Each area is equipped with activity stations for up to 32 students. The stations provide opportunities for teams of 2-4 students to participate in a planned sequence of experiments and observations requiring about 45 minutes to complete. Each station encourages students to apply their classroom knowledge of science and technology in new and exciting ways, while encouraging teamwork. At the end of the first 45-minute period, each group of students rotates to a different exhibit area featuring new activities and objectives.

After the second activity period, all four groups assemble in the cafeteria, where the robotic transports have delivered their lunches. After a lunch break of about 30 minutes, students form back into groups and proceed to their third exhibit area.

At the end of the third activity period, a scripted “base alert” signals the approach of a solar flare. All students are directed into a special underground chamber designed to look like a protective bunker. Here, students view a briefing on the dangers of space weather, solar flares and radiation, and how the Earth’s magnetosphere protects life “back on Earth.” Throughout this activity, screens display the current position of the approaching solar flare so that students can monitor its progress. Luckily, the dangerous flare “just misses” the Moon, and students leave the bunker for their fourth and final activity period.

Upon completion of the final activity, students return to the theater for a short debriefing before their journey back to Earth. The visit concludes with an opportunity to visit a technology-oriented gift shop, an important revenue source for the facility.

The lunar base experience is scripted to last approximately 3 1/2 to 4 hours, providing enough time for students to return to their schools and ride their regular buses home.

Activities

The following are examples of activities students might experience during a visit to the lunar base exhibit.

Human biology and Earth science. A robot is stranded in the crater. One or more students put on pressure suits and go “outside” to retrieve it, crossing a set designed to resemble the lunar surface. The floor of the set is bouncy, simulating the effect of reduced gravity. “Radar” sensors in the suit guide the students to the location of the robot while students in the base monitor the vital statistics of the rescue team. This experience will demonstrate how gravity affects the human body, and how coordinate systems can be used to navigate unknown terrain.

Physics, mechanics and technology. Students use a real laser to machine parts required for base repairs. A laser of moderate power (safely operated by remote control, and monitored by video) is used to cut soft plastic sheets, based on engineering templates the students must learn to interpret. They are allowed to keep some of the parts they create as souvenirs.

Life sciences. Students perform laboratory observations related to greenhouse activity in the lunar base, using video microscopes to observe, compare and contrast plant and animal cells, and diagnose problems.

Advanced biology. Activities will involve the nitrogen, carbon and water cycles, the effects of reduced gravity on plants and animals (most notably humans, though lab rats may be present as well) and how our terrestrial biology is ill suited for the hostile lunar surface environment.

Chemistry. Students will study chemical reactions in a helium collection simulation, learning how helium can be converted into valuable resources.

A lunar geology activity uses foaming chemicals to simulate the volcanic formation of lava tubes.

In another area, students are required to inspect and repair defective robot batteries, combining conductive metals and chemicals in the correct proportions to achieve a stable source of electricity.

All activities will be created in consultation with middle-school science instructors and curriculum professionals to maximize "time on task," while remaining fun and engaging to participating students.

Architecture, Design and Atmosphere

The architecture of the facility must be both futuristic and believable. This required a balance between the design requirements of an actual lunar base and those of a robust, working science exhibit visited by hundreds of students weekly.

The Worcester Auditorium's Little Theater, reconfigured as a digital cinema and briefing room, is the first part of the exhibit the students will see. It should make a powerful first impression, suggesting an authentic and promising vision of man's future in space.

The rest of the facility must continue the illusion of visiting a real lunar base. Corridors may have wires or pipes running overhead, together with structures resembling bulkheads along their length, lined with futuristic strip-lighting.

The activity stations should be styled to resemble workstations in a mission control center. Computer monitors, some equipped with stereoscopic display technology, will provide support for a broad range of activities that can be readily customized for different age groups and educational objectives.

The cafeteria could be made a bit more conservative to help provide a break to students who may feel overwhelmed half way through the day's events. This should still be made futuristic enough so as to not break to continuity of the experience.

The underground bunker occupied during the solar flare activity needs to be able to accommodate all 128 students at one time. It should be darker than the other activity rooms, with warmer lighting and a sparse, minimalistic feel. More metal, wires and pipes may be exposed to help portray the feeling of being deeper underground in an area that is intended for refuge and not prolonged living. During the solar flare, many of the strip lights in the hallways should turn yellow, orange or red, forming a path leading to the bunker.

Behind the Scenes

The Worcester Auditorium is a very large facility. Even limiting the lunar base exhibit to the basement leaves plenty of room. The facility can potentially handle two or more 128-student groups running in parallel, offering the potential for significant savings due to economies of scale.

The building is currently not compliant with ADA and fire safety requirements, a major reason why it is currently abandoned. These considerable challenges must be considered in the architectural plans. Adequate restroom facilities must also be available to handle the volume of visitors. A small medical infirmary will be necessary to handle minor sickness and emergencies.

Middle-school students are highly efficient destroyers of educational exhibits. Mechanical and electronic workshop areas must be available to maintain and repair equipment.

Ideally, the facility will be open for professional development during the summer months. The benefits of this are threefold. First, it will provide greater occupancy and return on the investment in the facility. Second, it will offer teachers a valuable and unique opportunity to discover new and engaging methods of teaching their students. Third, assuming the facility is state-sponsored, the money from these professional development sessions that might otherwise go to private entities would instead be reinvested.

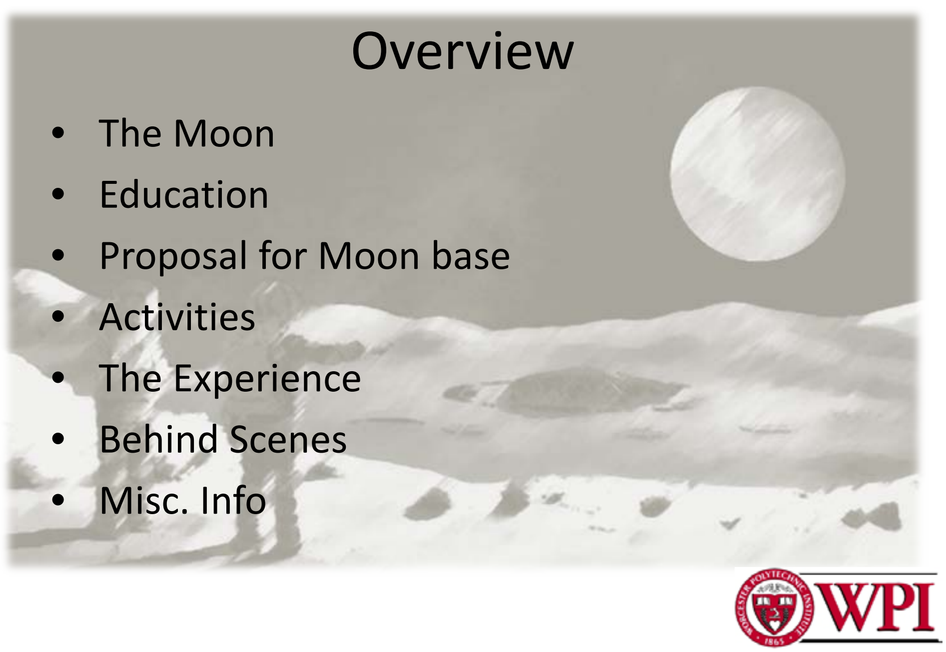
Several conference rooms should be available, both for professional development and internal needs of facility staff.

None of these areas will be seen by students and so will not require the futuristic décor of the main facility. This will be more financially feasible and also promote a sense of professionalism for teacher development sessions and other conferences or meetings where students are not directly involved.

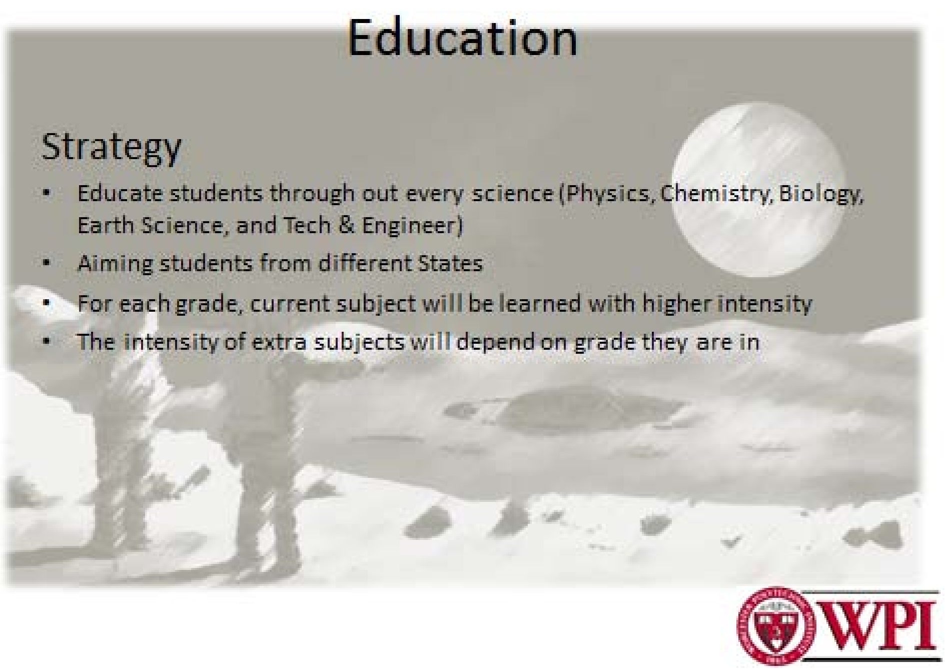
The Rest of the Building

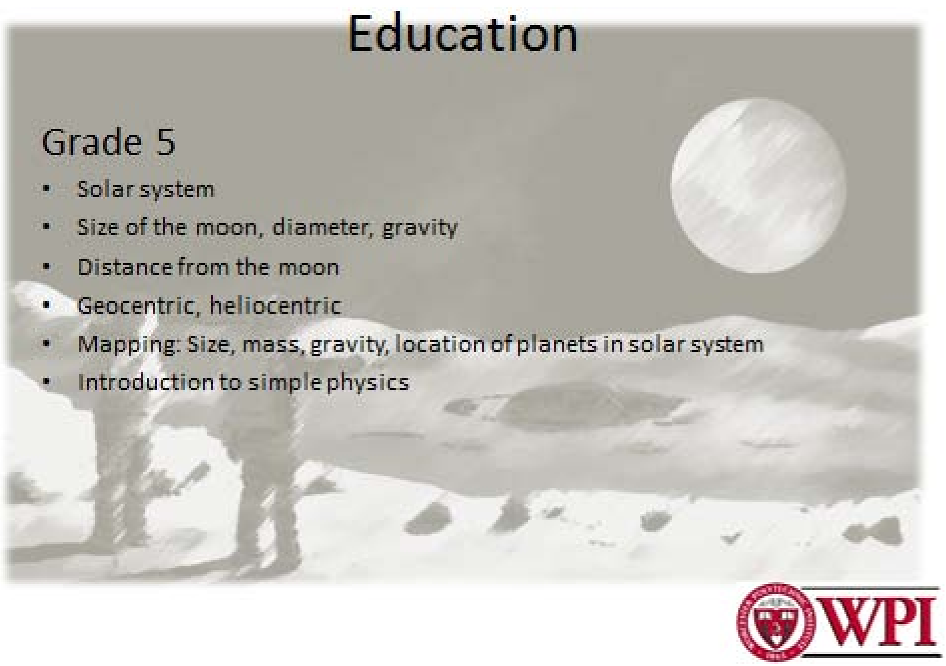
Ideally, the entire building could be salvaged. While a complete restoration would be costly, it could and should be done in conjunction with the proposed lunar base exhibit. To provide a feeling of continuity within the building, the auditorium could perhaps be restored with a science and technology theme. The space could be rented out for various gatherings and activities to bring in money to the city and state. The restored Little Theater could potentially become a small movie theater that could open during evenings and summer months.

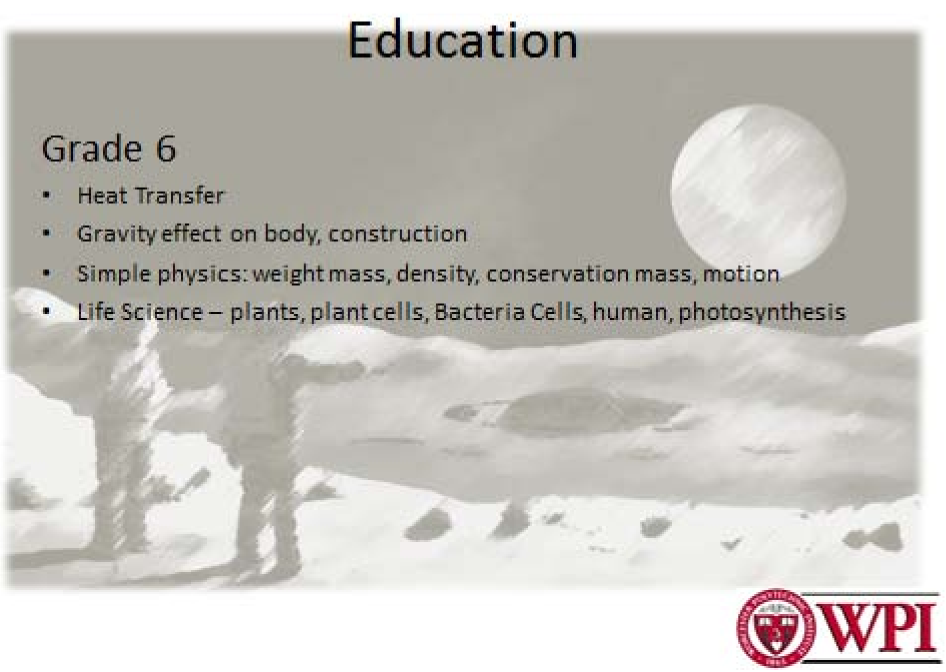
Appendix B: AIAA Presentation

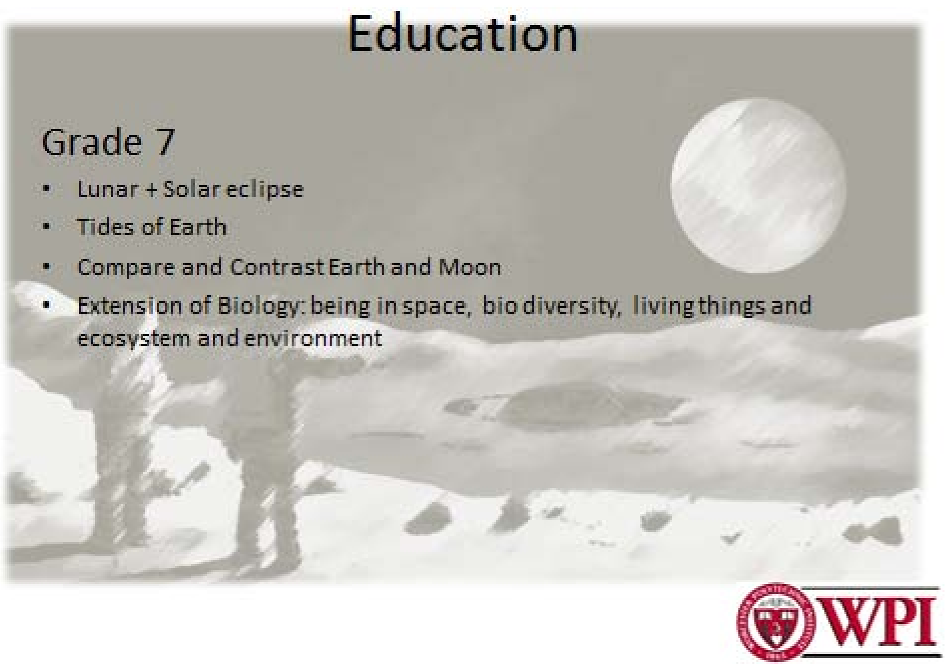


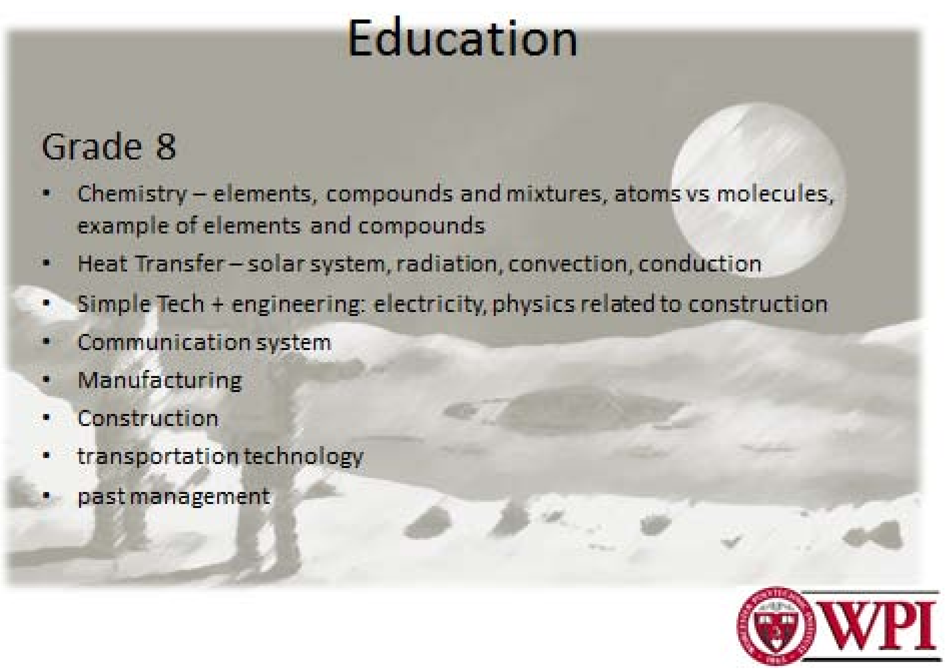

The Moon
How are we going to set up the lunar base?
• Craterville:
– Built into wall of crater at south pole
– Near sources of frozen water or hydrogen
• Lava tube:
– Natural cravens/conduits of underground lava rivers
– Natural protection
– Relatively constant temperature
WPI

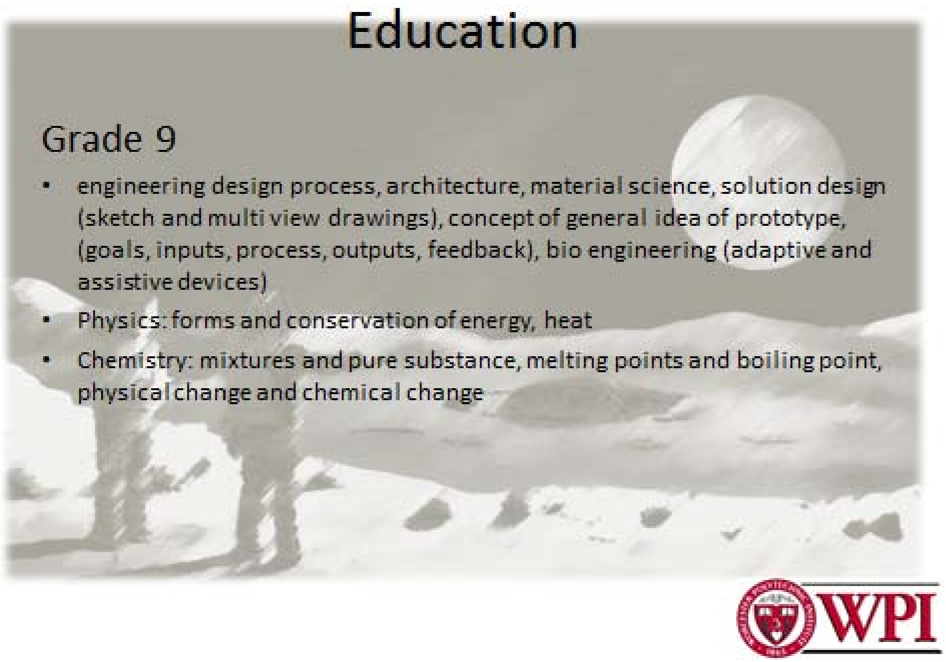

Education
Strategy
• Educate students through out every science (Physics, Chemistry, Biology, Earth Science, and Tech & Engineer)
• Aiming students from different States
• For each grade, current subject will be learned with higher intensity
• The intensity of extra subjects will depend on grade they are in
WPI


Education
Grade 5
• Solar system
• Size of the moon, diameter, gravity
• Distance from the moon
• Geocentric, heliocentric
• Mapping: Size, mass, gravity, location of planets in solar system
• Introduction to simple physics
WPI


Education
Grade 6
• Heat Transfer
• Gravity effect on body, construction
• Simple physics: weight mass, density, conservation mass, motion
• Life Science – plants, plant cells, Bacteria Cells, human, photosynthesis
WPI

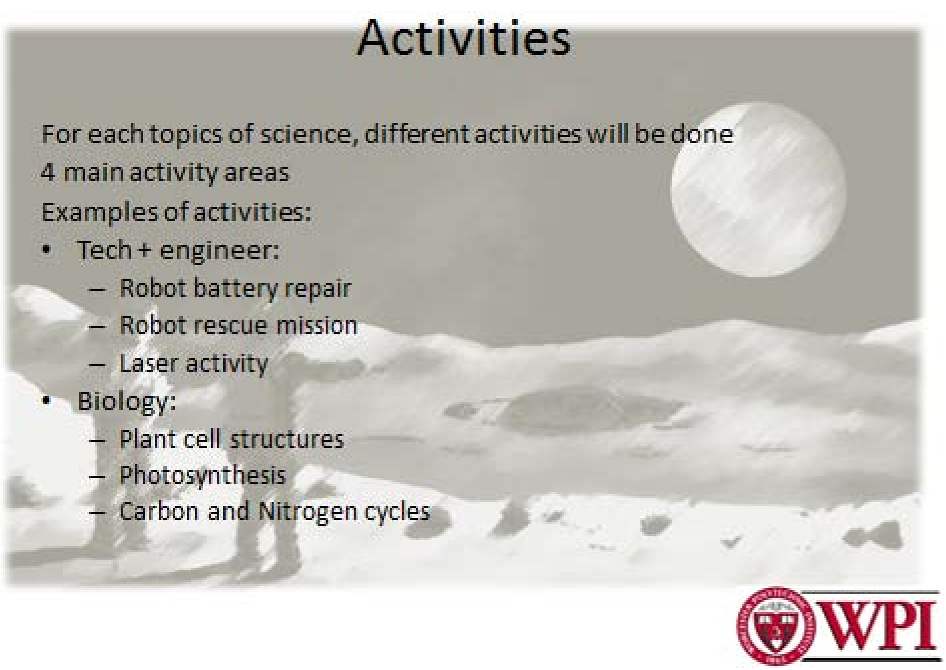

Education
Grade 7
• Lunar + Solar eclipse
• Tides of Earth
• Compare and Contrast Earth and Moon
• Extension of Biology: being in space, bio diversity, living things and ecosystem and environment
WPI

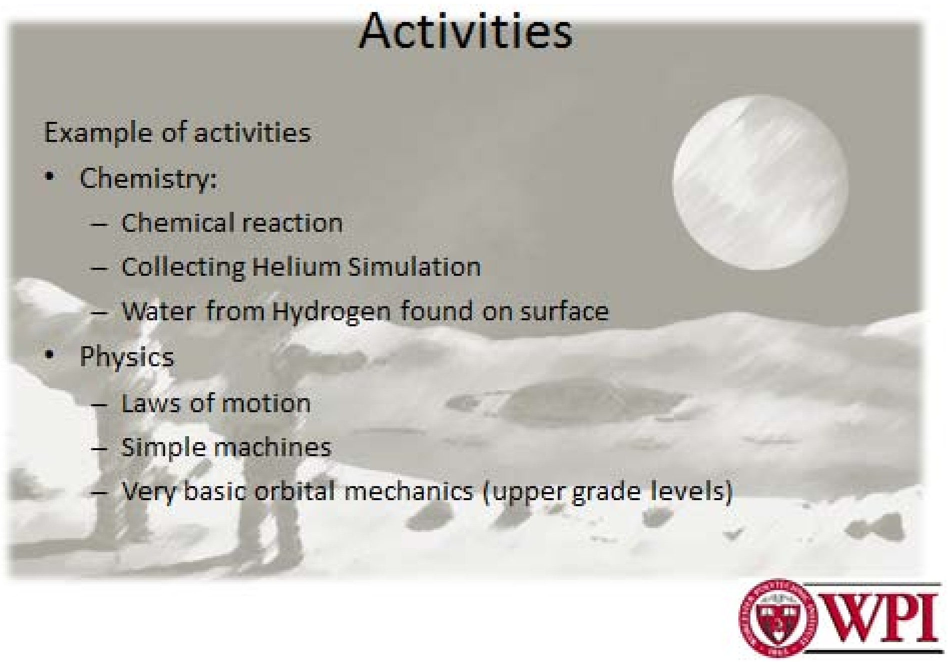

Education
Grade 8
• Chemistry – elements, compounds and mixtures, atoms vs molecules, example of elements and compounds
• Heat Transfer – solar system, radiation, convection, conduction
• Simple Tech + engineering: electricity, physics related to construction
• Communication system
• Manufacturing
• Construction
• transportation technology
• past management
WPI

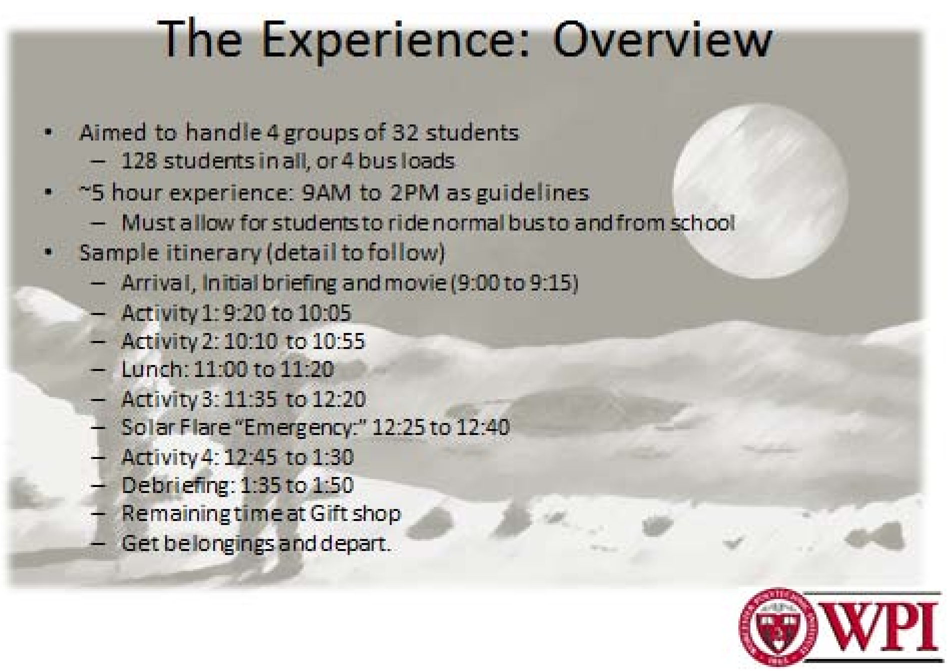

Education
Grade 9
• engineering design process, architecture, material science, solution design (sketch and multi view drawings), concept of general idea of prototype, (goals, inputs, process, outputs, feedback), bio engineering (adaptive and assistive devices)
• Physics: forms and conservation of energy, heat
• Chemistry: mixtures and pure substance, melting points and boiling point, physical change and chemical change
WPI


Proposal for lunar base exhibit
Purpose to educate students
• Real lunar base mission is expected to happen in 50 years from now.
• Younger generations will be performing the mission.
• Primary purpose is to educate students
– Massachusetts science and technology requirements
– Interesting and exciting setting for students
• Secondary purpose to excite students on the possibilities and future of space exploration
WPI


Proposal for lunar base exhibit
Activities that are built upon the requirements
• Entire facility and experience build around existing Massachusetts science and technology requirements
• Each section of the facility aims to assist with a specific section of the math and science requirements
– Experience can be tailored to grade level
– Can also be refined as technology advances and state requirements change
WPI


Activities
For each topics of science, different activities will be done
4 main activity areas
Examples of activities:
• Tech + engineer:
– Robot battery repair
– Robot rescue mission
– Laser activity
• Biology:
– Plant cell structures
– Photosynthesis
– Carbon and Nitrogen cycles
WPI


Activities
Example of activities
• Chemistry:
– Chemical reaction
– Collecting Helium Simulation
– Water from Hydrogen found on surface
• Physics
– Laws of motion
– Simple machines
– Very basic orbital mechanics (upper grade levels)
WPI

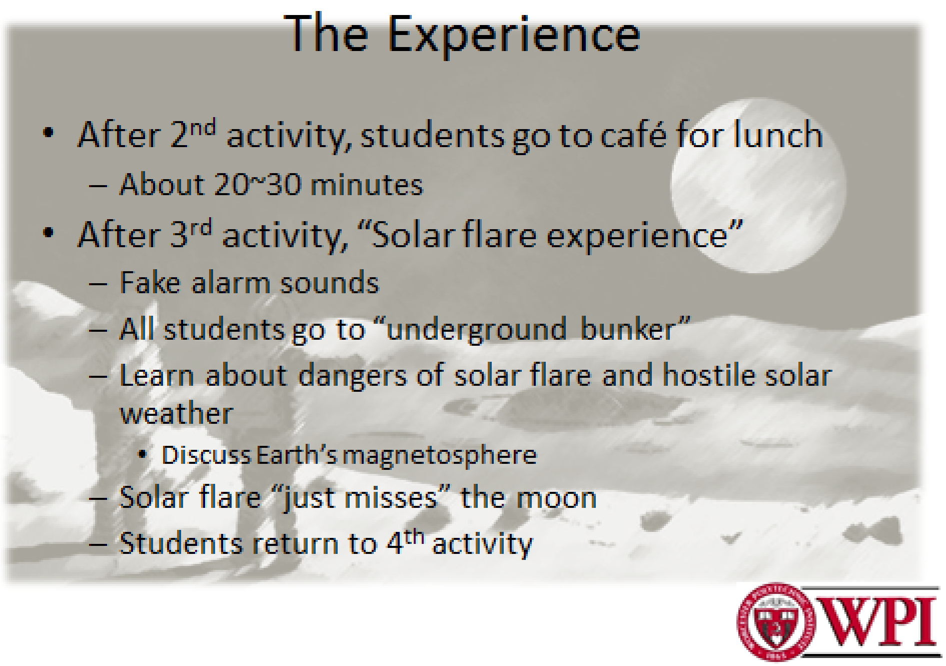

The Experience: Overview
• Aimed to handle 4 groups of 32 students
– 128 students in all, or 4 bus loads
• ~5 hour experience: 9AM to 2PM as guidelines
– Must allow for students to ride normal bus to and from school
• Sample itinerary (detail to follow)
– Arrival, Initial briefing and movie (9:00 to 9:15)
– Activity 1: 9:20 to 10:05
– Activity 2: 10:10 to 10:55
– Lunch: 11:00 to 11:20
– Activity 3: 11:35 to 12:20
– Solar Flare "Emergency:" 12:25 to 12:40
– Activity 4: 12:45 to 1:30
– Debriefing: 1:35 to 1:50
– Remaining time at Gift shop
– Get belongings and depart.
WPI

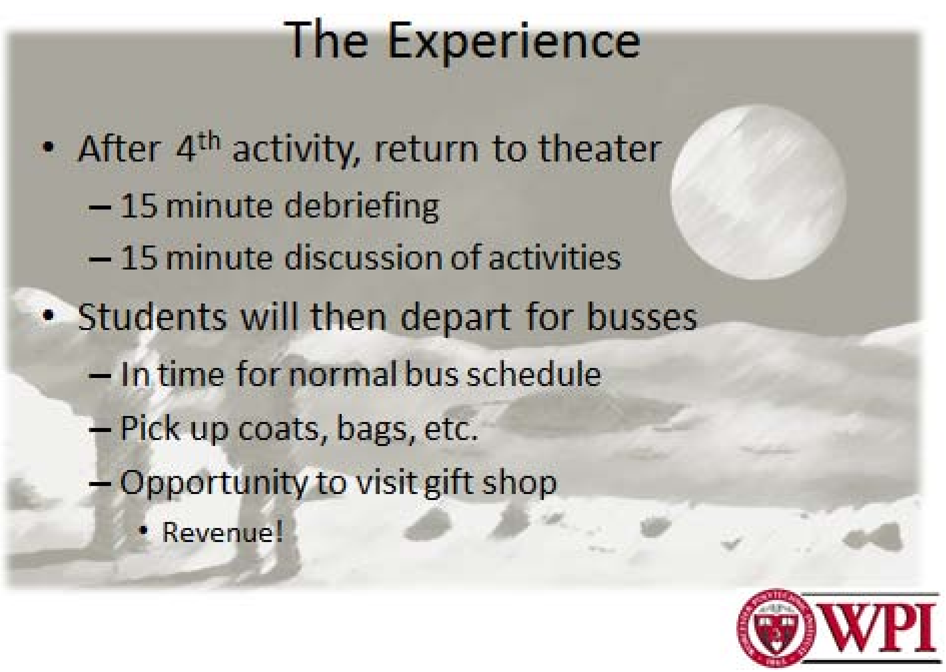
The Experience

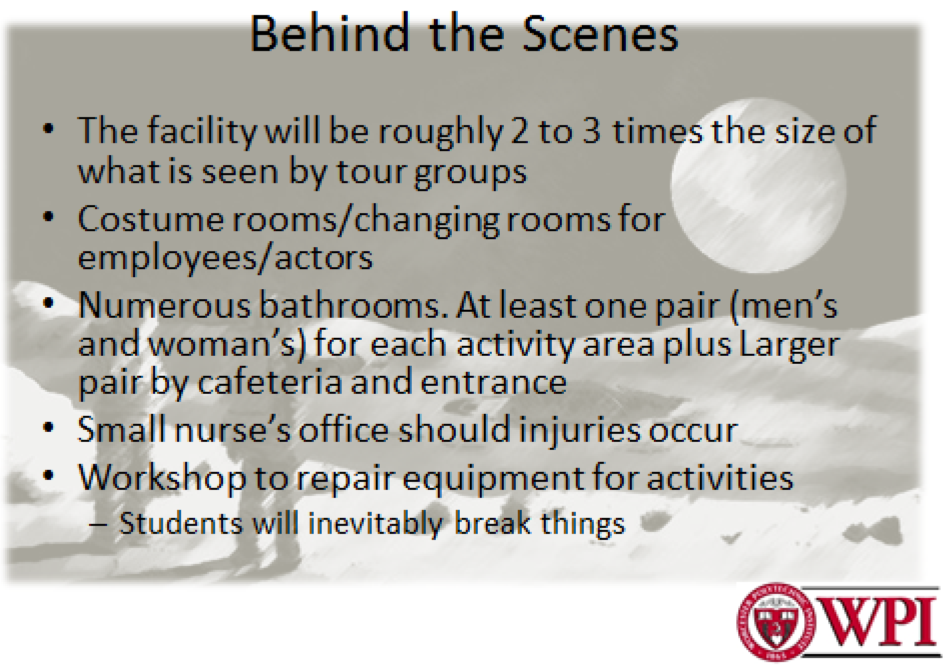
- Upon entering, students will drop coats and lunches in bins
  - Lunches must be labeled and brought to cafeteria
- All students will enter theater for initial briefing
  - This will last approximately 15 minutes
  - Overview of what to expect
  - History of moon, and purpose for going there
- Entire facility will be decorated and designed to look like a moon base
  - Futuristic
  - All employees/actors in costume
    - Orange jump suits, fake headsets, etc.

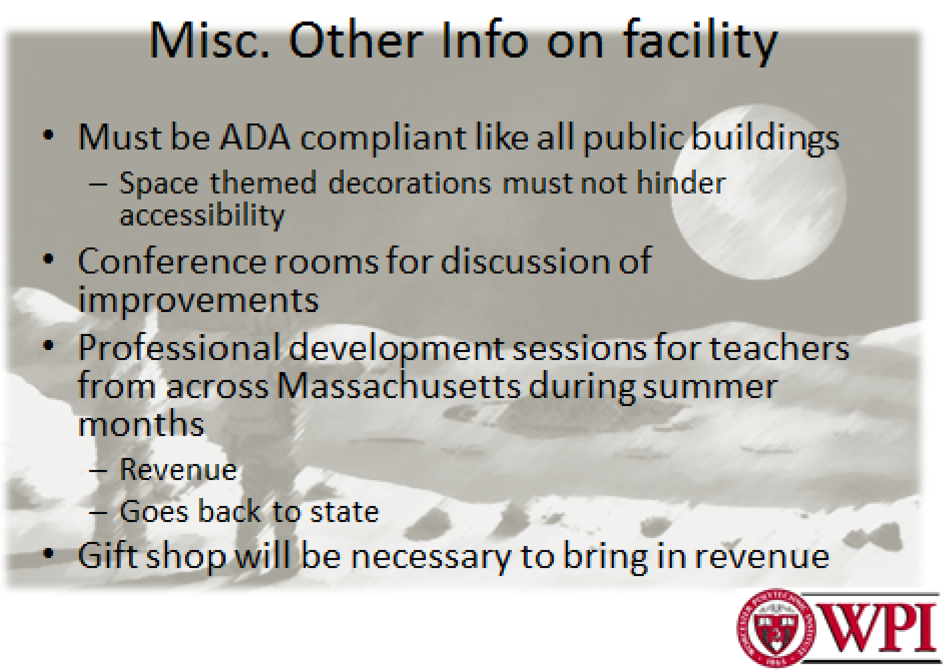
The Experience

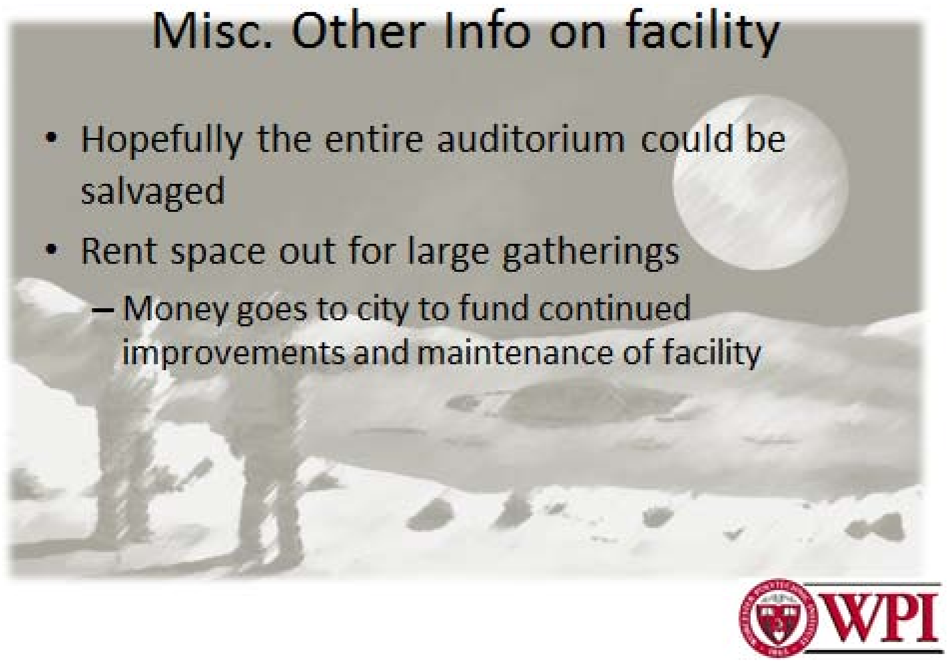
- Split into 4 groups (32 students each)
  - Each goes to different section
  - Expect each section to last 45 minutes
    - This is about the limit of the students' attention spans
  - Rotate after the 45 minutes is up
    - Move on to next section
    - 5 minutes given for transition


The Experience
After 2nd activity, students go to café for lunch
About 20~30 minutes
After 3rd activity, "Solar flare experience"
Fake alarm sounds
All students go to "underground bunker"
Learn about dangers of solar flare and hostile solar weather
Discuss Earth's magnetosphere
Solar flare "just misses" the moon
Students return to 4th activity
WPI

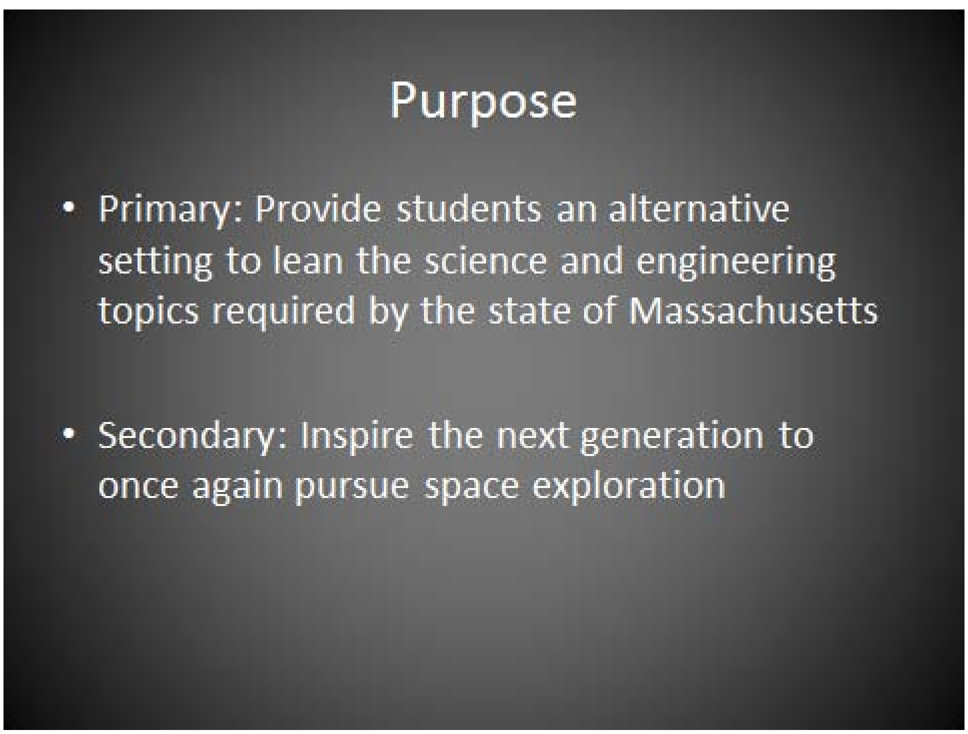

The Experience
After 4th activity, return to theater
15 minute debriefing
15 minute discussion of activities
Students will then depart for busses
In time for normal bus schedule
Pick up coats, bags, etc.
Opportunity to visit gift shop
Revenue!
WPI

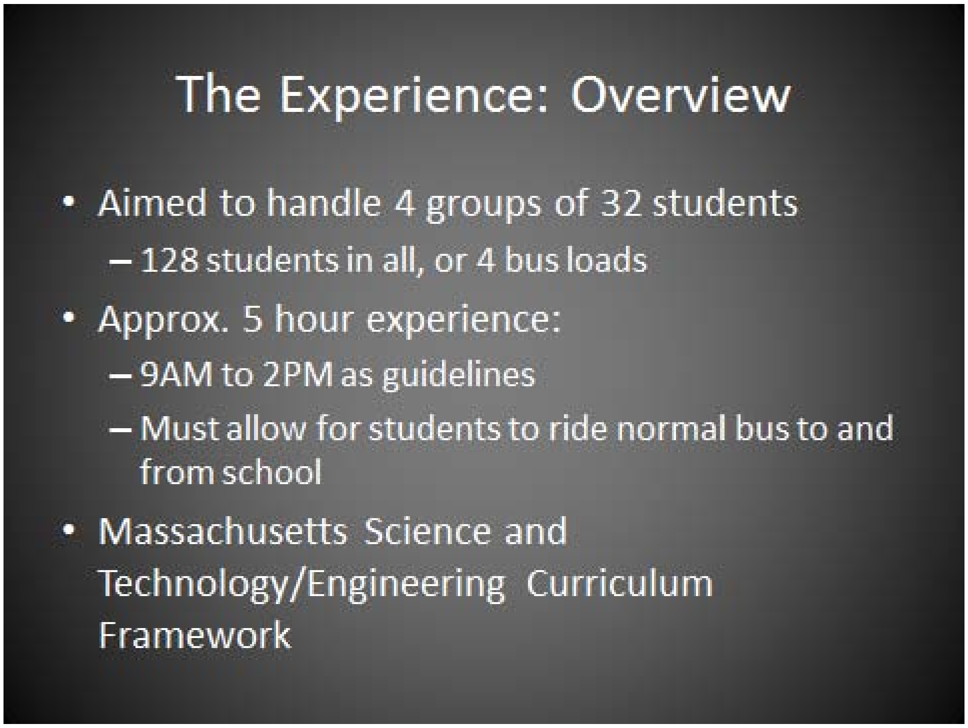

Behind the Scenes
The facility will be roughly 2 to 3 times the size of what is seen by tour groups
Costume rooms/changing rooms for employees/actors
Numerous bathrooms. At least one pair (men's and woman's) for each activity area plus Larger pair by cafeteria and entrance
Small nurse's office should injuries occur
Workshop to repair equipment for activities
Students will inevitably break things
WPI

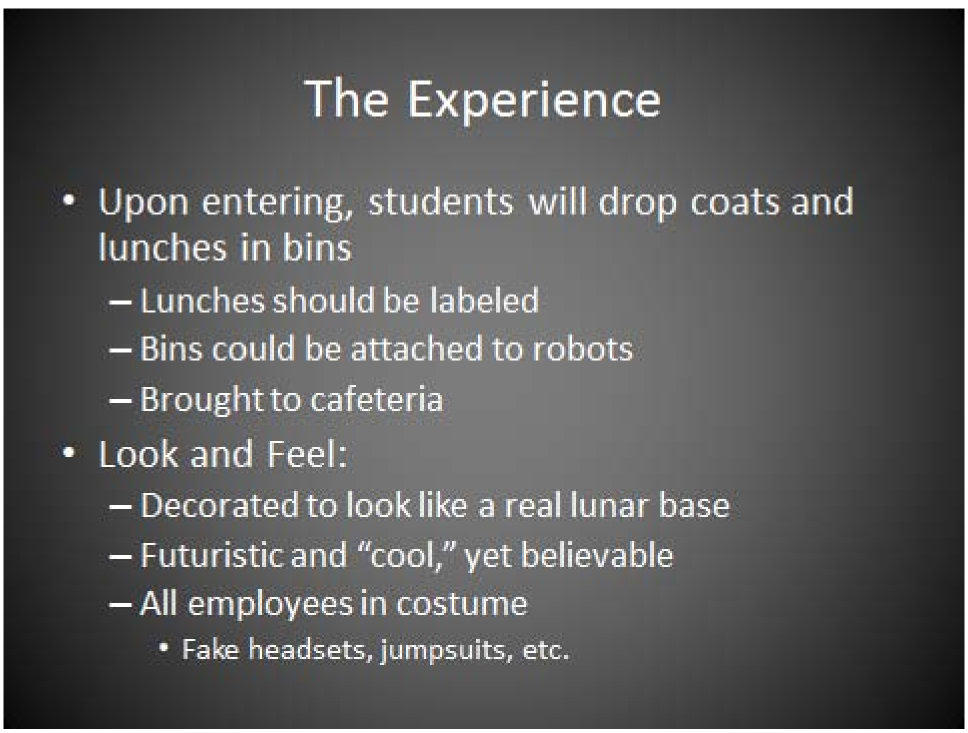

Misc. Other Info on facility
Must be ADA compliant like all public buildings
Space themed decorations must not hinder accessibility
Conference rooms for discussion of improvements
Professional development sessions for teachers from across Massachusetts during summer months
Revenue
Goes back to state
Gift shop will be necessary to bring in revenue
WPI

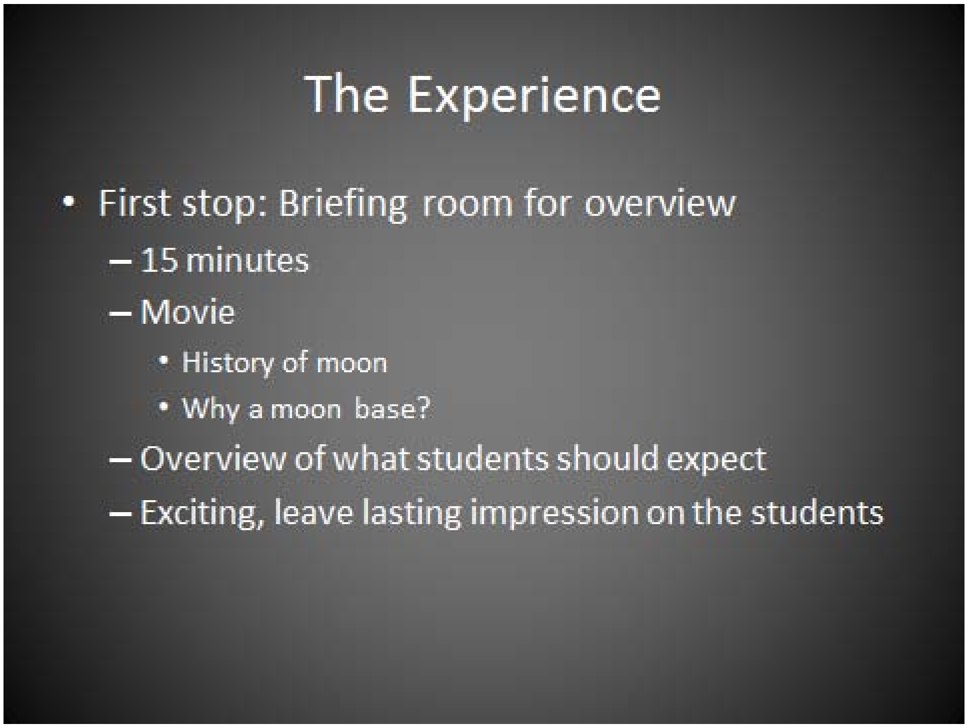

Misc. Other Info on facility
• Hopefully the entire auditorium could be salvaged
• Rent space out for large gatherings
– Money goes to city to fund continued improvements and maintenance of facility
WPI

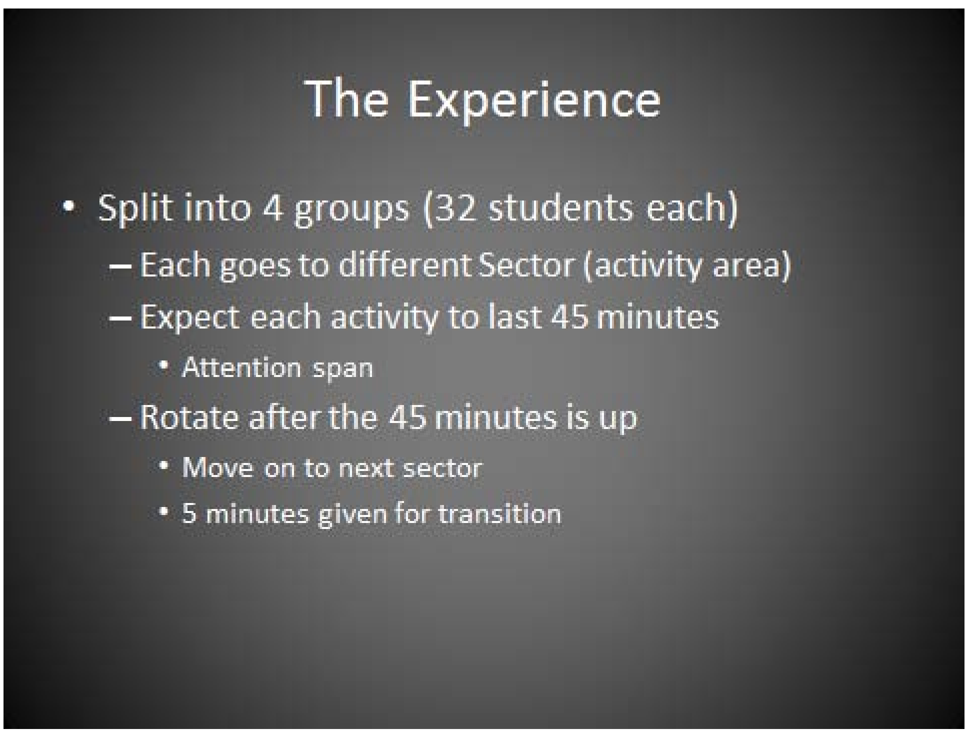
Appendix C: February 18th 2013 Presentation




The Experience: Overview
• Aimed to handle 4 groups of 32 students
– 128 students in all, or 4 bus loads
• Approx. 5 hour experience:
– 9AM to 2PM as guidelines
– Must allow for students to ride normal bus to and from school
• Massachusetts Science and Technology/Engineering Curriculum Framework


The Experience
• Upon entering, students will drop coats and lunches in bins
– Lunches should be labeled
– Bins could be attached to robots
– Brought to cafeteria
• Look and Feel:
– Decorated to look like a real lunar base
– Futuristic and "cool," yet believable
– All employees in costume
• Fake headsets, jumpsuits, etc.


The Experience
• First stop: Briefing room for overview
– 15 minutes
– Movie
• History of moon
• Why a moon base?
– Overview of what students should expect
– Exciting, leave lasting impression on the students


The Experience
• Split into 4 groups (32 students each)
– Each goes to different Sector (activity area)
– Expect each activity to last 45 minutes
• Attention span
– Rotate after the 45 minutes is up
• Move on to next sector
• 5 minutes given for transition

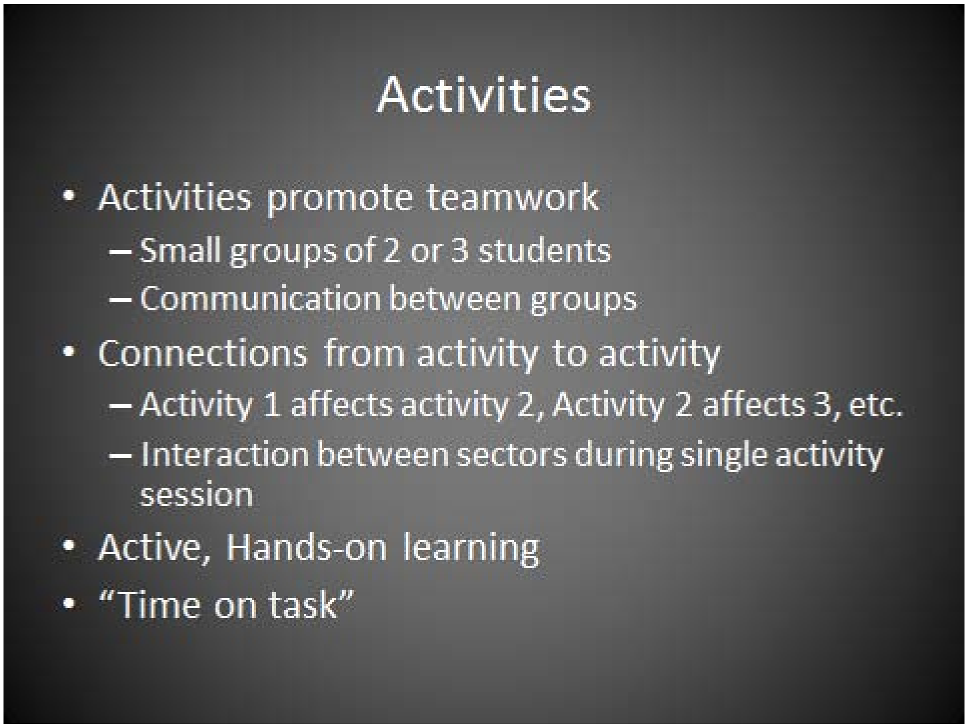
Activity Areas (Sectors)

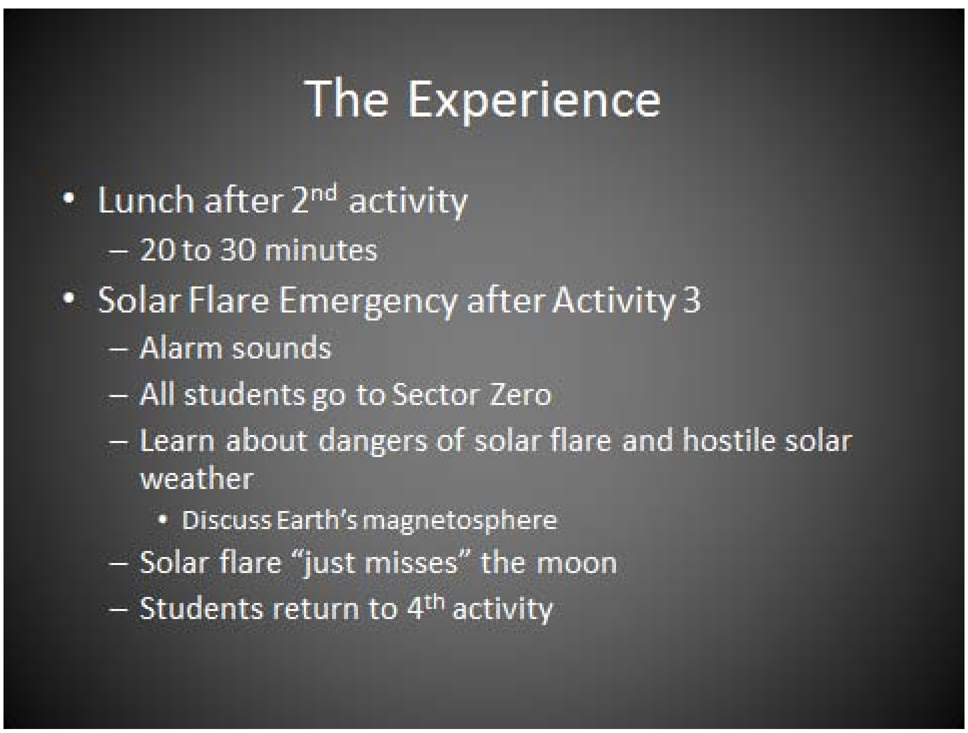
- 6 Sectors; Pick 4
  - Sector 1: Biology and Life Sciences
  - Sector 2: Chemistry and Chemical Engineering
  - Sector 3: Physical Sciences (Physics)
  - Sector 4: Earth and Space Sciences
  - Sector 5: Manufacturing and Repair
  - Sector 6: Electricity, Power and Utilities

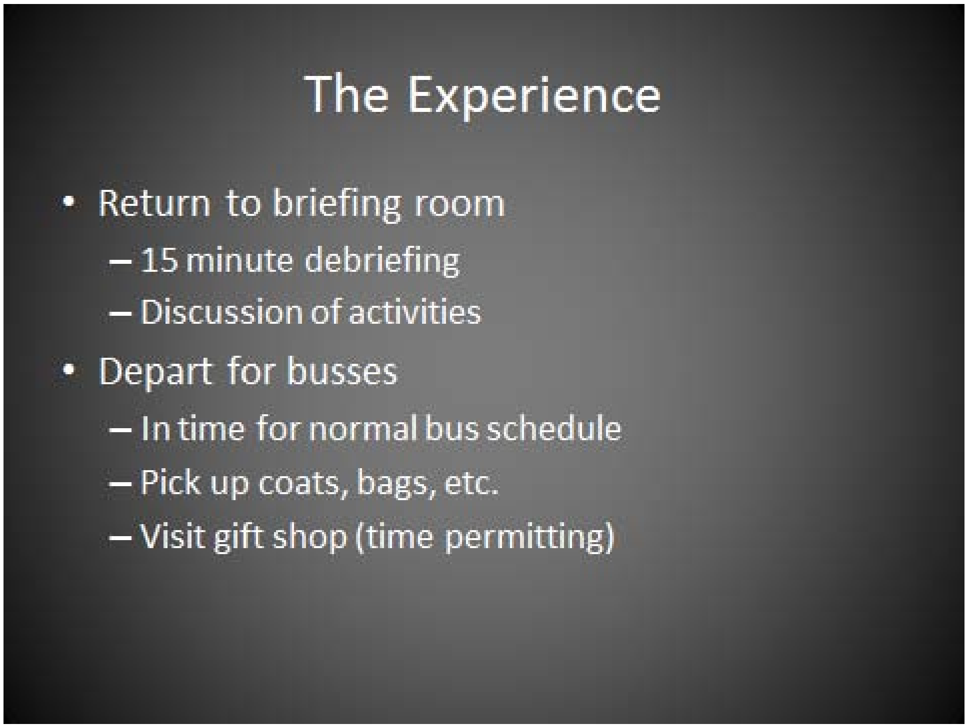
  - Sector Zero: Solar Flare Bunker

Activities

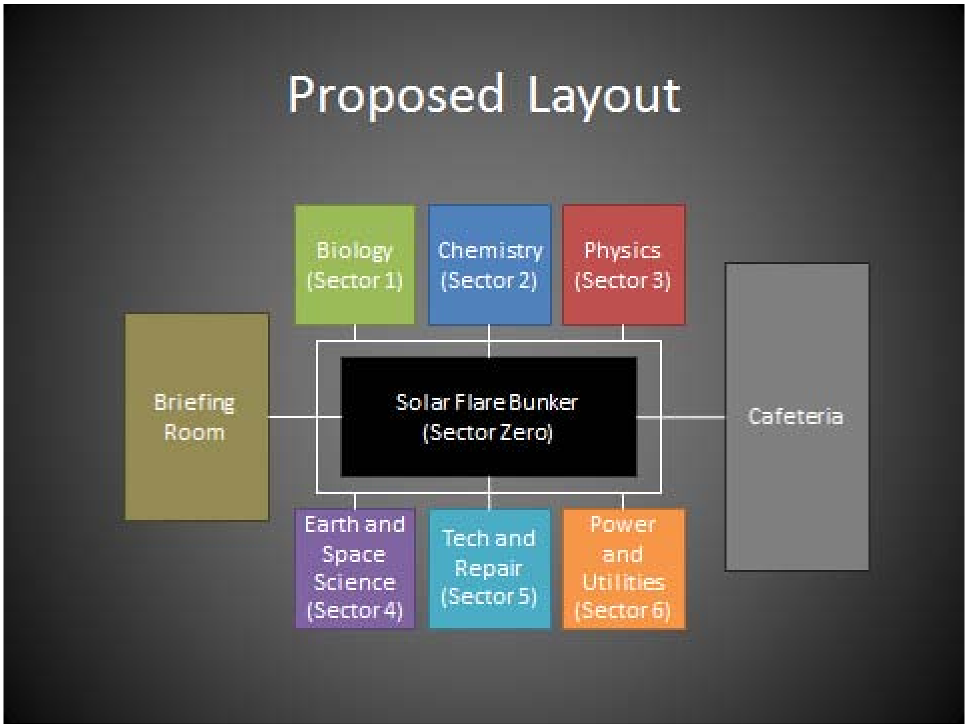
- Technology
  - Electricity and circuits
  - Energy transfer
- Physics
  - Simple machines
  - Laws of motion
- Earth and space science
  - Earth's magnetosphere
  - Gravity, orbits, and the solar system
- Chemistry
  - Simple chemical reactions
  - Hydrogen-3
  - Water from hydrogen
- Biology
  - Cell and plant structures
  - Photosynthesis
  - Carbon and nitrogen cycles

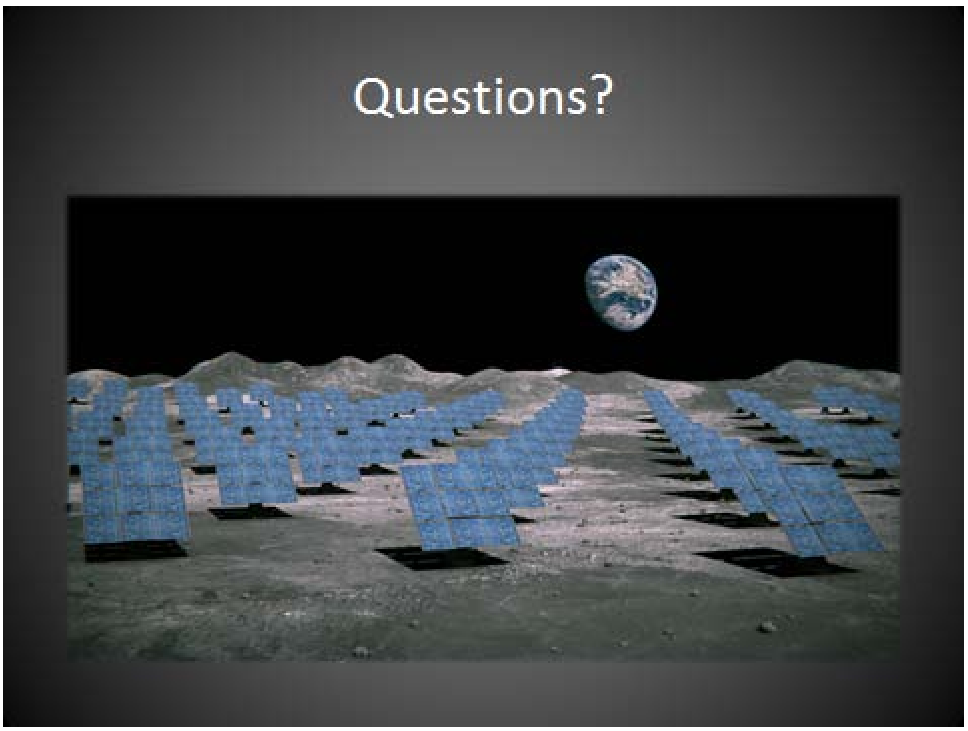

Activities
• Activities promote teamwork
– Small groups of 2 or 3 students
– Communication between groups
• Connections from activity to activity
– Activity 1 affects activity 2, Activity 2 affects 3, etc.
– Interaction between sectors during single activity session
• Active, Hands-on learning
• “Time on task”


The Experience
• Lunch after 2nd activity
– 20 to 30 minutes
• Solar Flare Emergency after Activity 3
– Alarm sounds
– All students go to Sector Zero
– Learn about dangers of solar flare and hostile solar weather
• Discuss Earth’s magnetosphere
– Solar flare “just misses” the moon
– Students return to 4th activity


The Experience
• Return to briefing room
– 15 minute debriefing
– Discussion of activities
• Depart for busses
– In time for normal bus schedule
– Pick up coats, bags, etc.
– Visit gift shop (time permitting)


The Experience: Summary
• Sample itinerary
– Arrival, Initial briefing and movie: 9:00 to 9:15
– Activity 1: 9:20 to 10:00
– Activity 2: 10:10 to 10:50
– Lunch: 11:00 to 11:30
– Activity 3: 11:34 to 12:20
– Solar Flare Emergency: 12:30 to 12:45
– Activity 4: 12:50 to 1:30
– Debriefing: 1:40 to 1:50
– Remaining time at Gift shop
– Get belongings and depart.
Briefing
Activity 1 & 2
Lunch
Activity 3
Solar Flare
Activity 4
Debriefing


Proposed Layout
Biology (Sector 1)
Chemistry (Sector 2)
Physics (Sector 3)
Briefing Room
Solar Flare Bunker (Sector Zero)
Cafeteria
Earth and Space Science (Sector 4)
Tech and Repair (Sector 5)
Power and Utilities (Sector 6)


Questions?

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