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Develop Engineering Lessons For 6th Grade at WPS

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Abstract

The goal of the NSF sponsored three-year PIEE project is to raise student interest in engineering and standardized test scores by assisting with the implementation of engineering concepts into the Worcester Public Schools curriculum. This IQP represents the second year of the program, focusing on supporting the sixth-grade teachers in the classroom. Teacher feedback confirms that student interest in science and engineering indeed increased. Additional analysis is required to determine if an increase in MCAS test scores has occurred.

Authorship

This project is authored by all team members with equal portions unless otherwise noted in the body of the report.

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Chapter 1 Introduction

As a result of scientific and technological growth in the past twenty years, the science and technology educational programs of American school systems are being constantly updated. The government, educators, and parents see a need to introduce ideas and concepts of science and technology to people at an early age so they are better prepared for their professional careers. New educational regulations and standards were developed, such as the Education Reform Act of 1993[1] in Massachusetts and the Federal No Child Left Behind Act of 2001.[2] With these rigorous governmental regulations, new and improved curricula are needed. In a parallel effort in Worcester Public Schools' Doherty Quadrant, the Doherty engineering pipeline was set up as a system of teaching engineering ideas to public school students in order to increase their understanding of and interest in engineering. Specialized examinations, such as the MCAS tests in Massachusetts,[3] and the new Palmetto Achievement Challenge Test in South Carolina,[4] were implemented to gauge the progress of schools and students alike across the country.

Spearheading the effort to improve science teaching, in 1999 the National Science Foundation (NSF) began funding projects in which college undergraduate and graduate students serve as knowledgeable sources to assist teachers from kindergarten to 12th grade to raise the quality and quantity of scientific and technological teaching; this experiment is known as the NSF Graduate Teaching Fellows in K-12 Education (GK-12) Program.[5] According to various project websites, many of these GK-12 projects have improved the quality of science and mathematics studies in their target schools. In projects that have specialized goals for learning based on the schools' geographic areas, students were able to experience how science and technology is closely related to their everyday life. For example, schools near the coast often have marine biology focused project goals.

In partnership with the Worcester Public Schools (WPS), and funded by the NSF, Worcester Polytechnic Institute (WPI) initiated the Partnerships Implementing Engineering Education (PIEE) project in 2003. Based on the engineering component of the Massachusetts Science and Technology/Engineering Curriculum Frameworks, WPI graduate and undergraduate students along with several elementary school teachers worked to improve the quality of engineering teachings in the schools and also to develop students' interests in the subject matter. In the first year of the project, three grade levels (in 4th, 5th, and 6th grade) in two elementary schools were involved. A lot of work went into the development of an effective working relationship between the WPI project teams and the WPS teachers. Many engineering-themed teaching materials were researched and some were implemented with the cooperation between the teachers and the project teams.

In this academic year (2004-2005) we expanded the project to include one more elementary school, two more grade levels (2nd, 3rd) and ten new classrooms/teachers. A number of Interactive Qualifying Project (IQP) students have also returned as fellows, bringing their experience to help coordinate the work between the new IQP students and teachers. The approach has not changed from last year; teams made up of fellows and IQP students are constantly developing new lesson plans and participating in out-of-school programs (mathematics tutoring at Elm Park Community School, and the NASA's Student Involvement Program (NSIP) after school program at Midland Street School). A summer workshop for teachers and fellows was set up to familiarize the new teachers with engineering concepts that were introduced into the curriculum, and throughout the school year meetings were held in order to have all the grade level teams report their progress and share their experience.

The authors of this proposal focused their work in three 6th grade classes at Elm Park Community School and Midland Street School. We worked with roughly eighty sixth grade students of different academic levels, from different parts of the city of Worcester, and different ethnic backgrounds. In addition to the four IQP students, we had three fellows and a project advisor. Our goal was to expose students in 6th grade to engineering and science concepts that appeal to them and improve their chances to pursue their interests academically and professionally. Also, we hoped to potentially improve their performance in the MCAS tests (mathematics in 6th grade) by offering them tutoring sessions, although this was a secondary goal. Most importantly, we tried to raise their aspirations for pursuing a higher education despite their personal backgrounds.

Chapter 2 Background for Literature Review

2.1 Government Education Reforms / MCAS

Massachusetts curriculum standards dictate the major concepts that should be studied by students in mathematics, English and literature, natural sciences, engineering, social sciences, and so forth, for each grade level. The responsibility of the government is to mandate programs via legislation such as the Massachusetts Education Reform Act (1993) and the federal No Child Left Behind Act (2001), and to make sure the standards are met by schools.

As part of the Massachusetts Education Reform Act, statewide frameworks were drawn up for all school subjects. Grades were divided into grade ranges in groups of threes: K-2; 3-5; 6-8; and 9-12. Each grade range has requirements mandating what students should know in all subject areas by the completion of that grade range. Before this Act, such frameworks were only in place for history and physical education. As a result of the legislation in Massachusetts, guidelines were subsequently drawn up for language arts, mathematics, science and technology, and the arts. These frameworks were nonspecific in that they did not mandate specific objectives for every grade, only for grade ranges. This made it possible to guide statewide curriculum planning throughout the state while allowing local districts to tailor their programs to best suit their students.

Under the Education Reform Act, Massachusetts schools have to submit plans for teaching students that ensure they spend a requisite number of class hours studying core academic subjects. Teachers also must, beginning in February 1998, pass the Massachusetts Tests for Education Licensure in knowledge of subjects taught and in communication.[6] To help facilitate these changes, the state education budget was steadily increased; by the year 2000 the funds allocated to education would be at a level dictated in the original legislation in 1993.[1]

The Massachusetts Education Reform Act was a landmark piece of legislation, virtually changing the way primary education was presented in the state. The changes mandated have since been put into place and have contributed to increasing standardized test scores. Once the changes were in place, the legislative focus shifted to further refining the goals of the Reform Act and making sure the lofty goals set down at that time are being met. A great deal of evaluation of the success of these measures was conducted by the Massachusetts Education Reform Commission[8]. This body was established in 1993 to monitor the Reform Act and remained busy until 2003, when the legislature discontinued funding for the Commission, effectively disbanding it. At this time most of the changes mandated by the 1993 Reform Act had already been evaluated and implemented fully, leaving no real task left for the Commission. While still active, the Commission produced many reports on how the Reform Act and various aspects of it, such as MCAS testing, have succeeded or failed over the years.

The Massachusetts Education Reform Act of 1993 created statewide frameworks; these, however, were broad objectives for age groups which simply specified what competencies students should have at what ages. In 2001 the Worcester Public School district created Worcester Student Benchmarks[9], which created more specific guidelines for curriculum planning than did the Frameworks. Every grade level has a specific set of concepts that students should be taught for all disciplines. Using the benchmarks, any teacher in the Worcester school system can know exactly what they should accomplish for their students over the year. In addition to being a helpful set of guidelines, they also serve as means of standardizing education, making sure that all students are given the same quality of education regardless of which school in Worcester they attend.

The state mandated curriculum standards serve as the basis against which educators test the success of a specific school system as well as an individual student. A comprehensive knowledge test called the MCAS exam has been instituted to help gauge the progress of those schools funded by the Commonwealth and their adherence to the standards. The MCAS test (Massachusetts Comprehensive Assessment System) is a multifunctional tool which can *"provide feedback that can be used to improve the quality of school-wide, classroom, and individualized student instructional programs* [and serve] *as an accountability tool for measuring the performance of individual students, schools and districts"*[2]. The MCAS is administered at the end of grades 4, 8, and 10. The tenth grade exam is significant in also serving as a capstone graduation exam; all students must pass this test to receive a diploma.[2]

At a federal level, in January of 2001 the No Child Left Behind (NCLB) Act was introduced to school systems nationwide. Its purpose is to insure that the standards are being properly implemented in schools. The NCLB act provides motivation through a system of rewards and deterrents that holds schools and districts accountable for their efforts, allows freedom for schools to transfer funding where they deem suitable, and permits students from failing schools to attend a different school within the same district.

The NCLB Act's goal is to ensure that all students reach proficiency in statewide exams, like the MCAS in Massachusetts, by the year 2014. Though a regional exam does not currently exist, states test within their populous individually. Presently, the act has generated steady rise in test scores all across America and can be deemed a success.[4]

Leaps have been made in the percent of students in Massachusetts who are at the minimum proficiency. Massachusetts sixth graders tested in mathematics have shown a steady improvement, with 26 percent proficient (refer to table below for a description of MCAS performance levels) in 2001 to 43 percent in 2004.[2]

Table 1: Description of MCAS Performance Levels

PERFORMANCE LEVEL	**Description**
Advanced	Student work at this level demonstrates a comprehensive and in-depth understanding of rigorous subject matter and provides sophisticated solutions to complex problems.
Proficient	Student work at this level demonstrates a solid understanding of challenging subject matter and solves a wide variety of problems.
Needs Improvement	Student work at this level demonstrates a partial understanding of subject matter and solves some simple problems.
Warning (Failing)	Student work at this level demonstrates a minimal understanding of subject matter and does not solve simple problems.

From the U.S. Department of Education Webpage [2]

2.2 Worcester Public Schools Science and Technology/Engineering Benchmarks

The most recent version of the benchmarks for the Worcester Public Schools was updated in 2002, following the guidelines from the most recent edition of the Massachusetts Science and Technology/Engineering Curriculum Framework published in May, 2001. In this new edition of the Massachusetts Framework, engineering is formally adapted into the Framework in the Technology/Engineering strand. The changes in the Massachusetts Framework are also reflected in the Worcester Science Benchmarks in the last of the five strands, carrying the same name as the Massachusetts Framework, Technology/Engineering.

Strand 1 is SKILLS OF INQUIRY, which carries the emphasis on the scientific method: hypothesis, experiment, data collection, and conclusion. This strand also exposes the students to different ways one can communicate their findings and conclusions.

Strand 2 is EARTH/SPACE SCIENCE, but more focused with geology rather than astronomy: The standards listed are about how the earth works and evolves.

Strand 3 is LIFE SCIENCE, a strand devoted to biology. Students are required to understand the differences between unicellular and multicellular organisms, the human body system, and classification of animals and plants.

Strand 4 is PHYSICAL SCIENCE, a cross between chemistry and physics. This strand exposes the students to concepts such as mass, volume, density, atomic models, and basic ways to measure and describe correctly the objects they are to encounter, such as sugar.

Strand 5 is TECHNOLOGY/ENGINEERING, and is mainly used to promote the use of the design process of engineering. Students are to learn about the correct way of using tools and to present their results and findings in multiple ways. The metric system is also to be introduced to the students.

2.3 Curriculum Standards of Other Cities/Towns

The communities discussed in this section are chosen because they are the hometowns of the authors of this proposal. The curriculum standards for three cities from three different states are described, so the reader can be shown how statewide standards vary. Interestingly, engineering is formally adapted into the state framework only in Massachusetts.

2.3.1 Quincy Public Schools Sixth Grade Science and Technology

In the Quincy Public Schools system, there are five middle schools with 6^{th} grade classes. The 6^{th} grade curriculum is based on the Massachusetts Science and Technology/Engineering curriculum Framework. The Quincy Science and Technology curriculum is currently divided into four strands

Strand 1 is INQUIRY which teaches the students basic skills for scientific experiments and the scientific method. The material stresses communication of ideas and identification of problems.

Strand 2 is called the DOMAINS OF SCIENCE that introduces the students to different disciplines of science. One of the focuses of this strand is Life Science, which is a combination of biology and ecology. The second topic is Earth Science, which is geology and elementary astronomy. Lastly, Physical Science is the combination of chemistry and physics that includes the fewest standards.

Strand 3 focuses on TECHNOLOGY; the objectives are to introduce the engineering concept, the design process, the history of technology and disciplines of engineering. It is a relatively new strand that was implemented to better prepare students for the science and technology/engineering section of the MCAS exam in the 8^{th} grade.

Strand 4 is called SCIENCE, TECHNOLOGY, AND HUMAN AFFAIRS, it is a mix of social science and science and technology. Students are required to look past the science and the technology into how they affect society and people in general.

Most of the guidelines between the Quincy and Worcester standards are quite similar, however, if we compare them, we can see that the Quincy 6^{th} grade curriculum does not have a focus on engineering and also the technology strand at Worcester is much more rigorous and much more detailed. For example, in the Quincy Technology strands, there are only three standards and the one that bears the most relation to engineering is to "list problems that a new design could resolve." A similar standard in the Worcester Science Benchmarks (06.Se.Te.07) is to "to identify and explain the steps of the Engineering Design Process, e.g., identify the need or problem, research the problem, develop possible solutions, select the best possible solutions(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign". This difference seems to put the Quincy students in a disadvantage during their 8^{th} grade science and technology/engineering MCAS test. However, the statistical report from the 2004 MCAS testing shows that there are more Quincy students reaching advanced and proficient levels than Worcester students. This may imply a more rigorous engineering curriculum in Quincy in 7th and 8th grade or special circumstances in Worcester that is yet to be investigated.

2.3.2 Orange, CT Public School Sixth Grade Expectations

Elementary school students in Connecticut are required to take the Connecticut Mastery Test (CMT) in grades four and six. Sixth graders are expected to show proficiency in mathematics, writing and reading. However, unlike Massachusetts schools, science, and more specifically engineering, is not part of their overall goals for the students. While there is a heavy emphasis on mathematics, scientific skills seem to come as an afterthought, as students do not have standardized testing in any field of science until the tenth grade Connecticut Aptitude Test (CAPT). So, although there is no apparent improvement thus far to the curriculum to enhance engineering education, the school board does recognize the importance of technology education, providing each classroom with at least four computers and also a separate computer lab in each school.

Orange students are not without hope though for an engineering education, however, because the schools have had a strong after school program in place for a number of years. The program, Future Scientists and Engineers of America (FSEA), involves students from elementary through junior high school, including myself when I was in grades four through six, in similar activities presented by the PIEE project. The hands-on activities were fun, open-ended, and informative, such as building strong towers out of only straws and scotch tape, making the most buoyant boat out of only aluminum foil, and creating a vessel that would protect a raw egg from breaking when dropped from atop a ladder.

2.3.3 South Carolina Academic Standards

In South Carolina, schools strictly adhere to a set of academic standards set by the state. These standards have all been revised since 1999, and include the following subject areas: English language arts, foreign language, mathematics, physical education, science, social studies, health and safety education, and visual and performing arts. There are no further standards imposed by individual school districts in the way the Worcester Public Schools have the Worcester Benchmarks.

Student performance is evaluated via the Palmetto Achievement Challenge Test (PACT). This is a demanding set of tests covering English and language arts, mathematics, science, and social studies. These tests were first used in 1999. Prior to 1999, evaluation was done via the Basic Skills Assessment Program (BSAP). Students also are required to take the Exit Examination, which has subtests in English, writing, and mathematics. Students can first take the exam in tenth grade and may take the test up to four times in one year or as many times as needed until they pass. Students must pass the exam in order to receive a diploma.

2.4 Worcester Public School System Overview

Worcester, Massachusetts is New England's third largest city, with a population of 172,648 people.[10] The city has grown to be an education and research center of New England, so much so that education could be called the primary industry of Worcester. The Colleges of Worcester Consortium, an organization of institutions of higher learning in the city, has thirteen member colleges and universities. Most of them carry on research, and in addition several research labs are also located in the city.

In addition to having a large population, the city of Worcester is fairly large in land area, resulting in a relatively low population density – 4646 people per square mile, about a third of Boston's 13488 people per square mile.[11] This sprawl requires a large number of schools spread throughout the entire district to accommodate all residents. To accomplish this, the Worcester Public School system is divided into four quadrants: North, South, Burncoat (the eastern quarter), and Doherty (the western quarter). Each quadrant has a high school that shares the name of the quarter, as well as one middle school. Each also contains several elementary schools and a few specialty schools, for a total of 48 schools.

2.4.1 Doherty Quadrant

Doherty Quadrant is especially significant because this project takes place at Elm Park and Midland elementary schools, both of which are our target schools. This quadrant also contains WPI, as well as Worcester State College, Quinsigamond Community College, and Assumption College, as well as three magnet schools for grade school education (Chandler, Tatnuck, and Jacob Hiatt). Doherty also has a reputation for its emphasis on engineering and science education, as evidenced in the quadrant's Engineering Pipeline Collaborative (EPiC).[12]

2.4.2 Burncoat Quadrant

Burncoat Quadrant families are on average less wealthy than those in Doherty Quadrant and contain a larger proportion of minorities. Their students also have some opportunities unique to their quadrant. Burncoat High School has a strong Air Force Junior ROTC program. In addition, the high school works with Holy Cross College in the Teacher Certification Program (TCP) and Professional Development School (PDS). The TCP works to prepare students for training as teachers, and their graduates oversee the PDS.[19]

2.4.3 North Quadrant

North Quadrant has a distinct advantage in being near the University of Massachusetts Medical School (UMMS). UMMS collaborates with North Quadrant on the Worcester Pipeline Collaborative (WPC), which increases interest in health and medical careers much like Doherty Quadrant's EPiC promotes engineering careers. WPC has been in operation for eight years and has received national recognition. The North Quadrant also boasts a Dual Credit program that allows high school students to take college level courses for college and/or high school credit.[19]

2.4.4 South Quadrant

Clark University, which is located in the South Quadrant, operates its own Professional Development School (not to be confused with Holy Cross's program of the same name.) Clark University has the Jacob Hiatt Center for Urban Education, which helps operate the Clark PDS to train students in teaching, especially in urban settings. South Quadrant also received technology grants that have allowed the purchase of more up-to-date computer and classroom technology.[20]

2.4.5 Specialty Schools

Several WPS schools have a more specific goal than that of simply offering a well-rounded primary education. The Worcester Vocational School teaches students a trade and allows them to gain skills necessary to enter the skilled workforce immediately after education. The ALL School caters to students with learning disabilities, difficulties, or special needs, utilizing a more specially trained teacher force and smaller class sizes that allow more individual attention. Similarly, the Worcester Alternative School teaches students with severe emotional or behavioral disabilities. The Massachusetts Academy for Science and Mathematics, familiarly known as Mass Academy, has a focus on science and mathematics education and allows students to take classes at WPI their senior year. In addition, Worcester has several magnet schools in addition to its solid public education program.

2.5 Engineering Pipeline in the Doherty Quadrant

The drive to improve engineering education has been implemented in different ways in different parts of Massachusetts. Even within the Worcester Public School system, each of the four quadrants has programs and plans for improving science education unique to that quadrant's K-12 curriculum. Each quadrant is also associated with certain nearby schools of secondary education that provides the public schools with resources and personnel to improve its programs.

WPI and Worcester State College are associated with the Doherty Quadrant of the WPS. This quadrant contains several elementary schools that send students to one middle school, Forest Grove Middle School, and to one high school, Doherty High School. To facilitate engineering education in the entire K-12 program, the WPS has formed a program referred to as EPiC: the Engineering Pipeline Collaborative.[12] The goal of EPiC is to coordinate and improve engineering education throughout a student's entire education, from kindergarten through high school and college. The emphasis is on STEM education: Science, Technology, Engineering, and Mathematics. The aims of EPiC are to get more students interested in engineering disciplines; to introduce them to a wide variety of engineering topics; and to focus on getting underrepresented minorities and women interested in engineering careers.

EPiC is further broken down into three smaller programs, one each for grades K-6, 7-9, and 10-12. The high school level (grade 11-12) program is referred to as the Academy of Engineering; the middle school (grade 7-9) program is the Pre-Engineering Cluster; and the elementary school (grade K-6) program, Partnerships Integrating Engineering Education (PIEE), is the focus of this IQP report.

EPiC was originally conceived in 2000 and at first consisted of only the middle school Cluster and the high school Academy programs. In 2003, after these two programs had been successfully implemented for some times, PIEE was added to bring engineering education to elementary schools. At first, PIEE was instituted in two elementary schools – Elm Park and Midland Street Schools. In 2004, Flagg Street School also received PIEE personnel and funding. Elm Park and Midland Street schools also expanded their PIEE programs to assist more classrooms and more grades.

In addition, the Doherty Quadrant has other programs and schools in the district that encourage mathematics and science education. One is the Massachusetts Academy of Mathematics and Science, commonly called the Mass Academy. This is a public school for advanced 11^{th} and 12^{th} grade students with a focus on science and mathematics. In addition to this focus, the school is located near WPI. Academy students therefore have access to WPI's advanced laboratory facilities and faculty readily, as well as the ability to take WPI undergraduate courses during their senior year. While Worcester boasts several magnet schools and alternative schools, the Mass Academy's focus on the sciences makes the school especially relevant in a discussion of the Doherty Quadrant and its dedication to improving science and technology education. Furthermore, WPI hosts several other activities such as residential academic camps which bring engineering to young students; several of these programs have an emphasis on educating girls and minorities, and all of them increase interest in engineering careers among young students.

The concept of a 'pipeline' to raise students in an environment where they are taught engineering is not unique to Worcester. On the contrary, education reforms in the last decade have demonstrated that the state of Massachusetts considers this a priority.

The statewide 2003 Economic Stimulus Trust Fund legislation set up a fund commonly referred to as the Pipeline Fund. This money is distributed statewide, divided into seven districts which in turn determine the best means of distributing funds to the best effect. Worcester falls into the Central district. The Worcester Public Schools were chosen to receive funding because of its diverse student body. Despite sharing a name with the Doherty Engineering Pipeline Collaborative, the state's Pipeline Fund is not related to EPiC except in their common goal of promoting statewide interest in engineering and science education.

2.6 NSF GK-12 Websites Review

The National Science Foundation funds nationwide programs, collectively called the NSF GK-12 projects, which are partnerships between universities and local schools to enhance science and mathematics education. There are 149 active projects in 2004-2005, with many of them working with multiple school systems, and out of these 286 targeted school systems only about 25 percent are of elementary schools, 41 percent are of middle schools, and 34 percent are of high schools. From the NSF's Graduate Teaching Fellows in K-12 Education website[13], there was a link to the GK-12 Project Information website[14]. After initial investigation of the many GK-12 websites listed there, the projects that were listed as having notable achievements or 'nuggets', as they were referred on the website, were the first chosen to be reviewed[15, 16, 17].

Many of the project websites indicated that they offer workshops for teachers and fellows, who are undergraduate or graduate students responsible for assisting teachers for the science lessons, before the start of each academic year. These events give the fellows more time to gather information and learn about teaching K-12 level students; and they give the teachers opportunities to learn more about science and engineering so they could gain insight to improve their own teaching methods and possibly update their science and mathematics curriculum. Also, the teams of teachers and fellows can decide, early on, what lessons they prefer to teach and how to enhance them for more educational value and accomplishing more goals set up by the schools' guidelines. According to the GK-12 Project Information website, biology and chemistry are the two most common subjects chosen to be examined and improved by the project teams; with 16 percent and 15 percent respectively, out of 683 chosen subjects. Geology and ecology are the two least common subjects chosen, with only 6 percent and 5 percent, respectively. As for the subject chosen by the project team at Worcester Polytechnic Institute and the Worcester Public Schools, only 11 percent of the projects chose engineering as one of the subjects.

One of the biggest projects, in terms of the number of targeted schools, is the Partnerships Involving the Scientific Community and Elementary Schools (PISCES) project at the San Diego State University[18]. PISCES works with more than 200 teachers in 3 different and very unique locations: San Diego County, the North Slope of Alaska, and Baja California Sur (BCS), Mexico. They all share a common goal: to provide elementary school teachers with materials to "teach science in inquiry-based lessons"[18]. Started in 1999, the project "has been effective in improving the amount and quality of science education"[17] with 40 different K-6 grade schools, and they all used the school's surrounding environments as bases for research for the students. The fellows, dubbed the "Science Corps"[17], have developed many science kits, each of which includes units of scientific lessons having a common theme. The project team split the academic year and the summer vacation into four cycles, and they assign different fellows different cycles, each teaching one science kit.

This approach gives the fellows unique and diverse experience working with different groups of kids from different locations and with different ethnic and cultural backgrounds. The website also has a section detailing expeditions of fellows teaching in Alaska, showing pictures and a diary to share with the students in different project sites. Some lesson plans (science kits) were also available online for the general public. Their website is dual-language, with emphasis on both English and Spanish, benefiting students without a language barrier.

To better benefit the students by providing a well-rounded scientific experience, a lot of the projects are divided internally into smaller programs that span the whole academic year. For example, at the North Carolina State University's K-12 Outreach Program, the fellows prepare for classroom visits and summer camps, and arrange for the teachers to attend the National Institute of Aerospace Teacher Workshop. Some of the notable achievements from this project are a daily in-school announcement for fellows and teachers to answer science questions from students submitted earlier; a website set up to answer science questions and provide samples of lesson plans; and one-time lesson plan and implementation request for schools that are interested in the program[14]. The goal of this project is to impact students with science and simultaneously improve the teachers' science teaching quality, and for that, they have been successful, because about "30 teachers sought additional professional development in science and technology this year as a result of participation in the GK-12 program"[15].

At the University of Colorado at Boulder's Inspiring and Building Tomorrow's Workforce: A Grades 3-12 Engineering Continuum project, hands-on engineering activities and the lesson plans developed by the fellows were all examined and approved by professional engineers at the university or in the industry.[16] This process could greatly improve the quality of the lesson plans, provide students with insights from current engineers, and ensure that the information the students receive is most up-to-date and interesting. Teaching only the science book provided by the school is not a very effective means of education; the students should be encouraged to explore their own ideas and that of the professionals. The fellows from the university also conduct after school programs and Saturday Engineering Expos for K-12 students.[15] With the lessons generated by the fellows over five years, TeachEngineering, "an on-line digital library of engineering resources for use by K-12 teachers and engineering college faculty conducting outreach in their communities" (TeachEngineering digital library – Hands-On Resources for K-12, 2004) is being developed.

Geography also plays a part in which fields of science can gain more emphasis; in areas that are fortunate enough to have an interesting outdoor area, the fellows on the project often bring the students out to do actual field research. At the University of Rhode Island's Rhode Island Marine and Environmental Graduate Teaching Fellows in K-12 Education projects, students from both coastal area schools and inner city schools were led by the fellows to different coastal sites to conduct research (Project Costal Field Site, 2004). Similarly, Oregon State University focuses on teaching the children from rural settings about agricultural sciences, and has even set up lab activities for them. In the author's opinion, this unique approach should be used by all the project sites that are located near some interesting fields of study related to the courses. The fellows also encourage the students to use an inquiry-based approach to their projects, which seems to work well in many of the other NSF funded project sites.

Many projects choose to develop web-based programs for the students and teachers to acquire more information on the subject matter. For example, at the Pennsylvania State University's M3 Hybrid and Electric Vehicle Education project, the fellows and teachers chose the theme of the research projects for the students to be hybrid and electric transportation vehicles in 2003. All areas of the inner-working of the vehicles are examined and taught, as seen at the "M3 GREATT Resources" site. In addition to teaching, a web-based game called HEVIG was developed for the students.[16] At West Virginia University's TIGERS project, the team of graduate students started a program called Community Atlas, which is an online discussion forum for students, teachers, and the fellows in two different schools to share information to "analyze the physical and cultural geography around the schools".[19] The success at this project site is seen by two of their teachers winning the Presidential Awards for Excellence in Mathematics & Science Teaching.

Besides bringing about a greater awareness of science and mathematics, many of these projects attempt to tackle other topics, such as issues with gender and minority groups in science. Examples of schools that are attempting to solve the gender barrier are Old Dominion University, Rice University and the University of Nebraska. Another important barrier that must be overcome is the inclusion of minorities, which is being addressed by such schools as Arizona State University, North Carolina State University and the University of Maryland. Also some schools like the University of Maine tackle both of these issues, and included disabled students in their projects.

Chapter 3 Project Objectives

The main goal of this project was to improve the understanding of science and engineering concepts in urban public schools. There has been a great deal of attention recently on the quality of public schools in America, and especially on their teaching of engineering. Most public schools today are attempting to improve the quality of engineering education given to students in K-12 curricula; however, many teachers have difficulties teaching engineering. Problems arise when teachers are required now to integrate engineering into their pre-existing lesson schedules; many teachers lack the resources, time, and knowledge necessary to make adequate lesson plans. Massachusetts teachers are required to have lesson plans in accordance with the Massachusetts Frameworks and Worcester Benchmarks, and some teachers have great difficulty fulfilling the science and technology requirements of these standards.

This project helped to remedy this problem by continuing to develop a set of engineering lesson plans that combine both engineering and science concepts. This integration can provide teachers in the Worcester Public Schools system or anywhere else with lessons that they can present to the students with instruction in engineering concepts that will engage the students' interests. Teachers can use these to provide proper instruction to students without having to research the necessary engineering concepts and plan the entire lesson out. Teachers can therefore use these lessons as a source of sufficient engineering knowledge for teaching engineering ideas as well as a source of proven lessons, saving teachers from having to plan and test lessons on their own.

There were also several secondary goals related to this compilation of resources. Among them was improving district standardized test scores. Massachusetts uses the

MCAS testing system to evaluate student performance. This test has a technology and engineering subtest that many students are under-prepared for. By giving students both knowledge of engineering and problem solving experience, test scores should improve. This project also sought to improve mathematics scores; mathematics is a topic closely tied to engineering and most science disciplines. Improving a student's understanding in one should aid him in learning all three subjects.

Another secondary goal of this project was to increase interest in engineering, especially among females and minorities. A disproportionately large portion of the engineering workforce is comprised of white males. Females make up a very small portion of all engineers, and most ethnic minorities are also underrepresented. By getting children at a young age to be interested in engineering, it may be possible to get an increased number of young minority and female students interested in engineering and to maintain their interest through their primary education and into secondary education.

Chapter 4 Methodology

4.1 Lesson Plans

The primary focus of this project was on creating and implementing a set of lesson plans. These lessons were meant to incorporate engineering ideas into the existing sixth grade science curriculum, thereby exposing students to those ideas while continuing to teach them other subjects as required by the state frameworks and Worcester benchmarks. They also had several criteria to satisfy in order to be successfully implemented in a classroom: The lesson plans had to integrate the teaching of both a scientific concept and an engineering concept. The activities must have had some aspect that requires a large amount of student interaction and/or creativity in order to stimulate their interest. They must have been able to be put into place at low cost. The lesson plans were designed by group members and implemented in one or all three sixth grade classrooms involved in the project. After the relative success or failure of the lesson was documented, the lesson plan was appropriately modified and then added to an online bank of science and engineering lesson plans, which can now be viewed and used by any educator with access to the internet.

4.2 Midland Street After School Programs

As another means of bringing engineering to students, project members helped with after school programs at Midland Street School. One such program is part of NASA's Student Involvement Program (NSIP), which gives students an engineering problem and requires them to not only solve the problem, but to document the decisions and steps they make in arriving at their final design. The project spanned eight weeks of the first semester; students met in groups for one hour a week. The program culminated in week eight with a presentation in which students describe all decisions and actions they took in the project, from original concept to final design.

The project itself required students to design a launch structure. A lever device was used to launch a 'rocket' (1 liter water bottle) by dropping a sandbag on the other end. Students constructed a device that went between the business end of the lever and the bottle. The final structure must be made solely out of craft sticks, cardboard, and glue; survive being used three times; be as light as possible; and adhere to certain design constraints. Students worked in groups of four and started with an initial design. They were required to document all major design changes, all launches, and all decisions behind their modifications to their structures. In this way the NSIP program simulated a real engineering problem in a way that is accessible to a sixth grade classroom.

The roles of IQP students and fellows in the project were many. They helped with organization by distributing materials and making sure all students had everything they needed. They also helped to answer questions students had. While they could not tell students how to design structures from start to finish, they provided advice to keep students on the right track. They also served as role models in a way – the IQP group built its own structures. Elementary school students had been more excited about the project when they had a perceived sense of competition with their teachers, and benefited from having another structure to compare to their own.

The second semester featured a similar eight-week long after school program. This second program focused on forensic science, giving examples of how scientific principles can be used in the field of crime solving and criminal justice. Each week featured a different scientific principle, such as fingerprinting or testing properties of substances, as well as a different exercise or set of exercises involving the application of that principle. The full details of this program are in section 5.1.7 of this report.

4.3 Mathematics Tutoring at Elm Park and Midland

To further prepare the students at the Elm Park Community School and the Midland Street School beyond having a better understanding of engineering, we had been invited to go into the less advanced sixth grade classroom during their mathematics sessions to tutor certain students who were lagging behind. The curriculum's goal was to prepare students for the MCAS test, however, a number of children were severely lacking in their mathematics skills and required one-on-one assistance that the teachers simply did not have the means to provide. The question of tutoring sessions was raised, and we decided to lend our help.

During the classroom's regular morning mathematics sessions we took struggling students aside for tutoring. Many of them needed these personal sessions to acquire basic mathematic concepts, as some students were well below grade level. There were a number of reasons for their needing this extra help; the most common were learning disabilities, little to no help from parents at home, and in one case a language barrier for an Hispanic child who had been in America for only one year. Our aid attempted to provide a much needed source of help to strengthen their grasp of major mathematics concepts and lead to better MCAS scores, one student at a time.

Chapter 5 Discussion

5.1 Experience in the Classroom

In this section we explore our experience in the class for the past six months. Due to time constraints of the teachers, the fellows and the IQP students, our time spent at the two different schools deviated from the original requirement of the PIEE project. William Wong and Melissa Costello spent one to two hours per week at the Elm Park Community School during the implementation of engineering lesson plans as well as the extra in-school tutoring program on which we collaborated with the teachers. During A and B term Melissa and Will went into both classrooms each week, for C term we each chose one classroom to visit once a week, and in D term Melissa went to one classroom and Will could not go to either because of schedule conflicts. Ben Johnson and Jim Rocci spent their time at Midland Street School during the engineering lessons for only about an hour or two a week because of the teacher's desire to handle distributing the lessons on her own. Jim spent one to three hours per week during B and C term and less during A and D term, and Ben spent two hours a week in the classroom during B and C term and less during A and B term. We focused primarily on the in-school tutoring program and also the science and engineering after school program at that school that was set up there. The best way to account for each of our experiences is to describe them individually in the following sections.

5.1.1 Melissa Costello's Experience at Elm Park Community School

Overall this was an enjoyable project. Working with the kids was a great experience and we sincerely hope that they retained the information from the lessons we provided. The majority of the students were eager to participate in our activities, and although a few struggled with some of the mathematics concepts, they seemed willing to stick with it and try to understand the knowledge we were trying to impart. Part of the PIEE project, besides general engineering education, is to encourage women and minorities to become interested in potential careers as engineers or scientists. Considering the diversity of our team, and of the Worcester Public School system, we were able to effectively serve as role models to a number of students, showing how anyone who has the interest can attend college.

I feel that we definitely left a strong impression on the children, and while we were there to be their teachers we also became their friends. When I would get to the classroom early before class time was supposed to resume after recess, a number of students, usually the girls, would have something they wanted to tell me that happened to them that day (good or bad) and would talk to me as if I were one of their peers. While normally this sort of interaction may cause the students to forget that we are an authority in the classroom, I found that the students still respected me when I tried to teach a lesson in front of the classroom. Also I think having a more friendly relationship with the students helped them not to be intimidated by us, as they had no problem asking me questions, yet they still knew to listen to me when I told them to stop talking while someone else was speaking.

Something that I learned while working in the classroom was how to project and make myself heard. Getting the attention of a room full of talking children is not an easy task for someone soft-spoken like myself, but during the course of the year I learned how to raise my voice above the chatter and get the attention of the students. Also, the very first time I implemented a lesson I was very nervous, because I was standing in front of twenty pairs of eyes looking expectantly at me and I was afraid I was going to either lose their attention or, worse, mess up what I had to say and have the whole class plunged into confusion. Fortunately, my first implementations went well, and by the end of the year I had very little trouble speaking in front of the classrooms.

5.1.2 William Wong's experience at Elm Park Community School

We had a slow start in the classroom due to the miscommunication between the teachers and the fellows; however, we did use that time to develop better lesson plans and define our project more clearly. I had spent some time during the summer workshop with one of the teachers and the fellow, so I was integrated into the program easily. We served at both sixth grade classrooms at the Elm Park Community School in which one of them has been described as the less advanced classroom. It is true that we encountered more student behavioral problems in that classroom, but their interest in learning engineering rivals the more advanced classroom. To be truthful, I enjoyed my time more at the less advanced classroom because I saw more "Eureka" moments from the students there when they suddenly understood the materials we were presenting. Students from both classrooms were very involved with our program as long as we could present materials that interested them and impressed them, otherwise they could be easily bored and require special instruction from us to bring them back to attention.

Role differences between us and the students was always stressed by the teachers; according to the teachers, the fellows and IQP students were to be treated as instructors and we must be referred to as "Mr." or "Miss" by the students at all times. An interesting note is that the students see people with different labels differently. For example, one of our fellows worked on this project last year and was referred to the students by his first name, and the students that knew him from last year used this first name all the time and the other students followed suit. There was a genuine difference in how we were treated, the fellow was taken less seriously and the IQP students were taken more so; we were always asked to give bathroom passes as we were the teachers. I always tried to be less serious with the students as often as I could; I believe if I can easily relate to them they can learn more from me. A major problem of role difference can be seen by the interaction between the substitute teachers and the students. Since the substitute teachers show up when the teachers are off, the students see them as strangers/intruders and not the figure of authority in the classroom. They become especially inattentive when there is a substitute teacher and it takes a lot of time and energy from all the instructors in the classroom to bring it to order. Interestingly, the fellows and the IQP students were not treated as strangers at all even at the beginning of the program. Perhaps it was the effect of our self-introductions and the teachers' politeness to us that the students perceive us with more familiarity and authority.

All of the students were quite energetic and it took a lot of effort from the teachers to bring them to attention after lunch time. The students behavior was often more childish than their age should dictate as they were easily distracted and verbal disputes were very common among them; a couple of times the principal or the vice principal of the school came in to talk to the students regarding name-callings and childish incidents that happened during break times. One might easily regard these incidents as immaturity but I choose to see them as little adults and that they are going though the change from children to teenagers where a lot of new sensations are developing in them and this unfamiliarity easily led to frustration. Some students were so discouraged at times that they would abandon their works to the point where even the teachers could not motivate them. There were times when I tried to talk to the students about their problems and I was truly amazed by their complexity and types of trouble.

According to the teachers, the students are easily impressed and amazed, which we used as a tactic to draw their attention. Seeing how students can become engrossed in new technologies, we often used a laptop computer and a projector to present our lesson plans in PowerPoint and video clip formats. It is true that the students will pay more attention to the new gadgets but it was easy to divert their attentions to our presentation. We have also found a good way to ensure their attention with candies. In the cell and heredity lesson plan that we presented, candies were used as materials for the experiment. It was very successful when we told the students they will construct a cell from candies and Jello then eat them. Little treats like candies as rewards often pays to get them to focus. It also impresses the students as I tell them about cartoons and movies that could be related to science and engineering. They were so used to the idea that adults do not watch cartoons that they were excited to talk about it with me, and I used it as an opportunity to teach them some more engineering and scientific concepts.

Even though most of the time the students were eager to learn new materials, there were some instances when they became too obsessed with their own ideas that we could not undermine it. For example, during a discussion of the plate tectonic concept, we could not convince one of the students of the validity of the theory. The teacher and I used several minutes and many examples to explain the theory to the student but he would not acknowledge it because he could not feel or see the changes in the plates so he was convinced that Wagner was wrong with the plate tectonic theory. It can be disheartening but it is refreshing to see the students presenting his case and tried to justify it with his own experience. There was another time when I tried to encourage a student who was not doing the activity because she could not understand the mathematics. I suggested to her that I was there to help her and it was very important to know mathematics because it relates to everyday life such as going to a bank, to which she replied, "I would not put money in a bank because they would just rip me off." I was taken back by her statement but I could not help but to agree with her to some degree; it was the first time I truly saw the lack of motivation originating not only from the student and the teacher but also the social structure of society.

The success of this project depended not only on the IQP team and the students but also the proactiveness of the teachers. If a teacher is not enthusiastic about the project, no matter how hard the IQP team tries, we would not be able to get the students to become motivated because they see the reactions of the teacher as their cue to pay attention. There were instances in the project where the cooperation between the IQP team and the teachers was compromised because the proactiveness of the teacher became a concern. Sometimes the materials we presented to the teachers were overwhelmingly complex, and sometimes the teachers were not as active in the project as we hoped they would be. This led to frustration on both sides and extra time was spent between us to smooth out the problems. The students often noticed this as we observed similar attitudes between the majority of the students and the teachers.

At the beginning of the project I was unsure of myself in the classroom; I did not know how I should act to command authority and be the students' peer at the same time.

I was nervous and I spoke too softly. But once I became familiar with the setting of the classrooms, I was much more comfortable presenting our lesson plans. My other responsibility as a role model to the students was also accomplished by being firm and yet easy going at times. I was able to walk in their shoes easily because it was not long ago that I faced the same situations at they do. I wanted them to see how engineering is not boring and that college is worth studying very hard for. We saw the effects of the project as we brought the students onto the WPI campus for a tour and they expressed interest in college life, especially at the idea of a buffet everyday at the school's cafeteria. Being a part of the classroom was an enjoyable experience and I learned as much from them as I hope they did from us.

5.1.3 In-School Tutoring Programs at Elm Park Community School

Portions of the time IQP students spent in the classroom was used to provide one-on-one attention to students. This was suggested by the teachers and the fellows; we all saw a need to improve the students' mathematics skills in order for them to perform better on the MCAS exam in late spring. We also realized that by tutoring the students it would be easier to present our engineering lessons in depth for we could relate more with mathematics and engineering while keeping the students interested. This service, however, was not a required part of the PIEE project, but it was made possible with IQP students and the fellows spending extra time in the classroom.

As we began the tutoring program, we had seen a reasonably large gap in the capabilities of students in the classroom; many were quite advanced, and some had a great deal of difficulty. This difference in ability was especially true in the Elm Park Community School's two 6th grade classrooms. Fellows and IQP students were able to help students having trouble keeping up in class by tutoring them one-on-one, working together on their homework. We often found that students being tutored understood the concepts well but they lacked the motivation to do the homework and seek the answer because they felt mathematics is too difficult and useless. Emphasizing the importance of mathematics in science as well as everyday living while we tutor the students, they were able to understand that mathematics is essential. It was also useful to discuss our personal experience with mathematics at their age with them so the students can see a relationship between us and them, which can motivate them to learn the subject matter.

Motivation is an important factor for a student to do well, if they could not understand the subject matter being taught, it was very common to see them abandon their work and stop paying attention. This led to extra problems that every teacher must deal with first and then proceed with the on-going lesson; this process hinders the progress of the class as a whole and it is unfair to the students that already learned the materials. It is also common to see this lack of motivation spread among the whole class like a disease; students tend to become distracted when teachers have to focus on other students who are not doing so well, which stops their interest because of slow lesson time. We have also observed that some of the more advanced students became irritated and started troubles in the classroom by playing, talking, and even name-calling the less advanced students for their slower progress. This also led to a cycle where the less advanced students became distracted and tried to respond to the other students with more name-calling that ultimately lead to the whole class taking a "time out" and the teachers spending several minutes calming down the students and demanding discipline. This is an outcome that we have observed happening too much.

By tutoring the less advanced students one-on one, this enhances their understanding rapidly and allows the teacher to focus her attention on the remainder of the class and make learning for all students faster because the teacher needs to spend less time ensuring the less advanced students had grasped the concepts. Also, it keeps the whole class' attention and they are more focused. However, due to some scheduling conflicts between the IQP students and the teachers for a suitable tutoring time at the two Elm Park classrooms, most work was performed by the graduate fellow with a Spanish background tutoring a new immigrant student without a substantial understanding of English. The IQP students only spent a few hours total tutoring different students having trouble with mathematics but the fellow spent an hour every week with the new immigrant student. Progress from tutoring was seen during engineering class times, for the students being tutored were often every engaged and could understand the concepts, as related to mathematics, quite well.

5.1.4 Jim Rocci's Experience with Tutoring at Midland Street School

The purpose of the PIEE program is to help the teachers of Worcester to implement engineering lesson plans so that they are comfortable within a couple of years to implement the engineering lessons on their own. As engineers within the PIEE program our group decided that simply implementing lessons was good but that we wanted to do more with the kids; we wanted to learn first hand how we can approach writing the lessons to cater to their needs. I began sitting in during class, I would sit along the side, arms folded, and just observe the approach that the teacher took to present material so that the students would absorb it. As I became more comfortable in the classroom, and similarly as the kids became more comfortable with me, I began circling around, talking with groups of students here and there, trying to inspire and motivate them. One group in particular was researching bees and their habitat; I mentioned that bees navigate using the sun. The boy was impressed by that bit of information and started to quote me directly. I told him no, that he had to go on the computer and find out for himself for sure, and quote his sources online. As my teacher began to notice that I enjoyed helping the kids she would send people over to me to work with me on mathematics for five to ten minutes at a time. Eventually, in B-Term, I came in twice a week solely to tutor one student.

I was really amazed by this student; he was gifted. But it was so deep seeded, like it had never been tapped before. He had difficulty reading (something he should work on at his home but his mother is single with two kids). When he did his mathematics problems he would do everything in his head and if he did not know the answer he would guess or leave it blank. But the problem, one of the reasons he had gone unnoticed, was because he had never been formally taught that he must show his work. I spent two and a half terms working with this student and would mostly just try to inspire him to "want" to do well and "want" to prove his work. I would encourage the way he worked but make a big deal when he would do a whole lot of operations in his head and be off by a little bit; I would say, "See? You lost track of where you were, and if you'd just write it down you won't lose your place!" I would embellish on my engineering projects to make them sound really interesting and tell him he could do it to if he wanted. Working with this student was the most positive experience for me throughout the entire IQP project.

I am grateful for everything that I learned throughout my tutoring experience and for being able to experience them as well. I think that if I do not eventually go into the teaching field that I will continue to be a mentor, to shed a positive light and motivation on everyone in my life.

5.1.5 Jim Rocci's After School Program at Midland Street School

Our participation in the Midland St. after school program, much like our tutoring, was a volunteer effort aimed at gaining experience with the kids. I lent aid to the program twice; it was an 8 week program that occurred in A-term and again in C-term. It was held on Wednesdays at 2:30 until 3:45. At its roots, the program was aimed at giving the kids something productive to do while their parents where still at work, but for the children it was an hour where they could be creative. We would provide all sorts of activities that involved hands on engineering tasks, from constructing a huge eight foot diameter hemisphere using rolled newspaper as trusses to building a variety of paper airplanes and testing different parameters in order to optimize fly time.

The third grade implemented lessons based on PBS's "building big" website.[21] An emphasis was placed on allowing the kids to discover on their own the compression strength of columns and their application in truss systems such as the geodesic dome.

The fifth grade worked with flight, and we developed objects made of paper that would twirl their way down three flights of stairs. We gave the students freedom to experiment with weights and designs. We also experimented with different types of "planes" or less typical objects that can be tossed and fly through the air.

My job was to help out the teacher in any way needed, from testing out projects before hand at home, to handing out supplies that the kids needed for their engineering tasks. I worked with the third grade in the first half of the program and with the fifth for the second. Both were valuable experiences. I found that my time spent there was rewarding when I would pass on my engineering knowledge and terms and the kids would actually retain the information. Also, I think it goes without saying that the kids are just plain fun to be around; all of the students had positive attitudes and were welcoming to anything that we had to offer.

5.1.6 Ben Johnson's First Semester Program at Midland Street School

The first semester's engineering after school program for the sixth grade allowed the students to participate in NASA's Student Involvement Program (NSIP.) The NSIP has several different programs tailored to different age groups. The one in which the Midland Street sixth grade group participated was entitled the Aerospace Engineering Technology Challenge, and it required students to design "launch structures". Students were given a "rocket", a one liter bottle of water that would be "launched" by placing it on one end of an approximately two meter long lever and dropping a ten pound bag of sand on the other end. The student-built launch structures were placed between the bottle and the lever. They had to be built entirely out of craft sticks, cardboard, and glue, had to withstand three launches, and had to be made as light as possible. Groups wrote up their procedures and observations in a report, a copy of which was then sent to a national judging panel in a nationwide competition.

Students were divided into two groups of four. Each group worked separately to devise how to make their launch structures lighter or stronger before going to work on putting them together. The result was that students used the engineering process of observing a problem and evaluating different solutions.

Each group had to design three structures. It was somewhat evident by each group's first attempt at a design that they were not entirely sure of the best way to design their launch structures; neither of the groups' first designs survived their first launch.

Following the first launches, each group was able to observe their damaged structures to see what parts failed first. In addition, the IQP students involved gave a brief presentation on forces, and specifically on the forces in effect when launching their rockets and structures. As a result of this, their revised structures fared considerably better. One group's structure survived three launches, and one survived one launch before being severely damaged in the second.

For the final revision and build, students were left on their own to determine what works and revise their structures. Both groups chose to build structures similar to their second builds, but with modifications. The group whose structure survived three launches made a structure almost identical but with less material, to decrease structure weight considerably. Their revision succeeded; the new, lighter structure still survived three launches. The other group revised their structure by adding more supports in crucial areas that failed on their previous attempt. The result was one of the lightest structures made for the program, and it survived three launches.

The NSIP program in general was quite successful. One can observe that students learned from their mistakes and from the advice of IQP students, as the structures quickly evolved, from crude and ineffective launch structures in their first builds to their third attempt's successful, well-designed structures that succeeded in the groups' task of surviving three launches.

Information on the program, as well as copies of each groups' designs and results, can be found in the appendices. The resource guide for this project can be found at http://www.nsip.net/pdf/ATEC.pdf

5.1.7 Ben Johnson's Second Semester Program at Midland Street School

Midland Street did not have another established after school program for its second semester. The NSIP program was part of a national competition following pre-established guidelines; the second semester program, however, was written from scratch by IQP students and fellows.

The theme for the program, selected by the teacher and IQP students, was forensic science. The program sought to teach after school program participants some of the basic techniques forensic scientists use to catch criminals, and then give them hands-on practice using their newly acquired knowledge.

The first semester program was cumulative in nature; students would conduct a test during one week's session and use those results in the next week's session. The second semester's program, by comparison, was more episodic. Each week, students were taught about some aspect of science and how it can be used in crime solving. The IQP students then set up a simple crime, provided the students with evidence, and guided them in using the science taught in that lesson to determine who had committed that session's crime.

The session was originally scheduled to run for eight weeks. One session was cancelled on account of weather, leaving seven sessions for the forensic science program:

WEEK ONE: INTRODUCTION: Students were introduced to what forensic science is and how it is used in today's society. Also, as a sort of lead-in to what the students could expect each week, they were presented with a simple crime – someone had taken food from the fridge. Students were told what they observed in this imaginary situation and were allowed to ask questions to the IQP students, who would in turn tell them what answers their questions produced or what information an inquiry yielded. In the end, students made guesses as to what the cause of the food disappearance was.

WEEK TWO: FINGERPRINTS: Students were taught about how modern fingerprinting works, and took their own fingerprints as practice. They then were given supplies for collecting fingerprints from a dusty chalkboard and attempted to match the fingerprint to a set of already obtained fingerprints, to attempt to find a match.

WEEK THREE: CHROMATOGRAPHY: Students were introduced to chromatography, the practice of separating the pigments in ink. They were given chromatography samples and then practiced on a number of markers, using one of two solvents. By comparing results, students were able to determine which marker was used to produce which samples.

WEEK FOUR: LOGIC: Students solved various logic puzzles. They were provided with information from a number of eyewitnesses. By using that information, and other information provided by the IQP students, the participants determined what happened in several imaginary situations the IQP students described and logically deduced who was a 'culprit.'

WEEK FIVE: PH: Students were taught about the pH scale and its use in measuring acidity. Supplied with litmus paper, they tested the pH of several household liquids and determined the identity of an unknown liquid.

WEEK SIX: DENSITY: Students conducted more tests on liquids, this time testing density. Students used a plastic barrel pipet filled with liquid as a hydrometer. They inserted the pipet into graduated cylinders filled with different liquid and observed how much they sank, then used their findings to determine which liquids were more dense than others.

WEEK SEVEN: HANDWRITING AND CRYPTOGRAPHY: Each student, including IQP students, made an anonymous handwriting sample by writing the same message on a sheet of paper. Each student then took notes on what each sample looked like. Students then wrote samples with their names on them, then matched these samples to the information they wrote about the previous samples to determine who wrote which sample and which handwriting was responsible for writing the 'original' note.

After this was done, students were given hints about the message (which was gibberish) and were able to decipher what the message was meant to say, in order to finally catch the program's criminal mastermind.

The thematic content of this after school program would prove to be its strongest characteristic. Students appeared to be more excited by the program when it required them to assume the role of a crime scene investigator. They were able to imagine themselves solving a crime during each session, as opposed to the first session in which students simply followed a design process because they were instructed to. Students were excited by the program, and even some of the instructors were impressed by the program. Some of the excitement faded over time; students appeared to be more excited over fingerprinting than over testing density and pH of liquids. This, however, did not appear to make the program cease to be fun for them.

Another important aspect of both programs was its motivating students to discover and investigate thing on their own; that aspect would prove to be more important in this program than the first semester's. The NSIP program had students design structures; when their structures succeeded, the students were excited by the fact that they had successfully designed a structure. In the forensic science program, each session featured a crime scene and a culprit or central question to answer. At the end of the session, students made guesses based on their findings of the session as to who committed that session's crime. Correct guessers were thrilled by their ability to properly use the techniques they were taught in the session, as well as the reward of candy for students who correctly guessed each session's culprit.

5.2 Lesson Plan Discussion

The following titles refer to the lessons that we, the IQP students, developed. Some were necessary as a result of fulfilling the requests of teachers and others were necessary as engineering lesson plans but both categories of lessons abide by the benchmarks put forth by the Worcester public school system. This section is used to discuss our experience with the lesson plans developed for this project in addition to the objectives and the activities discussed; alterations to the lesson plans and tips for implementation are also included.

5.2.1 Speed and Acceleration: Balloon Racers (Melissa)

The balloon racer lesson plan familiarized students with the concepts of speed and acceleration, and also friction, wind resistance and the purpose of prototypes. As part of the introduction, they learned how to solve speed and acceleration mathematics problems. For the activity, the students designed and constructed fins, nose cones and/or a keel to attach to a balloon that would propel itself along a string, using a straw attached to the top of the balloon as a guide for the string. The students competed for either furthest distance traveled or fastest speed.

In my opinion and according to teacher responses, this activity went very well; the kids enjoyed constructing the racers and the competition element always helps to increase participation. The kids were creative when designing their balloon racers, adding nose cones, top and bottom fins, or multiple fins along the sides. They had a good understanding of the principles involved, as was demonstrated by their knowledge of the key words before a formal definition was given.

5.2.2 Earth Movement: Plate Tectonics (Melissa/Will)

The plate tectonics lesson plan demonstrated to the students how the movement of the plates of the Earth's crust creates volcanoes, mountains, trenches and earthquakes. We first did a lecture with the students about plate tectonics, earth layers, the Pangaea continent, and the principles of plate tectonics. This lecture was a good way to start because the students needed this information to understand the concepts for when they did the activities. We put the terms on the blackboard and defined them, and we also drew the different plates and their movements; it is much easier to explain these concepts with pictures than with words.

The students were shown the differences among convergent, divergent and transform type plate shifting, which were then demonstrated with an activity that simulated these movements, using textbooks as the Earth plates. The students each had two books and we suggested that they move the books differently to simulate the plate movements and we had them describe the movement types and which geological formations could be created. In the second activity, we had all the students stand in a group with outstretched arms then had them carefully bump into one another to simulate how the plates can react to each other's movements, especially when considering the massive break-up of the Pangaea continent.

Some handouts were given out to the students; one showed them the different types of plate movements possible, and the other had information on the names of the plates, their locations, and their velocities. We gave the student some time to study the second handout and then asked them to give some characteristics about how the plates are moving. We were delighted to see that many of the students saw the pattern immediately; they suggested to us that most of the velocity vectors on the map are pointing at the same general direction, somewhere in the Pacific Ocean. Then we described how that trend could mean that the plates would come crashing together, which generated some discussions among the students that we calmed down by saying that the catastrophic event, if it shall happen, would not take place for millions of years. It was interesting to see how the students can understand scientific concepts if they can relate it to popular themes in movies and on television.

During the second activity, the students tended to be a little more preoccupied with the action of bumping into one another and often disobeyed our request to be gentle when they bumped around. They still saw what we were trying to demonstrate, however it took a lot of control to keep them from pushing each other a little too hard. It was then decided that we would not implement the second activity in the second classroom because of the behavior of students in the first classroom. However, in the second classroom we had more time to explain and discuss the important concepts as a result. While these activities did not have them design and construct anything, they still had some hands-on learning which certainly let the concepts stay with them, which we tested when we reviewed plate movement a week later along with the volcano lesson. As we asked the students about the plate movement concepts presented, they could answer, quite accurately, and also relate the concepts to our hands-on activities.

The plate tectonics lesson plan presented in appendix I.B has more information than we presented in the classrooms mainly because of time constraints. We had underestimated the time needed for the students to understand the materials. The teachers thought that the material was appropriate but that the second activity may have lost the students' attention, becoming distracted from the concepts we were trying to teach. Even though we went more slowly than originally intended, all the main points of the lesson had gotten across from our presentation to the students, hence we did not make any alterations to the lesson plan but only wished to give some tips and suggestions for its implementation in the future.

1. Make sure students understand the concepts before going on to the next point, or they will lose interests in the subject matter very quickly and it is hard to bring them up to speed.
2. Do not use the second activity with a class that is very "energetic", it will easily get out of control.
3. For the first activity use different combinations of hardcover and soft cover books to show how continental and oceanic plates act differently.
4. Have the students copy and label the diagrams on the blackboard as they learn the different ideas, it helps to refresh their memory later on.

5.2.3 Volcanoes: Beating the Inferno (Melissa/Will)

The volcano lesson plan explained to the students the different types of volcano formations and eruptions that can occur and how magma pushes up from below the crust after divergent Earth plate movement to form volcanoes. The activity had the students get into groups and construct volcanoes out of newspaper and aluminum foil and set up a town below it using tiny plastic houses (from Monopoly board game). They were then asked to devise and construct a way to save the town when the volcano erupted. Their ideas were tested when the volcano was made to erupt with lava of red-dyed baking soda mixed with vinegar.

We started off the lesson with a review of plate tectonics, and how it is related to the formation of volcanoes on Earth. We then talked about different types of volcanoes and the different types of eruptions that happen because of varying materials and conditions. It is important that the students understand how volcanoes operate and we made sure they were informed of the definition of different terms used in the lecture. We also tried to tie in the scientific material with history; Pompeii was mentioned and some pictures of encrusted human remains and the excavated town of Pompeii was shown to the amazement of the students. They were surprised to discover that the ash preserved some bread made on the day of the destruction of Pompeii. Then we discussed how people had survived volcanic eruptions and that with modern technologies, engineers can build towns that can be safe from an eruption; this led to the revelation of their project.

Initially, the activity called for the students to build their volcanoes around an empty twenty ounce soda bottle, but instead we decided to use a small (five ounce) plastic cup attached to one end of a rolled up newspaper to make the core of the volcano. The reasoning was to conserve materials, as filling the bottle with the baking soda and vinegar would use a lot more of the ingredients than just filling the small cup. This change worked very well in the classroom and we were able to "erupt" the volcanoes several times for each group. After the core was constructed, the students added layers of newspaper around the core to have a cone shape and then applied aluminum foil to the surface. Then the mock volcano was placed in a basin with empty spaces for the "town"; the basin was also used to collect the solution of the eruption, thus preventing a huge mess.

After the mock volcano was constructed, we gave the students the civil engineering problem of constructing devices to protect the town during and after the eruption of the volcano. We gave the groups some time to discuss the problem and make drawings of their designs. In order to help them use the Design Process, we provided the students with a worksheet containing instructions and space for them to put down the goal statement, the description and diagrams of the design, as well as the result and suggestions for improvements. After we had gone around and talked to the students about their problem and try to lead them through to the solution while giving them the maximum amount of creative freedom, we passed out the materials for their creations. The only materials we provided were aluminum foil, newspapers, tape, scissors, and glue; we felt these are the best materials to be used, most designs could be built but creativity and planning is needed on the students' part.

The students tried hard to construct the designs as they had envisioned, but limitation of materials (the aluminum foil was too thin and brittle) often hindered their progress. However, we did not encourage the students to abandon their design; rather, they should improvise to realize their design. This also acted to inform the students that engineering is often faced with difficult challenges that must be confronted with more thinking and creativity. After their constructions were completed, we distributed to each group the appropriate amount of vinegar, red food coloring, and baking soda. We were experimenting two different ways to make the eruption. The first was to put the baking soda in the cup first, then pour vinegar into the cup; this method supports a very quick reaction between the vinegar and baking soda that leaves a lot of baking soda undissolved. A second method in which a thin piece of paper towel wrapped around the baking soda was deposited in the cup and vinegar was poured in; this way, the reaction was slowed and it makes a more uniform mixing of vinegar and baking soda that makes a more foamy and slow eruption. This type of reaction was more desirable because of how the solution's characteristics resembled the eruptions in real life. As we erupted each volcano, we had the students observe the action of the solution and it affected the structures they built. They were also instructed to record the results and provide suggestions for improvements.

Overall the kids enjoyed this activity immensely. All of the groups were very creative and clever with their plans on how to save the town, such as making a tube of aluminum foil, setting it on top of the volcano then curving it down and away from the town to divert the flow of the lava, and constructing high "lava-proof" walls that would surround the town. We wanted the students to think of ideas that they could physically construct, but a couple groups wanted to, for example, send in helicopters to douse the lava and stop its flow. In these cases, we told them to try thinking of another solution in addition to that one, or even a back-up plan, because we wanted to actually test if their civil engineered constructs would work, even though sending in helicopters is a clever idea. However we did demonstrate to the student that with water we can dilute a solution of vinegar and baking soda but we suggested to them that a huge amount of water must be added to the lava to cool it down and stop its flow. In this exercise, it was very important that we try to support the students' ideas, even if they are absolutely wrong. It is better for them to learn from their mistakes than for us to step in and take out their learning experiences. The concepts of volcanoes and its relationship to plate tectonics was not the only focus of this lesson plan, but the importance of the design process was emphasized. The students were encouraged to follow the Engineering Design Process as closely as possible so they could have a realistic idea of what engineering truly involves.

With the help of the IQP students, the teachers, and the fellows, the lesson plan was a success, and we were glad that the students had fun while learning. It is important to stress that some students would be disheartened by a "failure" of their model but we must instruct them that it is an experience that would give them ideas to improve their models nonetheless. Some alterations were made in the lesson plan provided in appendix IC; they contained some information, such as the easier ways to construct the volcano and delaying the eruption, but nothing major is changed because the lesson went smoothly.

Some suggestions for future implementation:

1. Look for ways to make an "explosive eruption" by pressurizing the solution. This was requested by several students during the lesson but we never managed to display such an eruption in class.
2. Use more durable materials, such as higher gauge aluminum foil for more strength; also consider plastic straws.
3. Do not give out the vinegar and baking soda until the construction of both the volcano and the protective devices are finished by ALL groups. Students can get easily distracted with "exotic ingredients".
4. Do not erupt any volcano before ALL groups are finished with the preparation, students tend to forget their work and gather around the eruptions.

5.2.4 Jelly Cell Lesson Plan (Jim/Will)

This lesson is designed using nominal engineering background but was suggested out of necessity by the sixth grade teacher at Midland St. School. It satisfies the life science benchmarks and the fifth step of the engineering design process; developing a prototype.

This lesson involves a gelatinous base prepared for the students, who will be working in groups of two or four depending on the final cost of materials. The gelatin acted as the cell's cytoplasm in which all of the cell's other major organelles were placed. The interesting thing about this project is that all of the organelles were "suspended" in the "cytoplasm" in a similar way to that of a typical cell. Other organelles can be represented with beans, nuts, sunflower seeds…etc. all having relative size with respect to one another; the bean used for the nucleus should be larger than the nuts used for lysosomes or mitochondria.

This lesson plan never made it into the classroom at the Midland Street School because there were already enough similar lesson plans ready to be used in the classroom. However it was implemented at Elm Park Community School in both classrooms. One major change was made in the lesson plan so it may be implemented smoothly. The materials for the organelles were replaced as candies; it made the whole model edible and it boosted the students' interest in the project. The students were very excited to get their hands on the candies and very eager to work on the project; however they all lacked the skill to surgically place the candies in the jelly without it breaking up. In order to smoothly add the candies, incisions made in the jelly before putting them in were recommended. At the end most of the models were quite messy but the students had fun eating it. The teachers expressed their delight and enjoyment in implementing this lesson plan after seeing the students learn and have fun at the same time, they also felt that using candies as an alternative to seeds helped the students to pay attention. A note of interest is that the gelatin can be mass produced inside small Tupperware bowls and it was found that if the gelatin is prepared before the class that it must be stored in a cooler or fridge prior to implementation because it may become less like jelly, and more liquid.

5.2.5 Cell Analogy (Jim)

This lesson was designed as a result of necessity to fulfill a need for an adequate lesson to help the students with the understanding of cells. It was designed to allow for the students to research and correlate what they were researching about the makeup of actual cells. It was purposely repetitive. The lesson helped the student relate a definition to a picture – back to its name, and again from its name to its definition. It also allowed for students to really consider the meaning of each organelle within the cell by being creative and relating its function to that of an ordinary household item. The directions state: draw and label a plant cell using letters as keys rather than explicitly stating the name. On a separate sheet of lined paper; next to the correlating letter right the name of the organelle and a comparison to something that can be found in a house. Describe why this particular object was chosen, and how its function is similar to that of the organelle. The students could create a collage, drawing, or flow chart to help explain their cell analogy.

An example is given with respect to mitochondria as follows:

***Mitochondria** - Refrigerator*

I chose a refrigerator because that's where everyone in my house goes to get food which gives us all the energy to feel good throughout the day. The refrigerator stores and provides us with energy in a similar way that the mitochondria stores and provides the cell with energy.

The example just helps to express the level of thought the students put into their analogies.

The students were challenged by this but also had fun brainstorming within their groups. They came up with a lot of good ideas; one group suggested that their computer was the nucleus because that is where all the information is stored. While another group said that the walls to their house were like the cell membrane because it keeps them safe but still they can come and go. Since the teacher also expressed interest and positive attitude for this lesson plan, no improvement was made after the implementation.

5.2.6 Cell Functions (Ben)

This lesson was another addition to the cells and heredity unit, and helped reinforce teaching cell organelles and their functions. It also emphasized how organelles interact with each other.

Different sections of the room were to be labeled as different cell organelles, such as the cell wall, mitochondria, and so on. Each labeled section would also have a brief description of the organelle and its function, and a set of different ways in which the organelle can interact with others. Also, each station has a six-sided die. Students would read the information at the cell station, then roll the die; the result would dictate what happened at that organelle and where the student would go to next. Students repeat this several times, getting an opportunity to travel around the cell and visit most of its organelles. A cell station would look like this:

Chloroplasts

This is where photosynthesis occurs. Photosynthesis is a complicated process by which sunlight, water, and nutrients are turned in to sugars that can be stored and then used as energy.

1-3: These chemicals are needed in the ***Mitochondria*** where they can be turned into energy that the cell can use.

4-6: These chemicals can be stored for later use in the ***Vacuoles***.

Students at this station would roll the die after reading this information. On a 1, 2, or 3, they would then go to the Mitochondria station; on a 4, 5, or 6, they would instead go to the Vacuole station.

This lesson was not implemented, due to time constraints and the fact that a number of other cell organelle lesson plans had already been planned for implementation. It nonetheless remains ready for implementation. Possible lesson modifications could include changing the destinations listed for some cell stations, or the likelihood of arriving at those stations; whether such changes are necessary is hard to determine until the lesson has been tested, however.

5.2.7 DNA Codes (Ben)

Part of the cells and heredity lesson plan involves teaching students that cells receive instructions for carrying out their functions from DNA. This lesson sought to give students a way of understand what DNA is and how it can be used to send instructions to the rest of the cell.

The lesson began with a brief overview of what a code is: the translation of one set of symbols with some meaning to a different set of symbols. Usually translation between a normal message and a coded message is easy if one knows the key to the code, but difficult if one does not. Examples of codes were given, including rotary ciphers (each letter is replaced by the letter a set number of places after it in the alphabet), substitution ciphers (each letter is randomly replaced by another letter), and machine code (each letter is replaced by a string of 0's and 1's).

Next, the instructor went over exactly what DNA was – a long string of proteins. Four different types of proteins make up a string of DNA and are commonly represented by the letters A, T, C, and G. The properties of the DNA strand, and the information encoded in it, is determined by how those four proteins are combined in the long sequence that makes up the DNA chain.

The two ideas were tied together by the use of a made-up 'DNA Code', contained in the attached lesson plan. Each letter of the English alphabet was given a unique combination of three proteins (A, T, C, or G). Given this code, students could translate between English and DNA language. They tested their ability to do this on a simple worksheet. Half of the worksheet contained common English words that the students translated to DNA language; the other half contained DNA words that students translated into English.

This lesson was interesting in relying as much on a student's grasp of language as their grasp of science. This would prove to be both a blessing and a curse. Many students enjoyed the nature of the activities and its broad introduction to coding and decoding information. It relied on an understanding of both language and science, however. Some students were below grade level in one or both of these subjects; they subsequently struggled with the concept of the code. Most students, however, easily were able to use the DNA code as demonstrated. The fact that they could use the code with such ease should indicate that the students obtained a better concept of how DNA in our cells store information. The teachers and students all provided positive feedbacks about this lesson plan. Students enjoyed it, and it proved to be a valuable lesson for teaching DNA. As such, no changes were made to this lesson after its implementation, although it is certainly possible to alter the lesson simply by adding new activities to the activity sheet.

5.2.8 Newton's First Law of Motion (Jim)

Newton's first law is based on momentum and states, "If an object is in motion, it tends to stay in motion. If it is at rest, it tends to stay at rest." Using this postulate, Newton's First Law lesson incorporates the tendency of a mass of books to remain at rest. Originally designed for all students to participate, but underestimating the precariousness of the children it would be best as a demonstration. The lesson calls for an apple to be dropped from some distance onto a persons head, but the buffer, the thing that keeps the person from experiencing any feeling of impact, is a large mass consisting of a stack of books that he/she holds atop their own head. The principal is that the mass of the books is so much greater than that of the apple that the momentum from the impact is almost completely absorbed in the books as a result of conservation of momentum

(Mass1 x Velocity 1 = Mass 2 x velocity 2) and the resulting velocity of the books is almost nil. The impact is merely felt as a soft thud comparable to tapping oneself with a finger.

Sufficient as a demonstration and a valuable / practical lesson that can help up and coming engineers (even non-engineers) utilize Newton's first law. A buoy's natural tendency is to remain motionless despite the waves that continually pass under it; important if devising an ocean monitoring system capable of small tolerances. Harmonic dampening, the leveling of sinusoidal waves, has applications from earthquake preparations to motor vehicles.

The demonstration was never implemented as a result of its dangerous possibilities (understandable, since we would not want the students to try such a thing at home and end up getting hurt). Nonetheless, if a daring participant is willing to undergo the unnerving uncertainty that is a natural result of volunteering to have something dropped on your head, it could be a lesson that sticks with the kids and will be a resource when their studies review the practical sciences.

5.2.9 Newton's Second Law of Motion (Jim)

Newton's Second Law lesson explores the mass - weight relationship (mass and force). Since force is a result of mass multiplied by acceleration and acceleration due to gravity varies as a result of the mass of a body, it was fitting to include a lesson that explores a space traveler's weight on a multitude of planets. The constant is his "mass" and the students are asked to determine the "force" or his weight that he exerts on each of four planets with respect to Earth. The acceleration due to gravity is given for each particular planet. The lesson allows for the repetitive calculation under different parameters of F = MA. The variation in the formula exists in the acceleration due to the gravity of each planet.

Also included is a supplemental activity that deals with mass and acceleration in a different light. This activity allows the students to explore the resultant force with respect to the mass of a rolling object, which is similar to the above lesson with the variation existing with the mass of the body, rather than the acceleration due to gravity. Since acceleration is constant on the surface of Earth, we can just change the mass of a moving object and observe the effect on its "force". We built five carts for the students that would roll empty or with the addition of heavy weights down a ramp. The carts will be rolled and the students can observe the subsequent force that the cart exerts on a crash bumper. The students can then add weight to the carts and explore what the resultant force will be. This will be a good activity for the students to actually see how a force can change with the addition of mass.

These lessons were never implemented as a result of adequate lessons for Newton's laws already at Midland St. School; also, the first activity may be too in depth for them at the sixth grade level.

5.2.10 Newton's Third Law of Motion (Jim)

Finally, Newton's third law lesson incorporates an engineering task for the children to complete. It begins as a story surrounding a "task for your boss". Here the kids are asked to build a stand for his books out of paper and tape and make it as inexpensive and strong as possible. Each sheet of paper needed for the final design costs twenty dollars and tape is five dollars. This lesson incorporates a scoring algorithm in order to give the task a competitive edge.

$$\# \text{ of books supported} * \left[\frac{20}{(\text{cost})} \right] = \text{final score}$$

The scoring algorithm is designed to penalize for high costs since the minimum cost is twenty dollars. This lesson, as well as the other Newton's law lessons, were not implemented at Midland St. but had been placed in her storage and may be utilized in the future.

5.2.11 Conduction (Ben)

This lesson attempted to demonstrate heat transfer, specifically how conduction works. A slinky was to be used as the medium of heat transfer; vibrations at one end (representing heat) would conduct through to the other end. By holding the slinky differently, the rate at which the vibrations conduct could be manipulated.

This lesson was never implemented. It continues to be examined, as the lesson is almost entirely demonstration and lacks an engineering component. The engineering component may be added in the future as a lesson covering heat transfer, Newton's Laws as applied to materials, and space travel.

5.2.12 Mass and Weight—Skeleton Lesson Plan (Will)

This lesson plan was not completed due to time restriction of the project and also an uncertainty of ideas to be used and concepts to be taught. The concepts of mass and weight are very basic engineering and scientific ideas but it can be very hard to understand even for college students. This topic is to be introduced in the WPS's sixth grade based on the benchmark but the subject is also taught in college freshman physics class. The teachers' request to introduce more mathematics in our lesson plans were one challenge I had to face in this lesson plan; I've seen from experience that students generally pay less attention when mathematics is involved in our presentations with the fellows. I've tried to find ways around this problem but ultimately failed to come to one solid solution that can engage the students, teach them about mass and weight, and ensure them to use mathematics to for problem solving. Ultimate, part of this lesson plan, the PowerPoint presentation that shows the development of aviation, was presented by our fellow Edwin Mercado in the classrooms together with the Paper Airplane lesson plan also developed by Mr. Mercado.

The skeleton of this lesson plan is presented in Appendix I.L of this report. I intended to relate the importance of understanding mass and weight to problems that can be encountered in space travel. Students were supposed to be understand that mass does not change but weight does change if the gravity one experienced is different. The lesson plan suggests that students should calculate the mass and weight of different materials useable in space flight and determine which one of them should be used in a spaceship construction. Then the students would use mock materials, to represent the real materials, to construct models of the spaceships. I became too ambitious with this lesson plan and lost the focus of its materials as time ran out. However, if the students can be engaged with mathematics this lesson would proved useful in helping them understand the difference of mass and weight.

5.3 Inventor Biographies Discussion (Will)

The concept of doing an inventor biography section of lesson plans came about in the group's discussion section. We needed a mean for the students to become more interested in science and engineering; the idea came up that we should have each of the students research a specific engineer or the team could produce easy-to-read profiles of some inventors. We ultimately decided that it would be more feasible for the team to write the articles than to have the students take extra time doing research. As we produced these biographies, we tried to select inventors who invented things which are used or seen in the students' everyday lives. Also, we tried to tie in the biographies with the lesson plans being implemented in the classrooms so the students could better relate the materials being taught and the extra reading materials. Another criterion that we tried to follow was to focus more on "inventors" who made novel products easily identified by students than "scientists" that produced theoretical results in their fields of research; the reasoning was because we had found earlier on that students can relate science and engineering better with physical objects than with scientific theories. Since the student population in our classrooms was of diverse ethnic groups, our teachers suggested that we also focus the biographies on engineers belonging to a minority group. This choice may have allowed the students to better relate to the inventors about whom they had read.

The production of inventor biographies started at the end of B-Term at WPI, and since then we had produced fifteen short inventor profiles with a short question sheet for each. The question sheets developed were based on the request of the teacher for them to gauge the students' work and progress. They are each made up of four or five short questions based on the information presented in the biographies. There are several types of question that we employed, including defining terms, putting the working principles into the students' own words, and some critical thinking questions that required the students to deduce the answers by understanding the whole biography. Questions such as:

> "Which one of Nobel's contributions do you think is more important? Dynamite or the Nobel Prize? Discuss your reasons." (From the Alfred Nobel biography)

> "Why did Eli Whitney move to the South to be a school teacher? Do you think an engineering degree now is useful?" (From the Eli Whitney biography)

These were employed in several biographies to gauge the students' interest in the subject matter and may be used as a basis to develop better lesson plans that suit their interest. Extra credit questions that require the definition of terms not defined in the biographies were also implemented, and were used to give students the motivation to use the dictionary or the internet to explore further on the subjects. The teacher and we believe that the questions should not be too hard because the students need to focus on their other homework more; also, the biographies should only serve as an extension of the lesson plans that may stimulate the interest of the students.

Another feature that we implemented in the inventor biographies was how we underlined the terms that we felt the students would not understand. These can be used as vocabulary words that the teachers practice with their students or they can be looked up by the students using the internet or a dictionary. The teachers had expressed their concerns that the inventor biographies contain too many hard words, so this is a way to list them out explicitly so the students would not be distraught if they do not know them. We also encouraged the students to circle words that they did not understand and define them. This can prove to be a good practice for each student to gain an extensive vocabulary.

At the end of the project, we have only implemented three or four of the biographies as they are relevant to the subject matter being taught in the class. On several occasions we were able to observe the students as they read the biographies, and to our surprise, there are a lot of words that they circled that we thought they could understand. We also noticed that the circled words were not necessarily scientific terms, but rather terms that also relate to social science and history. It is disheartening to see that the students' reading levels are lower than our expectations, and the same goes for their mathematics skills, which have been discussed earlier in this report. The problem we see is that, upon encountering the new words, the students are usually not motivated to look them up and try to understand them because they feel it is extra work that "doesn't matter". It is also possible that the teachers and parents of the students intend to focus on their mathematics and scientific knowledge more so than the history of science and engineering that we try to incorporate into the projects by the implementation of the inventor biographies. But given the students' need for higher mathematics and science skills, it is understandable that the teachers focus more on those aspects to prepare the students for their MCAS exam in late spring.

Learning from our experience with the use of the inventor biographies as a mean to heighten student interest this year, there are some improvements that we can make. First of all, the inventor biographies must suit the reading level of the students; otherwise we may not achieve our goals. In order to determine the reading level of the class, the teachers must be interviewed and the curriculum for language arts must be reviewed. Secondly, the students would most likely not look up words unknown to them unless it is made a requirement that they read and understand the articles to prepare for a quiz or such. This adds to the burden of the teachers and it is crucial that an understanding be made between the teachers and the project team to ensure the responsibility on both sides; namely, the projects would support the teachers in their correction of the students' inventor questionnaire and that quizzing times are not overly long. We still believe that the inventor biographies are a good way to introduce the more human aspect of science and engineering; however, it would be best if more support from the teachers and more time are provided to us, and to the elementary school students.

Chapter 6 Conclusion

Despite the lack of numerical data in this project, it is possible to determine to some degree the success of the IQP students' efforts. This came largely in the form of feedback from the elementary school teachers that worked alongside us. In order to gauge our progress, teachers were given a questionnaire about the effectiveness of the IQP students and of the lesson plans they wrote. In addition to the teacher questionnaire we developed a lesson plan evaluation form to measure the effectiveness of our lesson plans and presentations. Using feedback from these forms the IQP students were able to come up with their own suggestions for future implementation. As this IQP is the second part of the three-year PIEE project, concluding statements are meant to summarize our experience and make suggestions for future participants of this program. Our accounts from the past year are meant to benefit groups involved in follow-up projects in forming more effective lesson plans; they will be useful to the elementary school teachers who will continue to bring engineering concepts to their classrooms when the PIEE project finally concludes.

6.1 Lesson Plan Post-Implementation Evaluation Form

We developed this post-implementation evaluation form for our lesson plans in order to receive some quantitative data on how appropriate the implemented lessons were (See Appendix III.A). As a result of the creation of this evaluation form, any decision concerning whether or not the lesson plan went well and was appropriate could now be ascertained. There could have been a lesson we designed that taught the students a lot and had a fun activity as a part of it, so we would be inclined to say that this was a good lesson. But if we then looked back and considered factors such as inclusion of engineering topics, repeatability, and opportunity for creativity, then while some lesson plans went well, perhaps they were not as good as they could have been or did not include some of the aforementioned aspects. This original evaluation form improved the situation, gave us concrete data for a clear analysis, helped to guide our interpretation of lesson plan effectiveness, and provided a scale on which to compare the different aspects of what makes an excellent lesson plan.

6.2 Teacher Questionnaire Review

Based on the feedback given to us by the teachers (see the teacher questionnaire form in Appendix III.B) they felt that their students enjoyed the lesson plans presented immensely and that their interests in the subject matter heightened. However, the teachers also felt that they were not as prepared as they would like to have been before teaching these lessons on their own. They also expressed that we did not meet all of their expectations and that while we tried to improve the students' mathematics our aid did not cause a significant change. The main improvements they felt were needed were more and better access to new teaching resources and materials, and an increased amount of time spent in the classroom by the college students.

From the survey, the teachers rated us above average in questions that are related to the students' interest in engineering. It is a good sign that signifies a degree of success from our project, as we have achieved part of a goal of this year's project. The teachers also suggested that our activities were greatly enjoyed by the students and this also links to their interest in science and engineering.

While many resources are available online, it is unfortunate that many of the teachers do not have regular access to the internet. However, hard copies of the lesson plans were given to them and kept in a binder, in addition we set up an online repository to which all the teachers had access. Also, all lesson plans developed have references to online sources throughout that can be used as starting points for the search for more teaching materials online; it may be beneficial that teachers are constantly reminded of this fact. However, it is possible that we relied on the new online technology too much and forgot that many sources which teachers are more familiar with are hardcopy sources.

While we tried to incorporate as much sixth grade level mathematics as we could in each of our lesson plans, by the teachers' requests, we were reluctant to do so because of the students' strong attitude against mathematics. Our focus shifted to creating more accessible and enjoyable engineering activities rather than push the mathematics because we felt this approach would have a longer lasting effect on the students. It was more important that they understood the materials and had fun doing the activities than struggling with numbers and equations that could discourage them from wanting to participate.

As far as time spent in the classroom, the teachers possibly had a vastly different view of what the role and level of commitment was expected from us students. Several instances arose at the beginning of the project where we had to clarify our roles and time commitment in the classrooms. However, even after the project has been almost completed, they are still unclear as to our and their roles in the project. While we tried to spend as much time as possible presenting lesson plans in the classrooms, it was very difficult to find suitable time slots that fit everyone's schedule. There are many hours each week in the students' schedule in which other classes are mandatory; teachers have commitments to their jobs; and as undergraduate students, we also have a lot of academic responsibilities that must be taken care of in a timely manner.

The teachers generally enjoyed having us take part in their classes as instructors. Also, the tutoring was implemented as we saw the need to heighten the students' mathematic skills; it was not part of the PIEE project objectives and the teachers were unclear on this point and were often very unyielding to compromise with scheduling difficulties.

On the whole the teachers' and students' relationships were good, but the need for a better line of communication between them is apparent, as most of the communication occurred via the graduate fellows. Fixing this problem would be an important stride that the next years PIEE students should try to achieve in order to ensure the program's success.

6.3 Comparison of the WPI's PIEE and other NSF GK-12 Programs

The success of the WPI PIEE project has always relied on strong communication among the teachers, the fellows, and the IQP students. Using websites and discussion boards generated a lot of feedback and comments from the students and some teachers to improve the quality of the lesson plans. This is crucial, as the limited hours of interactions between the fellows and the students in school do not allow enough time for the necessary communication. We can only spend one or two hours a week in our sixth grade classrooms because school regulations dictate that the students need a certain amount of time on other subjects to improve their writing and mathematics skills for their MCAS exam, and this does not leave much time for engineering activities. The creation of online lessons viewable by the elementary school students had been discussed before, but this undertaking is impeded by the lack of internet access in some students' homes.

Another key component of PIEE is its lessons and the interest they generate; the crucial aspect of the lessons is that they are interesting and designed for maximum effects on the students in our limited time at the classrooms. Field trips to WPI allowed students to relate more to engineering and science with their education by impressing them with our campus. Monthly projects such as "Engineer of the Month" and "Tools of the Month" were discussed but never implemented fully. However, in place of "Engineer of the Month" projects, the inventor biographies were set up to increase the students' awareness of engineering and history.

During the 2003-04 academic year (August 2003 to May 2004), members of the WPI PIEE teams have reported on the challenges they faced. While the overall project was a definite success, the implementers experienced difficulty in trying to conduct the activities of the engineering lessons within the allotted classroom times. There were also difficulties with how they presented the concepts to both teachers and students of the WPS system. These two problems were experienced by our project team as well, but the situation improved as we gained more experience. Some students had not yet been exposed to this engineering program and had to adjust to its novelty, and some teachers who had never taught these types of extended lesson plans were at first apprehensive about implementing them in their classrooms. The purpose of the IQP students' presence in the classrooms served to provide support to the teachers.

The driving force for success in this project in past years was the growing interest among the teachers and students, without which the project would have failed. WPS teachers and WPI students alike were excited about implementing the engineering activities, which enhanced the crucial bond between WPS and WPI. The bond was further strengthened by the WPS system's teachers' sentiment towards the college students, who respected the teachers' role of authority over the children and worked together with the teachers to help implement the new lesson plans instead of taking complete control over the classroom for the duration of the activities.

Compared to the other more established NSF sponsored projects, WPI's PIEE project is just an infant. Our project had doubled its size from the 2003-2004 academic year but is still quite small in comparison to the other GK-12 projects. The only focus of the PIEE project, engineering, is one of the most neglected subjects by the other GK-12 programs.

There are also similarities between PIEE and the other projects. Holding a summer workshop is a very common tool to speed up the collaborations between the fellows and the teachers that had generated good results among projects. Larger meetings that invite everyone involved to share their diverse experiences were also common between projects, as it helps to generate cooperation among teams and enhances the learning curves of all the team members. Other projects also set up showcases during the year to bring the project as well as the progress of the students to the knowledge of the parents. It is used as another means to share experience and spread the reputation of the project. Many projects also co-sponsor science fairs, tutoring, and after school programs in their school systems. Another common aspect of the other projects is the online repository of lesson plans, and most projects intend to put up revised lesson plans online for the use of the teachers and any other interested persons.

6.4 Suggestions for Next Year's IQP Students

Next year's project will be very different from the past two years, as the roles of the IQP students and the fellows become a behind-the-scenes support team for the teachers developing their own lesson plans and locating resources. The PIEE teams will not present their lesson plans, rather, they will suggest them to the teachers and the teachers will in turn use the materials and conduct the lesson plans themselves. Our team as a whole had learned a lot these past six months, and though we have had some successes, some mistakes were still made. Even though the format of the project will be different, suggestions we present here at the conclusion of our project shall be very valuable for next year's project teams.

It is very important to communicate the roles and responsibilities of teachers, fellows, and IQP students to everyone involved in the program very clearly. A misunderstanding of role and responsibility from anyone could lead to unpleasant situations where the expectations of duty may become overly burdensome for certain members in the team. It is absolutely essential that communication be clear and concise within the group and any problems that arise must be dealt with swiftly.

Do not rely on e-mail as a means to contact the teachers. Internet mails may be a very convenient mean of communication between college students, but by no means can one assume that the teachers will check their e-mails at all times unless they specifically instruct the IQP team to communicate with them in this manner. It is much more reliable to make plans with the teachers via telephone or in person; these may be cumbersome but can save one a lot of trouble if the teachers are not familiar with using the internet.

Anything one says in a classroom carries weight and is not easily forgotten by the students. Suppose that the team promises the students something in return for their attention in an activity, one must follow through with the promise or the students will bring it up at the most inconvenient of times. The same goes with any planning between the team and the teachers. If there are extra commitments made one must be ready to follow through or it will lead to an unpleasant relationship between the teacher and the team.

Try to walk in the shoes of the students. If an IQP student can relate to the students' life in some ways such as having a common favorite sport or TV show, by all means exploit the relationship and become more familiar with the students. It always helps to gain their trust so that they will be more forward with their suggestions and questions.

Lessons must be conducted in a timely manner. It is very important to some students and teachers that the lesson be short and concise so they can gain the maximum amount of information with the minimum amount of time. Students and teachers both have other responsibilities and it is best not to conflict them with overly long and exhausting engineering activities.

6.5 Suggestions for Expanding the PIEE Project to Other Schools

For the last two years the PIEE project has been a success. Many students became interested in the fields of science and engineering and returning teachers had expressed their comfort for researching and presenting their own lesson plans. It is very possible that WPI and WPS can expand the PIEE projects out of the Doherty quadrant.

However, a lot of manpower and other resources must be located before any expansion can take place. Such and expansion would require:

-More funding

-More people (teachers, advisors, fellows, and IQP students)

-Better communication for the whole group

-More flexibility in the schools' schedule

-A new format of projects (more background support)

The ultimate goal of this project is to be able to implement engineering lesson plans on a broad scale; the only way this can be accomplished is through giving teachers sufficient information and instruction to form lesson plans on their own. The first two years of the PIEE project have served as a solid foundation for this growth. WPI students have proven the viability and effectiveness of engineering lesson plans in elementary school classrooms. This leaves two major goals. First, the resources required to teach an engineering curriculum must be gathered and organized so that the public school teachers continue to implement existing lessons and create their own, without necessarily relying on outside help such as that given by the IQP group. While this group does not doubt the capability of the teachers associated with this project, it is still necessary to ensure that the shifting of the responsibility to the teachers themselves goes smoothly. This will likely become less of a challenge as more and more engineering lesson plans become available, making it no longer necessary for teachers to continually craft new lessons from the ground up. Second, there has to be some established method of bringing engineering lessons to new classrooms. Everything the PIEE project seeks to accomplish would be useless if an IQP group had to assist every classroom in starting the implementation of engineering lessons. There therefore needs to be a means of not only distributing engineering lessons to new classrooms, but distributing with them the engineering background knowledge necessary to teach those lessons confidently.

This IQP accomplished what it set out to do by continuing to support the use of engineering lessons in area classrooms. Engineering in elementary schools represents a considerable change for the current school curriculum; such large scale changes take a considerable amount of resources, time, and energy. The important first steps in this process have been taken. If the improved curriculum can be proven sustainable – that is, if its implementation can continue without the constant support of outside assistance – then the transition will be a success. The task of ensuring that teachers can carry on the teaching of engineering after the IQP groups have left, however, is beyond this IQP's scope. PIEE is an ongoing effort to be carried on by next year's teams; to them we entrust the future of the PIEE program.

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APPENDIX I Lesson Plans

This section contains all the lesson plans developed by the IQP students over the course of the project from A-term to D-term. All of the lesson plans presented here include the plan for the lesson, the objectives, the procedure, and any handouts that were developed. Some of the lesson plan materials had been reduced to fit in this report. The entire lesson plan collections from the project team can be located in the CD-ROM submitted with this report.

List of Lesson Plans

I.A Speed and Acceleration: Balloon Racers

GRADE: 6

DISCIPLINE: PHYSICAL SCIENCE, ENGINEERING

BENCHMARKS:

06.SC.IS.02 – Design and conduct an experiment specifying variables to be changed, controlled and measured.

06.SC.TE.09 – Describe and explain the purpose of a given prototype.

06.SC.TE.11 – Explain how such design features as size, shape, weight, function and cost limitation would affect the construction of a given prototype.

06.SC.TE.14 – Using test results, modify the prototype to optimize the solution, e.g., bring the design closer to meeting the design constraints.

06.SC.TE.17 – Apply the metric system in design projects and experiments.

LESSON DURATION: 60-80 minutes

STUDENT OUTCOME: Through the use of prototype design and testing, students will understand more about the concepts of speed, (negative) acceleration, wind resistance and friction and how they can apply that knowledge to building better prototypes.

BACKGROUND MATERIALS: Give a handout with the following terms. ("Balloon Racer: Words to know" at end of document)

- DEFINITIONS:

- SPEED: The rate of distance traveled, e.g. miles per hour.

- ACCELERATION: The rate of change of speed over time. In today's activity there is negative acceleration, or deceleration, as the balloon racers slow down.

- FRICTION: The rubbing of one object or surface against another. In today's activity friction occurs between the string and the straw and acts as an opposite force, slowing the racers down a little.

- WIND RESISTANCE: Another opposite force in today's activity, which will tend to slow the racers down.

- PROTOTYPE: An original working model that serves as a basis for later improvements.

-ENGINEERING DESIGN PROCESS: Why do we use prototypes?

- Brainstorm with the students on why engineers use prototypes and the redesign/test process.

ACTIVITY: Designing and testing the balloon racer

MATERIALS: Measuring tape
Stopwatch
String
Balloons (1/group of 3-5, extras in case any break)
Straws
Scotch tape
Sturdy construction paper

PROCEDURE:

1) Have the group members take a few minutes to brainstorm and discuss ideas for how to construct a balloon racer that will travel the farthest OR the fastest. Encourage sketches in their engineering notebooks. Factors for them to consider are straw length and placement, fin/nose shape and placement, and how much air they put into their balloon.
2) Have them build the first prototype, inflating the balloon then cutting out and taping on fins, and nose or keel if the group wishes to construct one, then attaching the straw on top to be used as a guide for the string, which functions as the track cable. They should <u>not</u> tie off the balloon, but rather have one student hold it shut while the others construct the fins. There is no limit to the number of fins they can construct and the straw length can be altered.
3) Test the racer on the string line by letting the air out, encouraging the students to make observations of how their racer performs, then have them record the distance in metric units. Time the racers also with the stopwatch and have the students calculate the speed. Strings should be at least 15-20 feet.
4) Have the students improve upon their prototype, then retest. They could also try their racers at high or low 45 degree angles to see the affect of changing this variable.

ESSENTIAL QUESTIONS:

1) Why is prototype testing and redesign important in the engineering process?
2) What factors/variables affected how far and how fast the balloon racers traveled?
3) Do the racers accelerate or decelerate as they move forward?
4) What affect did changing the angle of the track have on the balloon racers' performance?
5) How do you calculate speed?

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Balloon Racers: Words to Know

Speed: The rate of distance traveled.

Example: If a car travels 100 miles in 2 hours, its speed is 50 miles per hour. (100 miles/ 2 hours = 50 miles/hour)

Acceleration: The rate of change of speed over time. In today's activity there is negative acceleration, or deceleration, as the balloon racers slow down.

Example: If a car is traveling 50 miles per hour and then during 1 hour speeds up to 60 miles per hour, its acceleration is 10 miles per hour.

Friction: The rubbing of one object or surface against another. In today's activity friction occurs between the string and the straw and acts as an opposite force, slowing the racers down a little.

Wind Resistance: Another opposite force in today's activity, which will tend to slow the racers down. Fin design is important to try to lower wind resistance.

Prototype: An original working model that serves as a basis for later improvements.

I.B Earth Movements: Plate Tectonics

TITLE OF LESSON: EARTH IS A PLATEFUL

UNIT TITLE: UNDERSTANDING THE EARTH

GRADE: 6TH

DISCIPLINE: EARTH/SPACE SCIENCE

STANDARD: (06.SC.ES.03) Describe the layers of the solid earth, including the lithosphere, the hot convecting mantle, and the dense metallic core

LESSON TIME: 45 minutes

STUDENT OUTCOME: Students would play a game that introduces to them the Plate Tectonics Theory and how tectonic activities of one plate can affect the whole world.

BACKGROUND MATERIALS:

- The backbone of the Plate Tectonics Theory was first presented by Alfred Wegener, a German meteorologist in 1912 as the Continental Drift Theory.
    - Earth was once (200 million years ago) made up with a supercontinent, called the Pangaea which breaks up over time and the continents moved to their present day locations
    - His evidences include: the matching shapes of some of the continents; the fossilized records of same species of organism on different continents; similar ancient climate on different continents; the moving magnetic poles of the Earth; and similar sequence of layers of rocks in different regions
    - He proposed that the split up of the Pangaea was caused by the Earth's spin
    - His hypothesis was not accepted until the 1960's

- In min 1960's, the new theory of Plate Tectonics was born
    - The plates are actually broken pieces of the Earth's lithosphere, which is made up of the crust and the harder part of the mantle. It can be about 2 km to 130 km for oceanic plates and about 300 km thick for continental plates
    - The plates (lithosphere) are on top of the asthenosphere layer, which is the softer, liquid-like part of the mantle
    - The plates are moved by thermal convection currents of the circulation of magma in the asthenosphere. Much like how hot water rises up and cooler water sinks down in a bathtub.
    - It is proposed that there are 12 plates in the present day, and some are oceanic and some are continental

- There are three types of movements for the plates, described by the motion of the boundaries of the plates

- Divergent plate boundary
  - Two plates move away form each other, the liquid mantle from the asthenosphere move up and form new crust at the surface
  - This process forms ridges in land or under the sea, ridges are especially high area, example: mid-Atlantic Ridge
- Convergent plate boundary
  - Two plates move together, and one is pushed down under the other, called subduction
  - This process forms trenches, which are deep area in land or at the sea. Example: the Mariana trench in the Pacific Ocean, near Japan. The deepest point in the Earth
  - This process may also form mountains. Example: the Himalayan mountain range
- Transform plate boundary
  - Two plates sliding pass each other horizontally in different directions
  - This process forms faults as seen in California's San Andreas Fault

➢ The movement of the plates are the causes for earthquakes and also volcano eruptions

ACTIVITY 1 (From the student's Science book)

TITLE: Movement of the plates

MATERIALS: two or more books/binders

PROCEDURE:

1. Have the students put two books/binders side by side on the table
2. Discuss the divergent plate boundary movement
3. Have the students mimic the divergent plate boundary movement by moving their books/binders apart in opposite direction
4. Discuss the formation of ridges by this plate tectonic movement
5. Discuss the convergent plate boundary movement
6. Have the students mimic the convergent plate boundary movement by moving their books/binders together
7. Show the students that this type of movement can from a mountain or a trench
8. Discuss the transform plate boundary movement
9. Have the students mimic the transform plate boundary movement by grinding their books/binders in opposite direction
10. Discuss formation of faults

ACTIVITY 2 (From "The Layered Earth", a website of Montana State University)

TITLE: The Human Plate Tectonics Statue

MATERIALS: students, room

PROCEDURE:

Each student represents a plate of the earth's crust. One by one, students begin to make a "plate statue" by freezing in a position at a designated spot in the room. They are to stand very close to each other, but not touching.

1. Once the entire class has formed the plate-statue, give directions for students to move slightly but without touching anyone else.
2. Now have all the students touch hands with another plate (student) and bump softly.
3. Discuss this would be the movements described in the earlier activity.
4. Have all of the students connect their hands and let one, the more of them make waves. Notice that some waves are smaller and some are larger, but all are connected together.
5. Explain to the students that earthquakes are just like making the waves, one starts and it goes around. And if there are more waves, they interact with each other too.

Instruction Mode:

Whole Class

Essential Questions:

1. How are the plates moving?
2. What is the theory that predict this event?
3. How does plate tectonics affect our life and history?

Assessment/Evaluation of Students – end of lecture discussion

Lesson Extensions:

Attachments: Locations and names of the plates
Velocities of the plates

Keywords:
Pangaea, Theory of Continental Drift, Theory of Plate Tectonics, lithosphere, ridge, trench, fault

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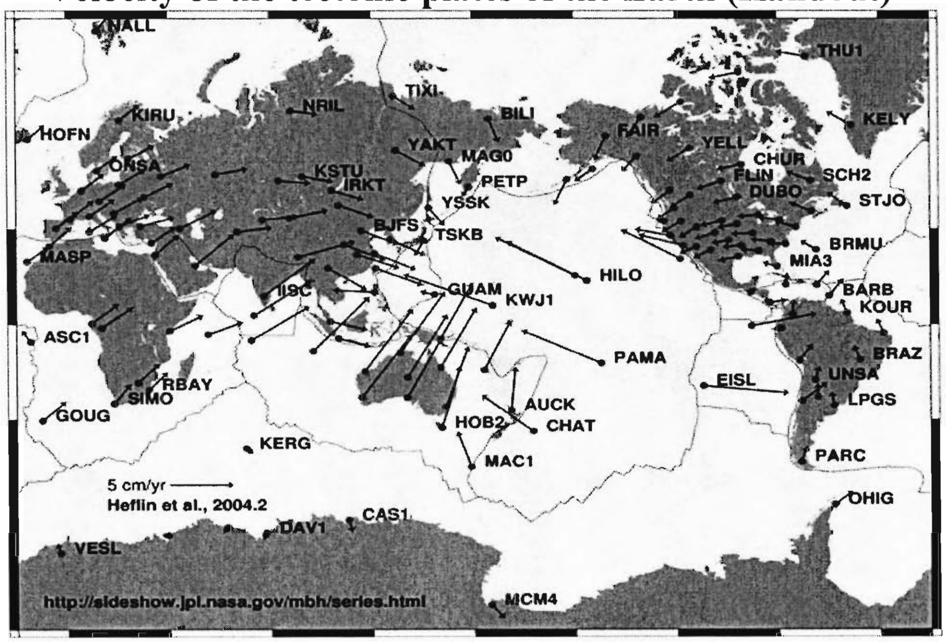
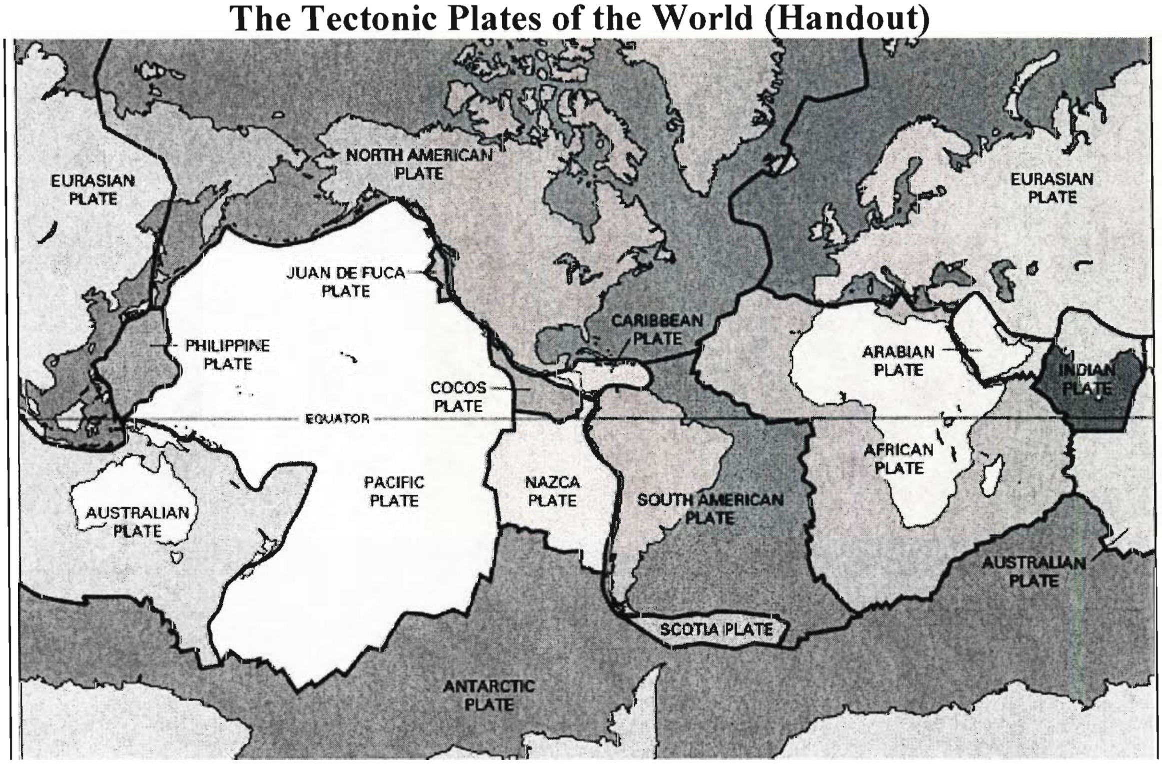
Velocity of the tectonic plates of the Earth (Handout)



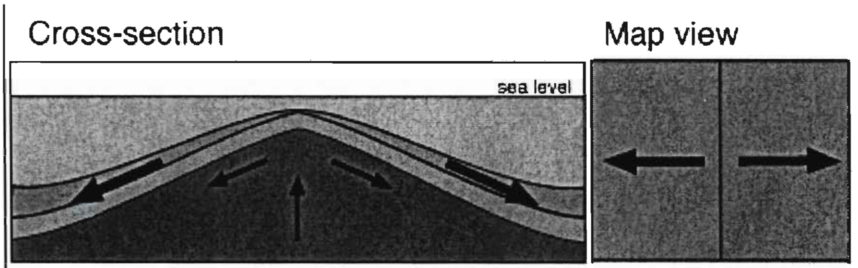
The arrows represent the direction and speed that the plates are moving. Notice, at the boundaries of the plates are where volcanoes form and earthquakes occur usually.

The Tectonic Plates of the World (Handout)

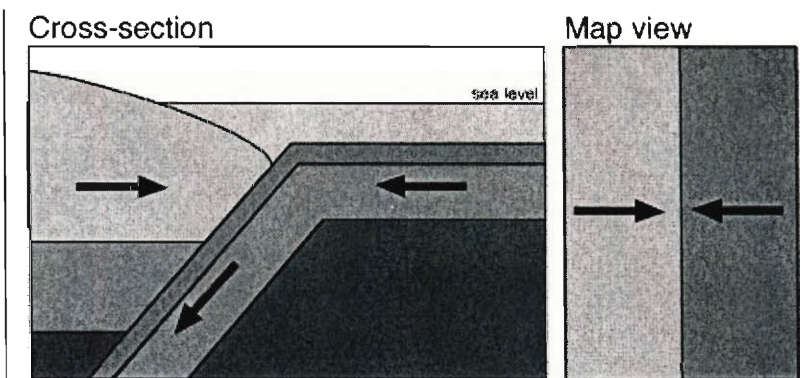


(From the website of USGS, Image URL: http://pubs.usgs.gov/publications/graphics/Fig1.gif)

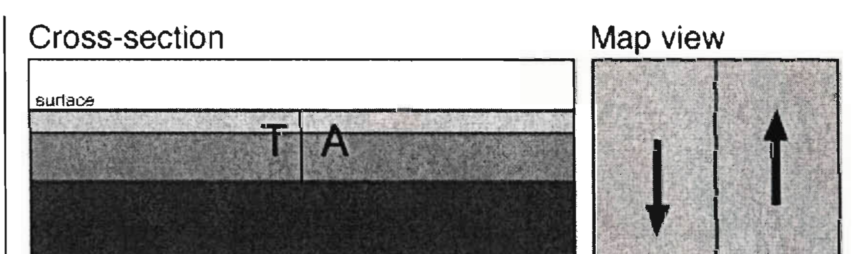
Different Plate Movements



Divergent plate boundary



Convergent plate boundary



Transform plate boundary. T = towards and A = away.

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I.C Volcano: Beating the Inferno

TITLE OF LESSON: VIOLA! VOLCANO

UNIT TITLE: UNDERSTANDING THE EARTH

GRADE: 6TH

DISCIPLINE: EARTH/SPACE SCIENCE

STANDARD: (06.SC.ES.03) Describe the layers of the solid earth, including the lithosphere, the hot convecting mantle, and the dense metallic core
(06.SC.TE.11) Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype
(06.SC.TE.14) Using test results, modify the prototype to optimize the solution

LESSON TIME: 2 lessons each 50-60 minutes

STUDENT OUTCOME: After the introductions and the activities, students would have an understanding of the formation of volcanoes, the inner working of the volcanoes, and they would gain knowledge from the experiments about engineering and the design process

BACKGROUND MATERIALS:

- ❖ The materials from inside the planet
  - o Magma—molten material within the earth, a mixture of gas, solid, and liquid, comes from the mantle
  - o Lava—molten rock(magma), as it is called when it reaches the surface of the planet

- ❖ Production of magma under the Earth's crust
  - o Mostly formed by the movement of plates of the Earth's crust (Plate tectonics)
  - o Spreading Center Volcanism—plates floating away from each other and the pressure in the layer under the crust causes magma to come out of the cracks. The magma cools and forms new rock layers for the crust
  - o Subduction Zone Volcanism—plates collide and one gets pushed down, heats up, melts, and turns into magma
  - o Hot Spot Volcanism—unusual hot mantle forms and floats up right under the crust, because of thermal buoyancy, forming a plume, and melts the rock on the underside and turns it into magma. This pocket of magma is stationary but the plate moves on top and the magma forms a string of volcanoes. Most volcanoes were made this way

- ❖ The magma is pushed out by the gaseous substances in the magma
  - o The higher the concentration of gases the more violent the eruption will be

    - Also, viscosity, the ability to resist flow, plays a major roll in the level of eruptions. Also: higher viscosity (harder to flow, such as syrup) creates bigger eruptions, and lower viscosity (easier to flow, such as water) creates calmer eruptions
    - It would be easy to visualize a volcanic eruption as shaking a soda bottle and then opening the cap: when you shake the bottle, the gas is mixed into the liquid, creating more gas bubbles and higher pressure

- There are several types of eruptions, mainly depending on the level of gas pressure and the viscosity of the magma
    - **Effusive eruptions**
        - Low viscosity and low gas pressure
        - Lava flows down slowly during the eruption
        - Considerable damage to properties and the environment but not much life loss generally
    - **Explosive eruptions**
        - High viscosity, high gas pressure
        - Produces an eruption column composed of hot gases, ash and solid volcanic material
    - There are more ways to identify eruptions based on their destructive power, eruption type, and characteristics of the lava as it erupts
        - Plinian eruption—large, slow (last for days), fast lava, destructive eruption, a lot of fallen materials, buried Pompeii
        - Hawaiian eruption—slow lava flow, not much destruction done, causes lava fountain and lava lakes, common to the Hawaiian Islands
        - Strombolian eruption—huge booming noise, but small eruptions, small amount of lava flow, erupts like fireworks
        - Vulcanian eruption—no lava flow, series of short explosions, a lot of volcanic materials (mostly football-sized)
        - Hydrovolcanic eruption—occurs near water sources, water breaks up the volcanic materials to create fine ash
        - Fissure eruption—occurs when magma flows through cracks between tectonic plates, creating a long curtain of lava which is slow moving

Different Shapes and Sizes

Most land volcanoes have the same basic structure, but volcano shape and size varies considerably. There are several elements that these different volcano types have in common are:

- a **summit crater** - the mouth of the volcano, where the lava exists
- a **magma chamber** - where the lava wells up underground
- a **central vent** - leads from the magma chamber to the summit crater.

The biggest variation in volcano structure is the **edifice**, the structure surrounding the central vent. The edifice is built up by the volcanic material spewed out when the volcano erupts. Consequently, its composition, shape and structure are all determined by the nature of the volcanic material and the nature of the eruption. The three main volcano shapes are:

- **Stratovolcanoes**: These are the most familiar type of volcanoes, and generally have the most destructive history of eruptions. They are characterized by a fairly symmetrical mountain edifice, which curves steeply near the relatively small summit crater at the top. They are usually built by Plinian eruptions that launch a great deal of pyroclastic material. As the lava, ash and other material spews out, it rapidly builds the edifice around the vent. Stratovolcanoes tend to have highly infrequent eruptions -- hundreds of years apart -- and typically form in subduction zones.

Photo courtesy USFWS

Kanaga Volcano, a stratovolcano in Alaska

- **Scoria cone volcanoes**: These relatively small cones are the most common volcano type. They are characterized by steep slopes on both sides of the edifice, which lead up to a very wide summit crater. This edifice is composed of ashy tephra, usually spewed out by Strombolian eruptions. Unlike stratovolcanoes, many Scoria cone volcanoes have only one eruption event.

Photo courtesy USGS

Sunset Crater, a scoria cone volcano in Arizona

- **Shield volcanoes**: These wide, relatively short volcanoes occur when low-viscosity lava flows out with minimal explosiveness, such as in Hawaiian eruptions. The lava disperses out over a wide surface area -- sometimes hundreds of kilometers -- building up a shield-shaped dome. Near the summit, the edifice gets a little steeper, giving the volcano a slightly raised center. Many shield volcanoes erupt with great frequency (every few years or so).

Photo courtesy USGS

Mauna Loa, a shield volcano in Hawaii.

Volcanic activity can also produce other interesting structures, such as **calderas** and **lava domes**. Calderas, large crater-shaped basins, form when eruptions drain a magma chamber and the volcano edifice collapses into the empty space. These often fill up with water, creating round lakes, such as **Crater Lake** in Oregon. Lava domes form when most of the gas vesicles escape during an initial eruption, and the remaining viscous lava lacks the necessary pressure to spew out and so it flows out very slowly at the summit crater. This creates a domed plug at the top of the volcano, which may continue to grow over time.

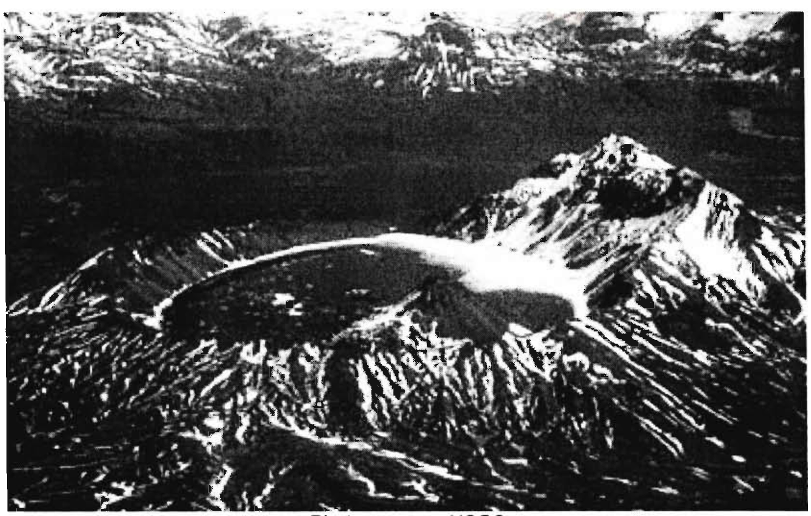


Photo courtesy USGS

The caldera at Kaguyak Volcano, in Alaska, is about 1.5 miles (2.5 km) in diameter.

Taken directly from the www.howstuffworks.com website

Activity 1

Title: Easy Volcano Construction

Materials:
1 20oz empty soda/water bottle
1 pan
saran wrap
newspaper (about 3-4 full sheets)
aluminum foil (about 1 sq. foot)
scotch tape
red food coloring
vinegar
baking soda
tissue paper
Small plastic cups

Procedure:

1. Fold sheets of newspaper around the empty bottle and tape in place, using more at the bottom to make a conical shape. Put the cup on top of the bottle.
2. Wrap sheets of aluminum foil around the newspaper base and secure with tape where needed.
3. Pour some vinegar into the cup, then add 1-2 drops of food coloring and a scoop of baking soda.
4. Watch the eruption and observe what happened.
5. Write down all the observations made and make some drawings.

Activity 2

Title: Beating the inferno

Materials: Cardboards, plastic houses from Monopoly board game, white glue, scissors, cardboard tubes, construction paper

Objective: The objective of this activity is for the students to learn about the design process and apply it to design a defensive system to counter advancing lava flow and other events in a volcanic eruption

Procedure:

1. Explain to the students the reasons why they need to engineer a defensive system to save a town from destruction by providing examples: Mount Santorini at Thera (1628 BC), Mount Vesuvius at Pompeii (79 AD), Mount Krakatau in Indonesia (1883), and Mount St. Helens in Washington state, USA (1980, 2004)
2. Suggest to the students that they are summoned to a small city that was built under the shadow of a volcano to design a defensive system that would protect the town from a forthcoming eruption (See the handout).
3. Help the students brainstorm ideas and also let them decide which idea to pursue while having them jot down all their thoughts and ideas with graphs and writing.
4. Help each group build their design and try it out by putting the town at the bottom of the volcano and "erupting the volcano".

5. Talk about the real life possibility of each design and give more restrictions to students to consider while they redesign their prototype.
6. Test the new prototype again and discuss with students the pros and cons of each design.

INSTRUCTION MODE:

Whole Class

ESSENTIAL QUESTIONS:

4. How does a volcano form?
5. What happens in a volcanic eruption?
6. What would happen to people's lives when a volcano erupts?
7. How can we make our designs better and more realistic?

ASSESSMENT/EVALUATION OF STUDENTS – end of lecture discussion

LESSON EXTENSIONS:

ATTACHMENTS:

KEYWORDS:

AUTHORS: William Chiu-Kit Wong and Melissa Costello

AUTHOR EMAIL: wckwong@wpi.edu, josey284@wpi.edu

REFERENCE:

http://science.howstuffworks.com/volcano.htm

http://volcano.und.nodak.edu/vwdocs/frequent_questions/group10_new.html

(this is a great Q & A website on volcano related subjects)

http://www.pgd.hawaii.edu/~scott/eruption.htm

http://www.volcanolive.com/contents.html

Beating the Inferno! (Worksheet)

As an experienced volcanologist and engineer, you are summoned to the City of Gotham, built years ago under the shadow of a sleeping volcano. However, studies have shown that the volcano, Mount Gordon, is awakening from its slumber and is likely to erupt in the next few years. From record of past eruptions of this volcano, it is determined that the next eruption would be a Plinian eruption, much like the one at Pompeii, with fast moving lava and long explosions. Your job (as a group) is to design a defensive mechanism that would protect the citizens of this city and prevent the destruction of the city itself. Also, bear in mind that the construction must be done in the next two years so we can beat the forthcoming inferno! The well being of the citizens of Gotham is in your hands, go for it!

This is a guide to help you design the defensive system

1. Discuss among your group, **what is the problem that you are trying to solve?**

   ____

   ____

2. Using your notes about the types of eruptions and think back about your earlier experiment, **what are the characteristics of a Plinian Eruption?**

   ____

   ____

3. Among you group, **brainstorm ideas about what is needed to be done and how to achieve your goals, write five of each down in two columns.**

4. From your ideas, **write about your team's design?**

____

____

____

5. Draw your design and label items as you see fit
6. Now, using materials provided, construct a prototype of your team's design, **remember, take into consideration the size of the city and only construct the parts most crucial to the design as we can talk about the rest and less important parts!**

7. Now, using vinegar and baking soda, make the volcano erupt and **observe what happens to the town and write down your observations.**

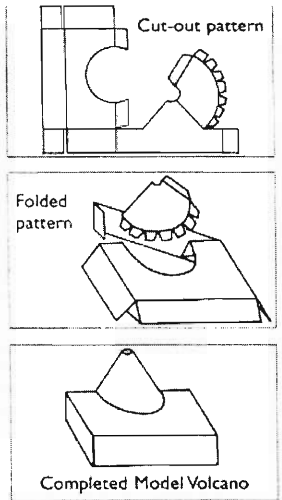
____

____

8. Using your observations, **go back to the team's design and think of ways to improve it, use the space below to write down your thoughts and any new drawings of the design. (Remember, do not change your drawings and writing from before)**

Extra Activity

Volcano Model



(a) (b) (c)

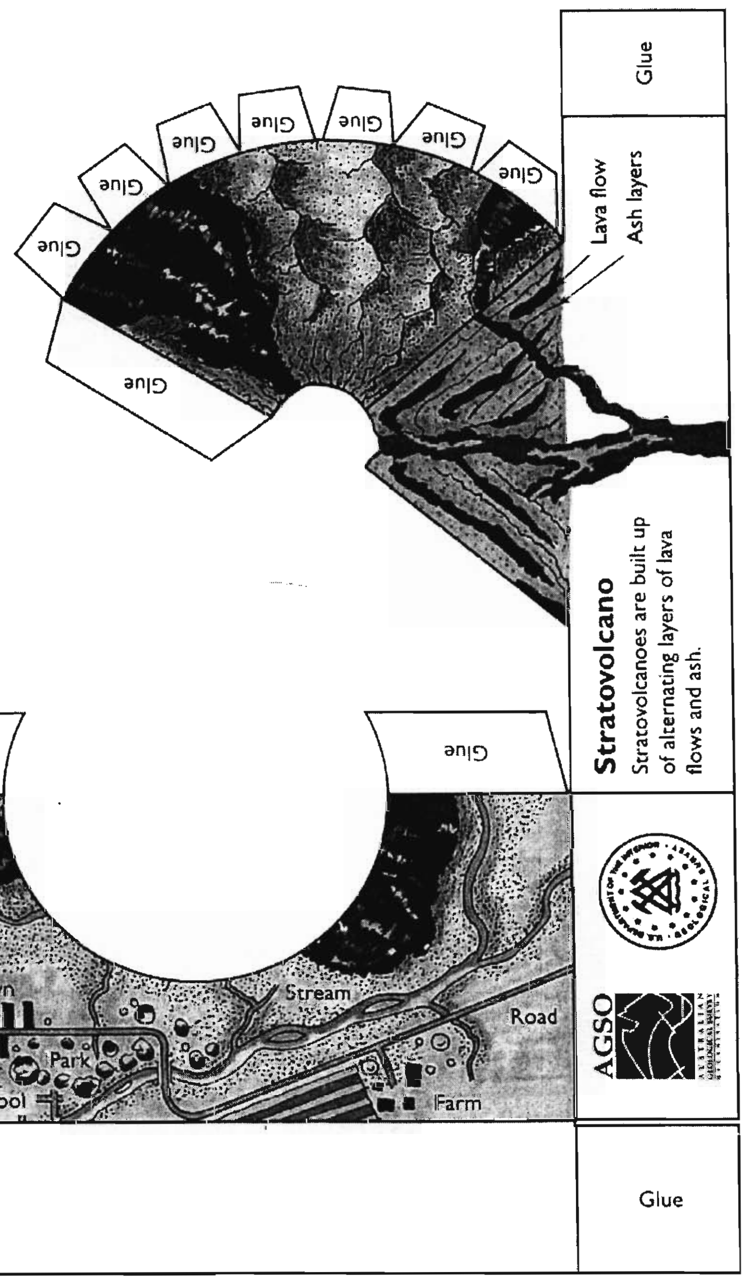
Cut out the paper volcano model by cutting along all its outside edges.

Fold the pattern as shown in the diagrams above, so the printed side faces outward.

Try the pieces for fit before applying glue or tape.

Glue or tape the tabs as indicated.

Your completed model should look like drawing (c).



Australian Geological Survey Organisation, Geoscience Awareness Unit - Phone (06) 249 9497

Name:

Plate Tectonics and Volcanoes Work Sheet

1) What type of plate movement (convergent, divergent or transform) causes volcanoes to form?

2) From which layer of the Earth does magma come?

3) What happens on the Earth's surface when two plates rub against one another? What is this type of plate movement called?

4) What happens to the lava after it has flowed out of a volcano? What does it turn into?

5) Was your group successful in saving the town? If not, what do you think you could have done differently?

I.D Jelly Cell

NAME: JAMES ROCCI

GRADE: 6

DISCIPLINE: LIFE SCIENCE/ENGINEERING

PURPOSE: For the students to recognize that within all living organisms lay cells consisting of organelles that carry out basic functions. These organelles are arranged in the cell 3 dimensionally.

OBJECTIVES:
- [06.SC.LS.06] To give the students an opportunity to observe a range of plant and animal cells to identify the cell wall, cell membrane, chloroplasts, vacuoles, nucleus, and cytoplasm when present.
- [06.SC.LS.07] For the students to recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out.
- To give the students a chance to explore the engineering design process by constructing a prototype.

STUDENT OUTCOMES: The students will research and understand organelles that makeup plant cells and use what they learn to construct a prototype of a plant cell. Demonstration of knowledge will be observed with a key that must be constructed along side the prototype.

ESSENTIAL QUESTION: How are the organelles within the cell arranged, what are there proportions and quanities.

ACTIVITY	STANDARD
UNIT QUESTION: Can I distinguish a plant cell as well as characterize its various organelles?	**STANDARD ADDRESSED:** 06.SC.LS.06 **INSTRUCTIONAL MODE:** Small groups
UNIT QUESTION: What are the functions of the organelles within a cell?	**STANDARD ADDRESSED:** 06.SC.LS.07 **INSTRUCTIONAL MODE:** Small groups

TOOLS AND RESOURCES:

```
Gelatin-
Nuts- $3
Sunflower seeds- $2 without the shell
Black beans- $3.5
Rice- $3
```

Dried Fava beans- $4
Waxed paper cups- $4

CELL ANALOGY WORKSHEET

LESSON DESCRIPTION:

A number of supplies must be accumulated prior to implementation of this lesson plan (refer to supplies). We'll have a gelatinous base prepared for the students who will be working in groups of two or four depending on final cost of materials (obviously groups of four rather than two could cut costs in half). The gelatin will act as the cells cytoplasm for which all of the cells other major organelles will be placed. The interesting thing about this project is that all of the organelles will be "suspended" in the "cytoplasm" in a similar way to that of a typical cell. Other organelles can be represented with beans, nuts, sunflower seeds…etc. all having relative size with respect to one another; the bean used for the nucleus should be larger than the nuts used for lysosomes or mitochondria. I will follow up this summary with suggested list of things to use to represent the organelles their cost based on providing enough for an entire class, in most cases things can be found in bulk in such quantity that the initial implementation of this project may be expensive but the remaining supplies can be used in the years to come.

After completing the prototype paste the supplies to a piece of construction paper, label and give a description of each organelles function within the cell.

Note: Certain types of gelatin can set at temperatures below 85 Fahrenheit; this would be very useful for our purpose.

Nuts-	mitochondria
Sunflower seeds-	lysosomes
Black beans-	Peroxisomes
Rice-	Golgi apparatus
Dried Fava beans-	nucleus

I.E Cell Analogy

NAME: JAMES ROCCI

GRADE: 6

DISCIPLINE: LIFE SCIENCE/ENGINEERING

PURPOSE: For the students to recognize that within all living organisms lay cells consisting of organelles that carry out basic functions. Organelles perform singular tasks in a cooperative effort relating to cell health. They work together as a team, each with their own job that helps the cell to stay healthy.

OBJECTIVES:

- [06.SC.LS.06] To give the students an opportunity to observe a range of plant and animal cells to identify the cell wall, cell membrane, chloroplasts, vacuoles, nucleus, and cytoplasm when present.
- [06.SC.LS.07] For the students to recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out.
- To give the students a chance to brainstorm as a group

STUDENT OUTCOMES: The students will research and understand organelles that makeup plant cells. They will grasp this concept by relating the functions of the organelles to functions of objects with which they are in contact on a daily basis.

ESSENTIAL QUESTION: How can I relate the functions of the organelles within a plant cell to the jobs that machines, systems, or objects carry out within my house?

ACTIVITY	STANDARD
UNIT QUESTION: Can I distinguish a plant cell as well as characterize its various organelles?	**STANDARD ADDRESSED:** 06.SC.LS.06 **INSTRUCTIONAL MODE:** Small groups
UNIT QUESTION: What are the functions of the organelles within a cell?	**STANDARD ADDRESSED:** 06.SC.LS.07 **INSTRUCTIONAL MODE:** Small groups

TOOLS AND RESOURCES: Nothing more than regular classroom materials will be required: pencil, blank paper, lined paper and a reference book.

Cell Analogy Worksheet

Lesson Description:

With the students in groups of 2-4 have them Draw and label a plant cell. Rather than directly labeling the organelles within the cell use the letter in the following list and draw an arrow to its corresponding part. Label them as follows:

A: Nucleus
B: Endoplasmic Reticulum
C: Golgi Apparatus
D: Mitochondrion
E: Lysosome
F: Vacuole
G: Cell Membrane
H: Cytosol
I: Cell Wall
J: Chloroplast

On the attached page you'll find a list of letters with sufficient space to write out the name of the above organelles. Next to the correlating letter right a comparison to something that you can find in your house. It can be anything ranging from your refrigerator to your septic system. Describe why you chose this particular household object and how its function is similar to that of the organelle. The students may create a collage, drawing, or flow chart to help explain their cell analogy.

For example:

D: *Mitochondria* - *Refrigerator*
I chose a refrigerator because that's where everyone in my house goes to get food which gives us all the energy to feel good throughout the day. The refrigerator stores and provides us with energy in a similar way that the mitochondria stores and provides the cell with energy.

There is no right or wrong solution so long as your answer is adequately supported through your reasoning. Some hints to consider: septic system, intercom system, shingles (roofing), & solar panels.

CELL ANALOGY WORKSHEET

Draw the cell in space below
Connect the letter to its corresponding organelle

A-

B-

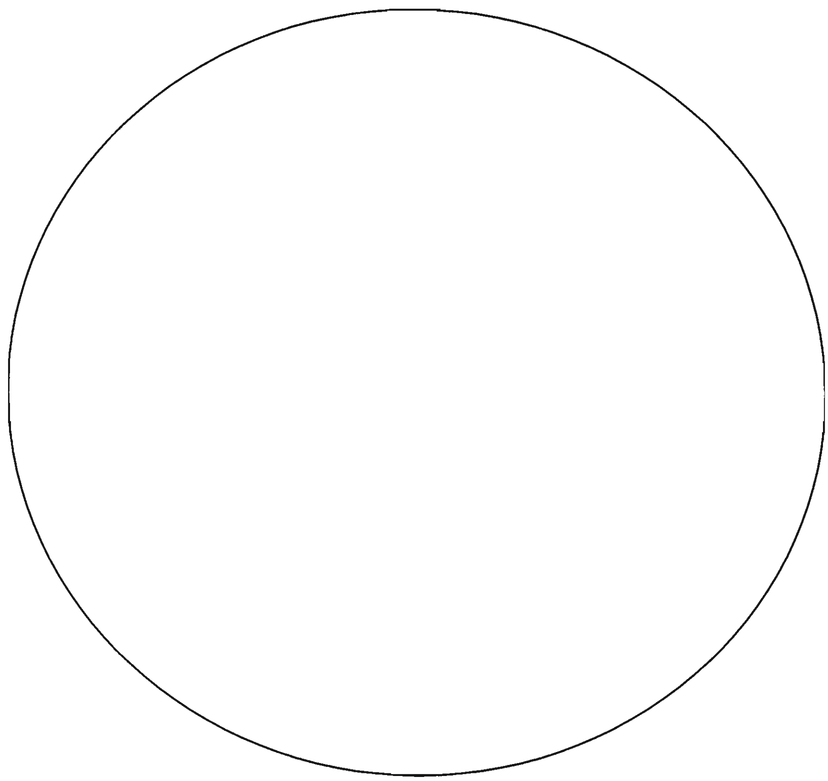
C-

D-

E-

F-

G-



CELL ANALOGY WORKSHEET

A:

B:

C:

D:

E:

F:

G:

As Revised by Mrs. Grey
6^{th} Grade
Midland St. School

Cell Analogy

In your assigned group, you must draw and label a plant cell on the worksheet. Rather than directly labeling the organelles within the cell use the letter in the following list and draw an arrow to its corresponding part.

A. Nucleus
B. Mitochondria
C. Vacuole
D. Cell Membrane
E. Cell Wall
F. Chloroplast

On the attached page you'll find a list of letters with a sufficient space to write out the organelles. Once this is done you are to brainstorm in your groups a comparison for each organelle to something that you can find in your house. It can be anything ranging from your refrigerator to your septic system. Describe why you chose this particular household object and how its function is similar to that of the organelle.

For example:

B: *Mitochondria* *-Refrigerator*

I chose a refrigerator because that's where everyone in my house goes to get food which gives us all the energy we need to feel good throughout the day. The refrigerator stores and provides us with energy in a similar way that the mitochondria stores and provides the cell with energy.

Supplemental Sheet

Rules of Brainstorming:

- Criticism of ideas isn't allowed
- All ideas, no matter how wild, are encouraged
- The more ideas, the better
- Every participant should try to build on or combine the ideas of others.

Supplemental sheet Taken from:
effectiveMeetings.com.
http://www.effectivemeetings.com/teams/participation/brainstorming.asp

I.F Cell Functions

NAME – BEN JOHNSON

GRADE LEVEL – 6TH

LESSON TIME – 1 class period (whatever is not completed during class period can be taken home as a homework assignment)

INSTRUCTIONAL MODE –SMALL GROUP (ACTIVITY)

TEAM/GROUP SIZE – VARIABLE

SUMMARY – For this activity, the classroom is set up like a cell, with different parts of the room representing different cell organelles. Students go from organelle to organelle to get a better grasp of what organelles do and how they interact with each other to make the cell as a whole function.

Learning Objectives –

Students will:	**WPS Benchmarks**
Observe a range of plant and animal cells to identify the cell wall, cell membrane, chloroplasts, vacuoles, nucleus and cytoplasm when present.	06.SC.LS.06
Recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out. The way in which cells function is similar in all living organisms.	06.SC.LS.07

Students will:	MSTECF Standards
Compare and contrast plant and animal cells, including major organelles (cell membrane, cell wall, nucleus, cytoplasm, chloroplasts, mitochondria, vacuoles).	6.2.3
Recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out. The way in which cells function is similar in all living organisms.	6.2.4

Essential Questions –

- How do organelles in cells interact with each other?
- How do cells function to carry out basic processes ?

Introduction / Motivation –

Students should understand that cells are the basic building blocks of living things and that cells contain numberous organelles. These organelles each have a specific function ; together they maintain basic functions in the cell.

Procedure –

1.) Introduce the activity (see Introduction/Motivation).
2.) Review cell organelles.
3.) Set up the classroom like a cell. Label different parts of the room as different organelles. Each part should be clearly labeled so that students can tell which part is which. Each also has a sheet explaining what the cell

does and how it can interact with other organelles, as well as a six-sided die.

4.) Explain the interactive part.

5.) Have the students visit the organelles:

Students randomly begin at an organelle, where they read the information sheet on the organelle. After reading it, they roll a six-sided die. Based on the results of the die, they travel to some other organelle. Repeat this process until the travel sheet is full.

Materials List (per class, per group and / or per student) –

Copies of the attached documents – one travel sheet for each student, and each organelle's information sheet.

6-sided dice

Tape

A room

Assessment/Evaluation of Students – The completed student worksheets.

Attachments – Overhead and handout

This lesson is meant to be part of a more exhaustive lesson on cells and organelles. Students are assumed to have already had at least some instruction in organelles.

Outside the Cell

This is the area outside the plant cell. Oxygen and carbon dioxide are obtained here, as is sunlight and water.

1-2: Follow some sunlight to the ***Chloroplasts***, where the sunlight takes part in photosynthesis.

3-4: Before you can go into the cell, you have to go by the ***Cell Wall and Cell Membrane***.

5: Oxygen from outside is needed in the ***Mitochondria*** to process sugars into energy.

6: Follow some water as it enters the ***Vacuoles*** to be stored there.

Chloroplasts

This is where photosynthesis occurs. Photosynthesis is a complicated process by which sunlight, water, and nutrients are turned in to sugars that can be stored and then used as energy.

1-3: These chemicals are needed in the ***Mitochondria*** where they can be turned into energy that the cell can use.

4-6: These chemicals can be stored for later use in the ***Vacuoles***.

Vacuoles

Vacuoles are large spaces which can store chemicals that the cell needs, and which also assists in the removal of wastes from the cell.

1-4: Wastes in the Vacuoles are expelled to ***<u>Outside the Cell</u>***.

5-6: Chemicals and water in the Vacuoles can be sent to the ***Mitochondria*** to produce energy.

Mitochondria

Mitochondria process sugars and oxygen and produce energy for cell processes.

1-6: These cell processes are carried out under instructions from DNA contained in the ***Nucleus***.

Cell Wall/Cell Membrane

The Cell Membrane, present in all cells, is the outer border of the cell. It keeps materials in the cell inside and keeps out unwanted things. The Cell Wall, a structure unique to plant cells, is a thicker barrier which also is rigid and helps give plants a more inflexible structure.

1: You leave the Cell Membrane to travel ***Outside the Cell***.

2-4: Inside the cell membrane is ***Cytoplasm***, a substance filling the empty spaces of the cell which holds all the organelles.

5-6: By going to the middle of the cell, you will probably come to the largest organelle, the ***Nucleus***.

Nucleus

The Nucleus controls all activity in the cell. It stores chromosomes, which hold DNA. It also creates ribosomes, structures that grow off the nucleus and help generate proteins to be used in the rest of the cell.

1-3: Proteins made by the ribosomes are 'packaged' and sent to other parts of the cells by the ***Golgi Bodies***.

4-6: To get from the giant Nucleus to any of the smaller organelles, you must first travel through the cell's ***Cytoplasm***.

Golgi Bodies

The Golgi bodies work with the ribosomes and endoplasmic reticulum to make proteins for the cells. These protein molecules are sent by the Golgi bodies to all other parts of the cell, where they can be used to build up the cell or serve other purposes.

1: Some material from the Golgi bodies are sent back to the ***Nucleus***.

2-3: Other proteins are used to help build rigid structures in the ***Cell Wall***.

4-6: The rest of the proteins are sent via the ***Cytoplasm*** to all other parts of the cell.

Cytoplasm

Also called cytosol, cytoplasm is a sort of fluid inside the cell which all organelles 'float' in. It fills all the space in the cell not occupied by the organelles.

From the Cytoplasm you can easily see and visit any of the other major organelles, such as:

1: the ***Nucleus***

2: the ***Mitochondria***

3-4: the ***Chloroplasts***

5-6: the ***Vacuoles***

Name: ____________________

Date: ____________________

My Cell Travel Sheet

1: Starting location:____________________

2: Next Destination: ____________________

3: Next Destination: ____________________

4: Next Destination: ____________________

5: Next Destination: ____________________

6: Next Destination: ____________________

7: Next Destination: ____________________

8: Next Destination: ____________________

9: Next Destination: ____________________

10: Next Destination: ____________________

I.G DNA Codes

NAME: BEN JOHNSON

GRADE LEVEL – 6TH

LESSON TIME – 1 HOUR, CONSISTING OF A SHORT LECTURE AND ACTIVITIES.

INSTRUCTIONAL MODE – INDIVIDUAL

TEAM/GROUP SIZE – VARIABLE

SUMMARY – **This activity demonstrates how information can be coded into DNA in cells. Students are given a code which translates letters into a code of DNA base pairs. They can use this to change English words into DNA code and vice versa.**

LEARNING OBJECTIVES –

Students will:	**WPS Benchmarks**
Compare and contrast plant and animal cells, including major organelles (cell membrane, cell wall, nucleus, cytoplasm, chloroplasts, mitochondria, vacuoles).	06.SC.LS.05
Observe a range of plant and animal cells to identify the cell wall, cell membrane, chloroplasts, vacuoles, nucleus and cytoplasm when present.	06.SC.LS.06
Recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out. The way in which cells function is similar in all living organisms.	06.SC.LS.07

Students will:	MSTECF Standards
Compare and contrast plant and animal cells, including major organelles (cell membrane, cell wall, nucleus, cytoplasm, chloroplasts, mitochondria, vacuoles).	6.2.3
Recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out. The way in which cells function is similar in all living organisms.	6.2.4

ESSENTIAL QUESTIONS –

- How does DNA store genetic information ?

INTRODUCTION / MOTIVATION –

Explain that the nucleus is the largest organelle and that it contains chromosomes, which contain DNA, which contain information for the cell. This information is encoded into a series of proteins ; the sequence of proteins determines what they mean, much like a code.

PROCEDURE –

1.) Introduction / Motivation

2.) Demonstrate the idea of a simple substitution cipher – that is, one in which a letter of the alphabet represents a different letter of the alphabet. Show a few simple examples.

3.) Demonstrate how, if given the key to a substitution cipher, it is relatively easy to translate the code back into English. This shows that such a cipher would be very hard to read without the key, but fairly easy to translate with it.

4.) Explain how DNA is made of chains of four proteins (A, C, G, T) and that the significance of the DNA depends on how they are ordered in the gene.

5.) Show students the cipher key for the DNA code (below). Like a substitution cipher, each letter of the alphabet is replaced by a unique alternate; however, in this case the substitute is a triplet of DNA proteins.

6.) Let students work on the activity sheet.

MATERIALS LIST (PER CLASS, PER GROUP AND / OR PER STUDENT) --

-Copies of the attached activity sheet.

VOCABULARY WITH DEFINITION –

<u>DNA</u> – Deoxyribonucleic Acid. A chain of proteins found in the nucleus of a cell which governs the cell's actions.

<u>Chromosome</u> – A structure inside the nucleus made of DNA.

ASSESSMENT/EVALUATION OF STUDENTS – Activity Sheet

Lesson Extensions – none

Attachments – Activity Sheets

Troubleshooting Tips – none

Safety Issues – none

Redirect URL – N/A

Key Words – DNA

[Note: possible activity sheets are available as the word document DNA Activities. It is also possible to make other activities from the same code.]

A code is a system of translating a message into a series of letters and other symbols. The coded message then becomes very difficult to read without knowing how to convert between the coded language and one that is easy to read.

Here is a coded message:

Lutehk ehvunsydeuh ec y icavim sayhc uv cdunehk yht dnyhcvannehk tydy. Frema ahlutat, y saccyka ec jano tevvelimd du nayt. Fedr dra luta gao, rufajan, ec ed ayco du dnyhcmyda dra luta ehdu y naytypma myhkiyka.

It doesn't make much sense, does it?

You can't read this message now, but if you knew how to make this code, you could reverse the process. This would turn the coded words back into English.

Here is the key for the message code:

English	Code	English	Code
A=	Y	N=	H
B=	P	O=	U
C=	L	P=	B
D=	T	Q=	X
E=	A	R=	N
F=	V	S=	C
G=	K	T=	D
H=	R	U=	I
I=	E	V=	J
J=	Z	W=	F
K=	G	X=	Q
L=	M	Y=	O
M=	S	Z=	W

We can use this to replace the coded letters with English ones. That way, this:

Lutehk ehvunsydeuh ec y icavim sayhc uv cdunehk yht dnyhcvannehk tydy. Frema ahlutat, y saccyka ec jano tevvelimd du nayt. Fedr dra luta gao, rufajan, ec ed ayco du dnyhcmyda dra luta ehdu y naytypma myhkiyka.

Becomes this:

Coding information is a useful means of storing and transferring data. While encoded, a message is very difficult to read. With the code key, however, it is easy to translate the code into a readable language.

Other kinds of codes:

There are lots of ways to turn normal text into code.

-**Displacement Cipher**: Replace every letter in a message with the next letter in the alphabet. A's become B's, B's become C's, and so on. So, the sentence:

Let's go to the movies.

Becomes:

Mfu't hp up uif npwjft.

-**Replacement Cipher**: Replace each letter in the original message with a random letter. The first example was a cipher of this type. With that code:

Let's go to the movies.

Becomes:

Mad'c ku du dra sujeac.

-**Machine or Binary Language:** Computers and machines can't understand spoken language, so instructions for them must be translated into machine language, which contains only 0's and 1's. The sentence:

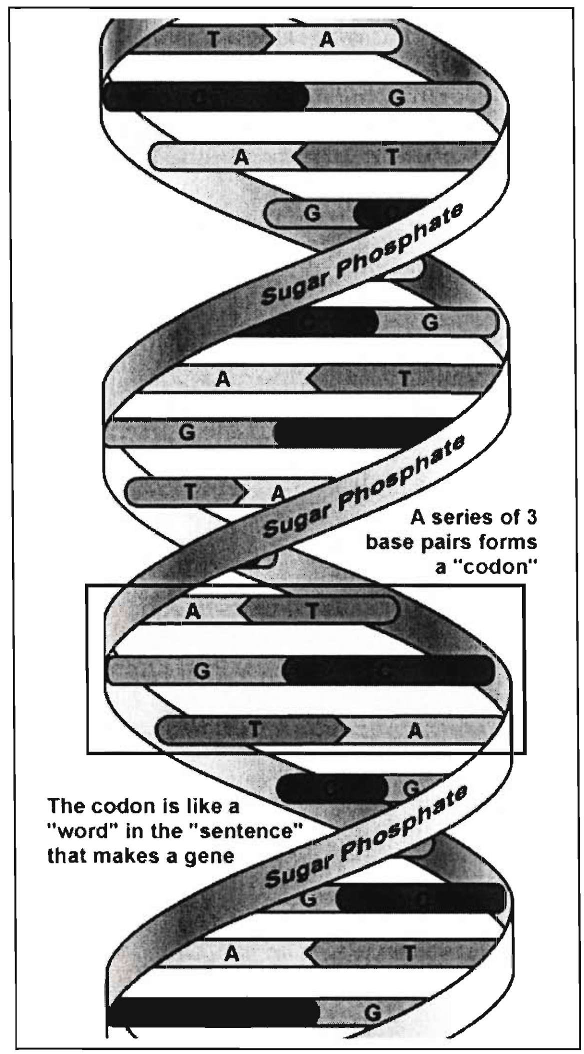
Let's go to the movies.

In binary language, looks like:
01001100 01100101 01110100 01110011 01100111 01101111 01110100 01101111 01110100 01101000 01100101 01101101 01101111 01110110 01101001 01100101 01110011.

DNA Coding

Your DNA contains instructions that tell the cell how to operate. It's like a computer, though - cells don't understand English! So, they have ways of encoding the cell's instructions in a way that can be stored and interpreted by the cell. That's what DNA is: the storage area for those encoded instructions.

DNA up close looks something like this:



The letters represent proteins; DNA contains long strands of four proteins in some combination: **Adenine, Guanine, Cytosine, and Thymine**, usually abbreviated A, G, C, and T.

A group of three of these proteins creates a DNA "letter". Long strings of these "letters" spell out the "words" that make up the cell's instructions.

DNA Code

A: AAA
B: GCA
C: CTA
D: GTA
E: AAC
F: ACA
G: GCC
H: ATA
I: AAG
J: GCG
K: ACC
L: TTA
M: ATC
Space: GGG

N: ATG
O: CAA
P: GCT
Q: GGA
R: TTC
S: CTC
T: TTG
U: GAA
V: TGA
W: ACG
X: TGC
Y: TCA
Z: AGA
Period: TTT

__Translation 1__: **Break down these English words into their genetic code.**

1) FAN ____

2) BOOK ____

3) ESSAY ____

4) FLOOR ____

5) WINDOW ____

6) PENCIL ____

7) STUDENT ____

8) ANSWERS ____

9) QUESTIONS ____

10) EDUCATION ____

__Translation 2__: **Translate these DNA codes into the English words they represent.**

1) ATCAAAATG ____

2) TTGTTCAACAAC ____

3) ACACAATTCACCCTC ____

4) CTCATCAAATTCTTG____

5) TTCAACCTAAACCTCCTC ____

6) GCTGAATTCGCTTTAAAC ____

7) TTCAACAAAGTAAAGATGGCC ____

8) ATACAAATCAACACGCAATTCACC ____

9) CTCAACTGAAACATGTTGAACAACATG

____

10) TTAGAAATGCTAATAGGGTTGAAGATCAAC

____

Mutation

A) Write a brief message here:______________________________

B) Translate it into DNA code:

____

Fold the paper so only part B is showing, and pass it to the next person.

C) Translate the code above into English:_________________________

Fold the paper so only part C is showing, and pass it to the next person.

D) Translate the message above into DNA code:

____

Fold the paper so only part D is showing, and pass it to the next person.

E) Translate the code above into English:_________________________

Fold the paper so only part E is showing, and pass it to the next person.

F) Translate the message above into DNA code:

____

Fold the paper so only part F is showing, and pass it to the next person.

G) Translate the code above into English:_________________________

Unfold the paper and compare the messages in parts A and G. Are they the same, or did the message mutate during the activity?

Extraction: **Translate the DNA codes below. You will get a phrase or group of words that describes something – can you figure out what?**

1) *CTATTAAACAAATTCGGGTTAAAGGGAGAAAAGGTA*
Translation: ______________________________
______________________ Answer: ______________

2) *CAATTCAAAATGGCCAACGGGAAAATGGTAGGGATACAATTG*
Translation: ______________________________
______________________ Answer: ______________

3) *ATCAACAAACTCGAATTCAACCTCGGGTTGATAAAGATGGCCCTC*
Translation: ______________________________
______________________ Answer: ______________

4) *TTCAACGTAGGGACGATAAAGTTGAACGGGGCATTAGAAAAC*
Translation: ______________________________
______________________ Answer: ______________

5) *AAGTTGCTCGGGAAAGGGCTCATCAAATTATTAGGG ACGCAATTCTTAGTATTT*
Translation: ______________________________
______________________ Answer: ______________

I.H Newton's First Law of Motion

NAME: JAMES ROCCI

GRADE: 6

DISCIPLINE: SCIENCE/ENGINEERING

PURPOSE: The students will observe the practice and application Newton's First law of motion:

i. If an object is in motion, it tends to stay in motion. If it is at rest, it tends to stay at rest.

OBJECTIVES:

- No standards are addressed; lesson was done per request of Mrs. Grey, 6th grade, Midland St. School

STUDENT OUTCOMES: The students will gain an understanding of Newton's first law by experiencing properties of inertia.

ESSENTIAL QUESTION: How is Newton's First Law, that is, objects at rest will remain at rest, applied in this experiment?

ACTIVITY	STANDARD
NEWTON'S FIRST LAW The students will experience Newton's first law of motion through an experiment	**INSTRUCTIONAL MODE:** small groups/pair

TOOLS AND RESOURCES:

1st law: Instruct the students bring in an apple from home; realistically it could be anything like a baseball or a tennis ball.

Lesson 1: Newton's First Law

i. If an object is in motion, it tends to stay in motion. If it is at rest, it tends to stay at rest.

Focus on the first law as applied to an object at rest, when an object is at rest, it wishes to remain at rest. (hint: the books)

It has been told that Sir Isaac Newton wrote his three laws of motion while sitting underneath an apple tree. It was said that he was in deep thought contemplating all of the forces of nature that were, at that time, unknown to mankind. He wondered why when rolling a marble across a large surface it would come to a stop. Many people who lived before him thought that an objects natural state is at rest and that was why his marble would come to a stop. Suddenly he was jolted out of his thoughts by an apple falling from the tree above. As thinkers often do, he resorted back to his thoughts on his marble but his thoughts kept returning to the apple for it was the reason why his head ached. And suddenly he came to the conclusion that like the apple falling from the tree, his marble would continue rolling forever had there not been a force acting against it, bringing it to a stop. Unfortunately for him the force that brought the apple to rest was the force exerted from his now swollen head.

We're going to attempt to recreate the very same circumstances that Sir Isaac Newton experienced while he had his great epiphany. By utilizing his first law, that is, that an object in rest will remain in rest and an object in motion will remain in motion unless acted on by an outside force. We're going to drop an apple on our partners head; something that would ordinarily hurt but since we're armed with Newton's Laws we'll be safe.

<u>Procedure:</u>

Consider the weight of the apple in your hand, is it heavy? Would you think it will hurt to have a partner drop it on your head? The higher up your partner holds the apple, the faster it will travel and the more it would hurt. Consider the effect of placing three books on top of your head. How much they weigh in comparison with the apple in your hand. Will you be effected by the apple's sudden drop on your head?

Write a brief paragraph explaining your ideas.

Next: choose which partner would like to be the dropper and which would like to receive the impact. Have courage because you're going to switch.

Move to a small area for which one person can kneel down, while the other stands above,

1. If you're kneeling: rest a stack of 3 books on top of your head
2. If you're standing: hold your apple above your partners head, line it up so that it will hit the stack of books. Make sure your partner is ready. And let it drop.
3. Switch roles with your partner and repeat steps 1 and 2.

After completing the activity answer the following question on your sheet of paper:

Using Newton's first law, specifically the part that states "an object at rest will remain at rest", explain why the force of the apple was not painful.

Supplimental Sheet

NEWTON'S FIRST LAW

1.) Law of inertia: object in motion remains...object at rest remains at rest

Newton's first law of motion states that "An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force." Objects "tend to keep on doing what they're doing." It is the natural tendency of objects to resist changes in their state of motion. This tendency to resist changes in their state of motion is described as inertia.

Listed below are some examples of Newton's first law occurring in everyday events:
a) Car suddenly stops and you strain against the seat belt
b) When riding a horse, the horse suddenly stops and you fly over its head
c) The magician pulls the tablecloth out from under a table full of dishes
d) The difficulty of pushing a car that won't start
e) Car turns left and you appear to slide to the right

EXPLANATION OF ACTIVITY

The activity will consist of having one student kneel or sit on the floor, while holding a stack of 3 books on top of their head. The other student should stand above them holding an apple above the stack, let it fall and the inertia of the books, their large mass will keep the force of the apple from hurting the head of the student. They will only feel a slight bumping sensation.

I.I Newton's Second Laws of Motion

NAME: JAMES ROCCI

GRADE: 6

DISCIPLINE: SCIENCE/ENGINEERING

PURPOSE: The students will practice and apply Newton's Second law of motion:

ii. An object will begin to move (or change its motion) in the direction that a net force is acting. It also says that to accelerate a large mass at the same rate as a smaller mass, you have to add more force.

OBJECTIVES:

- Lesson was done per request of Mrs. Grey, 6th grade, Midland St. School
- For the students to differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.

STUDENT OUTCOMES: The students will gain an understanding of Newton's Second Law beyond practical example and learn to utilize it in an engineering manner.

ESSENTIAL QUESTION: How is Newton's second law applicable for space travel?

ACTIVITY	STANDARD
NEWTON'S SECOND LAW (F=MA) The students will complete the attached worksheet and gain a practical understanding of the law	**INSTRUCTIONAL MODE:** small groups/pair **Framework addressed: [06.SC.PS.01]** Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.

TOOLS AND RESOURCES:

2nd law: Nothing more than regular classroom materials will be required: pencil, blank paper…etc.

Newton's Second Law

The constant within us is our mass, and as we travel to distant planets nothing is changing except the acceleration due to gravity; a result of the mass of the planets. Our "weight" is a determined by the "mass" of the planet that we are standing on.

John is an astronaut from Texas; he weighs 622 newtons (140 pounds) on Earth. Engineers at NASA have designed him a space suit to help him breathe in the vacuum that exists in outer space. They have used titanium parts in the suit so it would be as light and as strong as possible. John plans to travel in his lightship from Earth to the Moon, to Mars, Jupiter and finally all the way to Pluto before returning home again. If the space suit weighs 445 newtons (100 pounds) on Earth, clearly a lot for John to handle, how much will it weigh on the Moon, Mars, Jupiter, and Pluto?

Acceleration due to gravity on earth	= 9.8 m/s^2
Acceleration due to gravity on the Moon	= 1.63 m/s^2
Acceleration due to gravity on Mars	= 3.75 m/s^2
Acceleration due to gravity on Jupiter	= 26 m/s^2
Acceleration due to gravity on Pluto	= 0.61 m/s^2

Acceleration is due to the relative sizes of the planets and the mass is constant so the weight of the suit will change as a result. Thus weight is a force (F). Acceleration due to gravity on earth is a = 9.8 meters per $second^2$ so just divide by 9.8 in order to determine the mass (m). From there do the F=m*a calculations, providing the acceleration due to gravity for maybe 3 of the same planets.

Force = Mass * acceleration

Newtons = kilograms * $meters/second^2$

Example problem: *if I "weigh" 180 pounds (that's 800 newtons) on* Earth, *how much will I weigh on the* moon?

My mass is:

$$\frac{\text{my weight on Earth}}{\text{acceleration due to gravity of Earth}} = \frac{800\ \text{kg} \times \text{meter/second}^2}{9.8\text{meters/second}^2} = 81.6\ \text{kg}$$

My weight on the Moon *is:*

$$\text{Force} = \frac{\text{mass}}{\text{acceleration}} = \frac{\text{my mass}}{\text{acceleration due to gravity of the moon}} = \frac{81.6\ \text{kg}}{1.63\ \text{meters/second}^2}$$

Fill in the blanks in the space provided

Mass of John's suit: __________

Weight of suit on the Moon: __________

Weight of suit on Mars: __________

Weight of suit on Jupiter: __________

Weight of suit on Pluto: __________

Optional demonstration for Newton's Second Law

Acquire a piece of wood that would suit for serving as a ramp and a small toy car that will be able to take the addition of weights.

Introduce gravity to the children by first introducing acceleration. Explain what we know about gravity and that is essentially acceleration caused by the mass of all objects (and that *all* objects are a source of gravity including you and me). Explain that acceleration can be felt when you get in an elevator, or on a rollercoaster, or even when you're driving in your parents car (change in velocity). Acceleration is the force that makes your body slide left when you corner right, or moves your body into the seatbelt when the car stops suddenly.

Broaden their scope by explaining the mass of the Earth compared to that of the moon and that earth's gravity is much greater as a result of its greater mass. Relate this phenomenon to an image that they can all conjure, an astronaut walking on the moon, using little, bouncy steps in order to gap large distances. Finally relate the concepts; the gravity of the moon is less thus the downward acceleration is less, and minimal effort must be used in order to lift oneself from the surface.

Description of demonstration

The purpose of the activity associated with this lesson plan will be to observe the second law of motion as it occurs.

A car will be manufactured or purchased before the implementation of the lesson that will allow for the temporary addition of weights. A piece of clay will be placed as a crash bumper for which the forces can be compared between the two cars, weighted and non-weighted (F=ma, the proctor making note that the larger force is not due to a larger acceleration but rather due to the larger mass). The respective sizes of the force of the impact can be noted by the size of the indent left by the bumper into the clay.

The activity will be for the car to roll down a fixed slope and observe the effect that the bumper has on the piece of clay. The proctor will then add weight to the car and make note the much larger force being applied to the clay.

Force = **Mass** * acceleration

I.J Newton's Third Law of Motion

NAME: JAMES ROCCI

GRADE: 6

DISCIPLINE: SCIENCE/ENGINEERING

PURPOSE: The students will practice and apply Newton's three laws of motion:

iii. Forces work in pairs. For every action there is an equal and opposite reaction.

OBJECTIVES:

- No standards are addressed; lesson was done per request of Mrs. Grey, 6th grade, Midland St. School

STUDENT OUTCOMES: The students will gain an understanding of Newton's Laws beyond practical example and learn to utilize them in an engineering manner.

ESSENTIAL QUESTION: How is Newton's Third law applicable in everyday life?

ACTIVITY	STANDARD
NEWTON'S THIRD LAW & SUMMARY ACTIVITY What forces are at work?	**INSTRUCTIONAL MODE:** small groups/pair

TOOLS AND RESOURCES:

`3rd Law Lesson 1:` Nothing more than regular classroom materials will be required: pencil, blank paper, and books.

`Optional Demonstration:` A board for a ramp as well as a car with weights and some clay to be attached to a stopper.

Newton's Third Law

You are given an engineering design task by your boss. That is, to build a stand for his books out of paper and tape and to make it as *inexpensive* and *strong* as possible.

Instructions:

Work in pairs to design a structure to hold up as many books as possible. The structure must be at least 4 inches tall and is to be constructed from Xerox paper (regular 8.5 x 11 printer paper). Each sheet needed for the final design costs $20 dollars though your allowed as many as you may need for the brainstorming phase. Tape may be used at a cost of $5 dollars per half inch and may or may not be used, as you wish. Tape is free for the prototype, but use sparingly for the prototype should be designed with the same goals in mind as the final product.

Begin by brainstorming ideas with your partner. No idea is a bad idea at this point. You're only trying to stir up ideas within one another. Be creative; think about things that you may observe in buildings or in nature. Do this for approximately 5 minutes.

Now begins the fun challenge: make a prototype, don't be afraid to make mistakes in this stage because the paper is free to you.

Next: build your final product and record your costs on a separate sheet of paper.

Finally: we test our design to see who can hold the most books.

Scoring Algorithm:

$$\text{\# of books supported} * \left[\frac{20}{(\text{cost})}\right] = \text{final score}$$

Supplimental Sheet

Newton's Third Law

3.) For every action there is an equal and opposite reaction.

Listed below are some examples of the third law:
a) Rockets leaving earth--many physicists of the nineteen hundreds (Goddard's time) said that rockets could never leave the earth. Discuss how a spaceship flies in space.
b) guns being fired- discuss why they kick in proportion to the size of the bullet. Why is the stock of the rifle so large? What would happen if the stock of a shotgun came back to a point shape?
c) Two cars hit head on
d) Pool or billiards
e) Jumping out of a boat onto the dock
f) Sprinklers rotating

Explanation of activity

The scoring algorithm is designed to penalize for high costs since the minimum cost is 20 dollars.

I.K Conduction

NAME – BEN JOHNSON

GRADE LEVEL – 6TH

LESSON TIME – 1 CLASS PERIOD

INSTRUCTIONAL MODE –SMALL GROUP (ACTIVITY)

TEAM/GROUP SIZE – VARIABLE

Summary – This lesson uses instruction and demonstration to introduce students to the concepts of heat, heat transfer, and conduction (as opposed to other forms of heat transfer.)

LEARNING OBJECTIVES –

Students will:	**WPS Benchmarks**
Differentiate between radiation, conduction, and convection, the three mechanisms by which heat is transferred through the earth's system.	06.SC.ES.05

Students will:	**MSTECF Standards**
Recognize that heat is a form of energy and that temperature change results from adding or taking	

away heat from a system.	
Explain the effect of heat on particle motion through a description of what happens to particles during a change in phase	
Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium.	

ESSENTIAL QUESTIONS – -What is heat, and how is it different from temperature ?

-What is conduction, and how is it different from other forms of heat transfer ?

INTRODUCTION / MOTIVATION –

Make sure students understand the concept of heat – hot things have a lot of heat in them, and cold things have less heat.

PROCEDURE –

1) Introduction and motivation
2) Briefly go over temperatures and explain that temperature is a way of measuring how much heat is in something. Go over the two main temperature scales, Fahrenheit and Centigrade, and make sure students know important points on both scales – freezing point of water (32 F, 0 C), room temperature (about 70 F or 21 C), human body temperature (98.6 F, 37 C), and boiling point of water (212 F, 100 C).

3) Give a definition of heat in terms of molecules – objects are made of molecules, and objects with more heat in them have molecules that vibrate faster.
4) Explain that when things of different temperature are near each other, heat flows between them, from the object with more heat to the one with less. This happens in one of three ways: Radiation, Convection, and **Conduction**, the focus of this lesson.

Demonstration:

1) First take a slinky and two volunteers. Have them stand several feet apart, so that the slinky is stretched. Ask one to hold their end of the slinky still and the other to slowly shake theirs. Show that after a short while, the other end of the slinky will also be shaking. Explain that conduction works the same way. The molecules on one end vibrate, which impacts molecules next to them, so that soon all molecules have gained heat.
2) Have the students stop shaking the slinky and let it come to rest. Then ask one of the students to shake their end much faster. The vibrations should be greater and should transfer through the slinky more rapidly. Explain that in objects, more heat means more vibrations and that those vibrations conduct through the material faster.

3) Have one or two students come up and hold the slinky in the middle. Then have it shaken again. The students in the middle should interfere with the shaking, causing it to take longer for the entire slinky to shake. Have more students come up and repeat; it should take even longer. Explain that some materials do not conduct heat well; such materials are called insulators.

4) Have all students sit and divide into groups. Have them think of some materials that conduct heat very well and some that insulate very well. Ask them also to think of possible uses for these materials that take advantage of their heat transfer properties.

MATERIALS LIST (PER CLASS, PER GROUP AND / OR PER STUDENT) –

-A slinky

ASSESSMENT/EVALUATION OF STUDENTS – This lesson is part of a unit on heat and temperature, and will have one evaluation for the entire unit.

ATTACHMENTS – None

I.L Mass and Weight (Skeleton)

Lesson Title – (Mass and weight)

Grade Level – 6th Grade

Lesson Time – 3 Class Periods, 1 hour each

Instructional Mode – Small Group Activity

Team/Group Size – Groups of 2 - 4

Summary – The students will be introduced to the different concepts of mass and weight through investigations of properties of different materials in relation to a hypothesized space exploration to different planets. The lesson is composed of lecture, experimentation, and assessment.

Learning Objectives –

Students will:	WPS Benchmarks:
Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g., weight, strength, hardness and flexibility).	06.SC.TE.01
Identify and explain the steps of the engineering design process, e.g., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.	06.SC.TE.07
Demonstrate methods of representing solution to a design problem, e.g., sketches, orthographic projections, multiview drawings.	06.SC.TE.08
Describe and explain the purpose of a given prototype.	06.SC.TE.09
Given a prototype, design a test to evaluate whether it meets the design specifications.	06.SC.TE.13
Communicate the results of an engineering design through a coherent written, oral or visual presentations.	06.SC.TE.15
Develop plans, including drawings with measurements and details of construction, and construct a model of a solution, exhibiting a degree of craftsmanship.	06.SC.TE.16
Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object	06.SC.PS.01
Explain how to determine the weight of a dense object in air and in water	06.SC.PS.02
Differentiate between volume and mass	06.SC.PS.03
Explain and give examples of how mass is conserved in a closed system	06.SC.PS.07

Essential Questions –

- What is mass, and what is weight?
- Why do we have to differentiate mass and weight?
- Why must engineers use these concepts?
- What is aerospace engineering and where can it take us?
- Why do we have to figure out the mass and weight of everything in a space flight ?

Introduction / Motivation –

Space flight must be designed to be the perfect journey, and since gravity on other planets may differ from the Earth's, it is important to consider the mass and weights of objects to be put into a space exploration vehicle. This lesson places same amount of focus on the conceptual and mathematical parts of the ideas of mass and weight.

Procedure –

1. Ask the student to define aerospace engineering then give the right definition.
2. Shows Flying Machines PowerPoint presentation (inventions by aerospace engineers) with projector.
3. Point out to the students that physics, especially the relationship of mass and weight, and mathematics are very crucial in learning aerospace engineering.
4. Define for the student: matter, mass, weight, gravity, weightlessness.
5. Show video of: a mass on balance in an accelerating and decelerating elevator (to demonstrate changing weight but not changing mass); astronauts on the moon (to demonstrate affect of decreased gravity); astronauts in spacecrafts(to demonstrate weightlessness) , etc.
6. Point out to the students the possible problems in space exploration if the masses and weights of objects in different places in space
   - Too much mass than expected would cause too hard a landing and immobilization because of too much friction and not enough power.
   - Too little mass may cause the spacecraft to detach from intended trajectory or immobilization because of too little friction.

- Example: on the Apollo 13 mission, the astronauts needed to add more mass into the reentry vehicle so it won't skip off Earth's atmosphere.

7. Remind the students about the engineering process they are to employ in the experiment
8. Present the engineering problem (See attachment) to the students, by groups.
9. Assessment (worksheet as a quiz or homework) for students

Materials List (per class, per group and / or per student) – Quantity to be determined

Cardboard
Thin plywood sheets
Aluminum foil
Popsicle sticks
Plastic Straws
Glue
Paper
Tape

Vocabulary with Definition –

Aerospace Engineering – A discipline that concerns with the understanding, analysis, design, and operation of aerospace vehicles operating within, above, and beyond earth's atmosphere

Aerospace Vehicle – A device that is used or intended for flight (flying)

Gravity- the force of attraction that exist between any two objects

Mass – internal property of an object, describes the amount of matter in the object

Weight – amount of pull of gravity on an object's mass

Matter – Anything that has mass and occupies space

Gravity – attraction and acceleration of an object toward the center of another object

Weightlessness – experience of apparently having no weight. A person can experience weightlessness during a long fall, or in a spaceship.

Assessment/Evaluation of Students – handout, engineering design problem sheets, presentation of prototype, and worksheet with math and conceptual questions (as quiz or homework)

Lesson Extensions – Force and Motion

Attachments – Flying Machines PowerPoint presentation. Companion to Flying Machines Presentation. Engineering Problem Procedure for teachers and assistants (Attached in this document). Background information for teachers on mass and weight (Attached in this document).

To be designed: student work sheets of the problem, "data sheet for the planet", and "final assessment"

Troubleshooting Tips – none

Safety Issues – none

Redirect URL – none

Key Words – Aerospace Engineering, Mass, Weight, Matter, Density, Weightlessness, gravity

Developed by – William Chiu-Kit Wong (wckwong@wpi.edu)

Engineering Problem (not yet named) Procedure – For teacher and assistants

The problem involves students designing for NASA a space exploration vehicle that is to be deployed to planets with different gravities. **Each group would get one planet and a set of features of the planet, such as gravity and roughness of terrains.** The functional design of the vehicles is not important in this exercise, instead, we are going to specify what functions and features the machines would have; **the students' parts in this exercise is to conduct calculations and choose the right materials for the design**. **The intention is for students to decide the suitable materials to use in the spacecraft in order to have a successful flight –one that would be landed safely and still mobile in its destination.** Mass and weight are the focus and the deciding factors in this exercise.

1. Introduce the above problem to the students
2. Give out a worksheet that outlines the problem and also the constraints for each planets
3. Explain to the students the functionality of the vehicle along with its features that are required
4. Give out a data sheet with simplified data of the selection of materials
    a. Lists weight (on earth), density, and features such as hardness and flexibility
    b. Also lists the substitutions of the intended materials, for example: popsicle sticks = reinforced steel bars
5. Help the students with math involving the conversions of weight on earth and on the planets
    a. All the time remind students of the physical properties of the materials
    b. Try to steer the students to think of a light, yet strong design
6. Help to students decide what materials and how much of each to be used on the design
    a. Remember to put focus on mass and weight
    b. Try to steer the students toward a unified decision, since someone is bound to disagree with the group
7. Help the students figure out a design that is limited by the amount of materials used, rather than by functionality and features.
8. Help the students construct the mock prototype with the materials provided
    a. Remind students of the design process
    b. Require students to make drawings and write down important notes
9. Have the students present their design for the class
    a. What are the features of the planet
    b. What are the constraints of material
    c. How and why are the materials chosen
    d. Demonstration of how the vehicle works

If at all possible, the students can submit their drawings to be made into a computer model of the prototype. This may heighten their interests and prompt them to make better drawings and better explanations.

Mass and Weight

We often use the terms "mass" and "weight" interchangeably in our daily speech, but to an astronomer or a physicist they are completely different things. The mass of a body is a measure of how much matter it contains. An object with mass has a quality called **inertia**. If you shake an object like a stone in your hand, you would notice that it takes a push to get it moving, and another push to stop it again. If the stone is at rest, it wants to remain at rest. Once you've got it moving, it wants to stay moving. This quality or "sluggishness" of matter is its inertia. Mass is a measure of how much inertia an object displays.

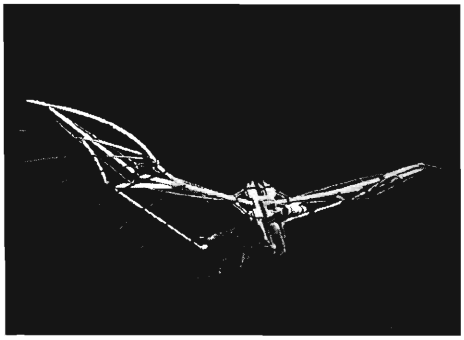
Everything with mass exerts gravity on other objects. The force of gravity is related to the sizes and the masses of both of the objects.

Weight is an entirely different thing. Every object in the universe with mass attracts every other object with mass. The amount of attraction depends on the size of the masses and how far apart they are. For everyday-sized objects, this gravitational pull is vanishingly small, but the pull between a very large object, like the Earth, and another object, like you, can be easily measured. How? All you have to do is stand on a scale! Scales measure the force of attraction between you and the Earth. This force of attraction between you and the Earth (or any other planet) is called your weight.

If you are in a spaceship far between the stars and you put a scale underneath you, the scale would read zero. Your weight is zero. You are weightless. There is an anvil floating next to you. It's also weightless. Are you or the anvil mass-less? Absolutely not. If you grabbed the anvil and tried to shake it, you would have to push it to get it going and pull it to get it to stop. It still has inertia, and hence mass, yet it has no weight. See the difference?

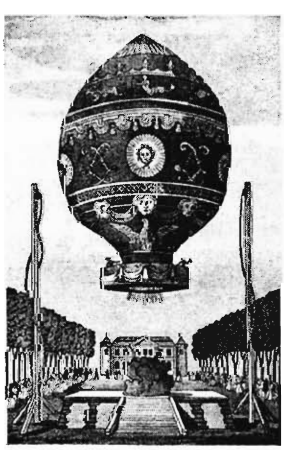
From website (http://www.exploratorium.edu/ronh/weight/index.html)

PowerPoint Presentation and its companion information sheet

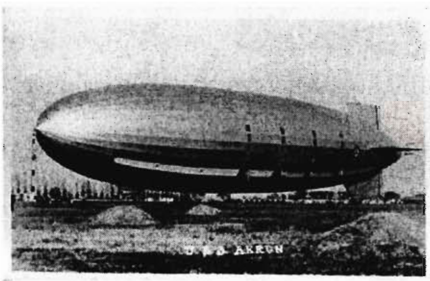


Slide 1 - Da Vinci Gilder
Model from drawings of Leonardo Da Vinci's concept of a gliding machine in the 15^{th} century A.D. It is not known if it was built, and it is only one of several concepts of flying machine he had.

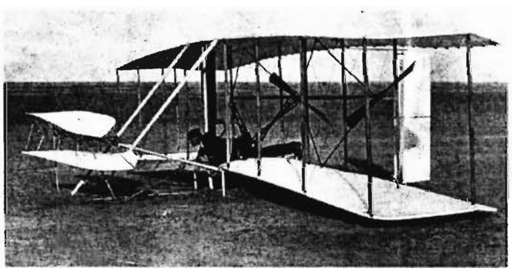
Slide 2 - Wan-Hoo's Rocket Chair
Chinese inventor Wan-Hoo's rocket chair around early 16^{th} century A.D. He tied 47 rockets to a chair to attempt to reach moon. He and the chair vanished after a huge explosion, gone to the moon?



Slide 3 – Hot Air Balloon
First manned air balloon flight in 1783 in Paris. The balloon was made with silk and paper. Flew 500 ft over the palace of Louis XVI and landed safely.



Slide 4 - Zeppelin
First zeppelin flight Took place in Germany in 1900. Flew by Count Ferdinand von Zeppelin at 18 mph for 3.1 miles.



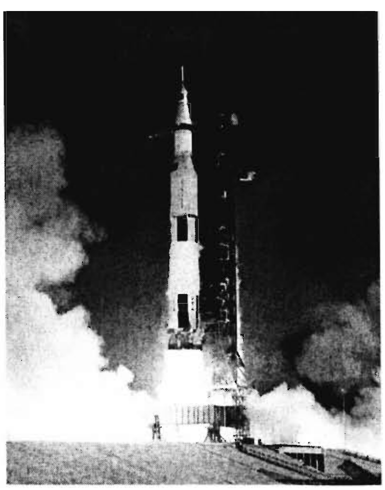
Slide 5 – Wright Brothers' Kitty Hawk
First manned airplane flight by the Wright brothers at Kitty Hawk, N.C.. It had a homemade 12-horse power engine, flew the first time by Orville for 12 seconds, and by Wilbur for 59 seconds.

Slide 6 - Helicopter
Helicopter of today. The first flight was conducted in 1907, a French scientist rode in a twin-rotored helicopter and hovered the ground for a few seconds.

Slide 7 – Liquid-Fuelled Rocket
A liquid-fuelled rocket developed by Robert Goddard, a former professor at Worcester Polytechnic Institute. First rocket that used liquid-fuel. Took flight on March 16, 1926 in Auburn, Mass. He is considered the father of modern rocketry.

Slide 8 - Sputnik

Sputnik, the Russian made artificial satellite became the first one to be launched into space on Oct 4, 1957. It was about 180 pounds and orbited the Earth in 98 minutes. It was the first step into space that many called the dawn of the Space Age

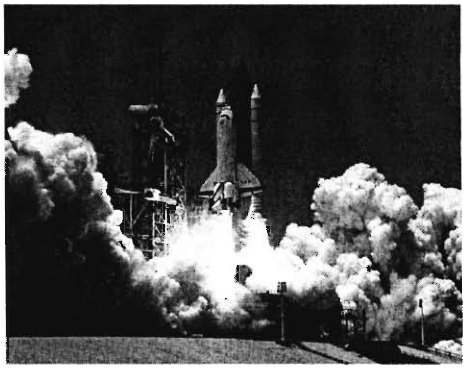


Slide 9 – Apollo 11

Manned rocket of Apollo 11 in 1969. It was the successful mission that landed two American astronauts on the moon. “One small step for man, one giant leap for mankind.”

Slide 10 – Concord Supersonic Jet

First commercial jet to reach the speed of sound in 1969. The Concord was one of the biggest and fastest airplanes ever developed. The last flight of the Concord Jet was in 2003. They stopped because of environmental and economic concerns



Slide 11 – Space Shuttle
The first space shuttle flight was made by the crew of Space Shuttle Columbia on April 12, 1981. It was the most technologically advanced machine in the world, and it also enabled a lot more activities and research to be done in space because of more space in the spacecraft than the small capsule form the space-rocket days.

Slide 12 - SpaceShipOne
The first suborbital flight of SpaceShipOne was made in Jun 11, 2004. It was the first flight into space by a privately own and operated spacecraft. It was designed by Burt Rutan and flew by civilian pilot Mike Melvill. The craft was carried by a plane, the White Knight into air then detach form the carrier and propelled into suborbital space by a rocket engine.

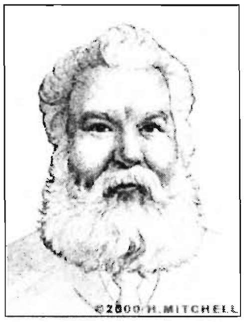
APPENDIX II Inventor Biographies (Will)

Significant Inventions and Inventor Profiles

These are the profiles of the inventors the students would be interested in reading. The underlined words in each profile are words that the students should look up and put into the engineering notebook for reference and may increase their vocabulary skills. The intention of having this activity was discussed in section 5.3.

Information on these inventors is gathered from an "Inventor of the Week" website hosted by MIT (http://web.mit.edu/invent/i-archive.html), and the Inventor Hall of Fame website (http://www.invent.org/hall_of_fame/1_1_search.asp). These two websites have useful information that was adopted and modified the contents to sixth-grade reading level.

The List of Inventor Profiles



Alexander Graham Bell

Born Mar 3 1847 - Died Aug 2 1922

Invention/Contribution

Telephone, Airplane, Watercraft, HD-4
Photophone (concept that led to the cellular phone technology)

Inventor Biography

A genius born in Edinburgh, Scotland, Bell spent several years at schools and universities but was mainly self-taught. His mother was almost deaf, and his father was the inventor of the world's first phonetic alphabet. Before he immigrated to the United States in 1871, Alexander would give speech lessons to deaf children that lived around him. Bell was very gifted with science and music in an early age; he was a capable pianist with very good ear for pitch but also noticed small details in the world that would lead to great scientific discoveries. For example, he noticed that a chord struck in a piano would cause an echo of the same pitch at a piano in the next room; Bell figured that the frequency of the vibrations in one piano could be transmitted through air to the second piano. It is a small detail that would lead to the concept of a telephone.

To create the first telephone, Bell remembered his experiments with pianos and realized that if a vibration of sound can be transmitted by air and by solid materials, it may as well be carried by electronic signals. So Bell studied the technology of telegraphy and the Morse Code in order to understand how signals can be transmitted through electric wires. He then combined different concepts of electricity and sound vibration to propose that vibrations from sound can disturb an electronic signal that can be carried from one end of the wire to another. Furthermore, he deduced that if human speech is just complex sound vibrations, we may be able to talk into one end of an electric wire and someone on the other end could hear us!

By 1875, Bell had made the first prototype of a telephone system, and in the next few years he demonstrated how people can talk to each other through electric wires and currents, overwhelming the public. In 1877, he planted two telephones in two towns, eight miles apart in Canada, and two months later, a long-distance phone line of 143 miles was created.

Bell did not only created the telephone, he patented a device call photophone, which uses lights to transmit sound, and was the basis of cellular phone we use now. Also, he created an airplane that flew half a mile six years after the Wright brothers' first flight. At the end of his life, Bell also created one of the best watercraft in the world, the HD-4. Even though he invented so much, Bell will always be remembered as the forerunner of the new science called telecommunications, which brought people all over the world together through technology.

If you are interested, you may visit http://www.indiana.edu/~ctwardy/ to read Bell's original notebook.

Name: ______________________________ Date: ______________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) What was the first phenomenon Bell encountered that led to his invention of a telephone?

2) What did Bell compare human speech to?

3) What is a photophone? Is it still in used in some form today?

4) Briefly describe Bell's conclusion involving the concepts of sound vibrations and electricity.

5) Fill in the blank: Bell is considered the father of the new science______________.

Extra credits: Define the following words

Phonetic alphabet -

vibration -

deduced -

Answer Key Bell

1) The phenomenon that Bell noticed that lead to his invention is that a chord struck at a piano would cause vibration of the same chord at another piano nearby. Scientifically it's called resonance

2) He suggested that human speech is a series of complex sounds and vibrations

3) A photophone is a communication device that uses light to transmit sounds. Just like today's cellular phone. (Cellular phones use electromagnetic waves for signal)

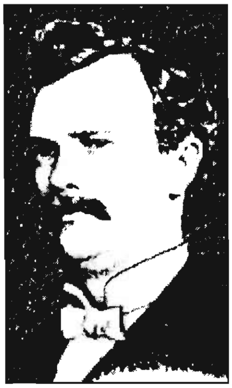
4) He proposed that vibrations from sound can disturb an electronic signal that can be carried from one end of the wire to another.

5) Telecommunications

E.C.

Vibration: things shaking, periodic motion of a body

Deduced: act of solving a problem though logics



William Seward Burroughs
Born Jan 28 1857 - Died Sep 14 1898

Achievement
Calculating Machine
Calculator

Inventor Biography

Born in Rochester, New York, Burroughs began his career as a bank clerk in the Cayuga County National Bank in Auburn, New York. Prototypes of calculating machines were already made by others but none worked well. Working in a bank and seeing how a machine that can perform accurate mathematical calculation can help accountants and bookkeepers spend less time correcting their mistakes; Burroughs started to have thoughts and ideas of such an invention.

In 1882, poor health forced Burroughs to relocate to St. Louis, Mississippi and Burroughs began work on his mechanical accounting device shortly after. Seeing his vision, a shop owner, William Joseph Boyer of the Boyer Machine Shop provided help to Burroughs in the form of a work bench in his company and an assistant, Alfred Doughty, who later became president of the Burroughs Adding Machine Company.

The first practical adding and listing machine was made in 1885, and in 1886 Burroughs and several St. Louis businessmen formed the American Arithmometer Co. to market the machine at a price of $475, a price so huge at that time only large businesses could afford them. The first machine, however, required a special way and force to pull the handle, so many inexperienced users had gotten wildly differing sums depending on the force they used in operating the machine. In 1893 Burroughs received a patent for an improved calculating machine, which incorporated an oil-filled 'dashpot,' a hydraulic regulator. This device enabled the machine to operate properly regardless of the manner with which the handle might be pulled.

Burroughs retired from his company in 1897 due to poor health and moved to Citronelle, Alabama, where he died one year later. In the same year more than 1,000 machines had been sold, and by 1926 the company, renamed the Burroughs Adding Machine Company, had produced a million machines.

Name: ______________________________ Date: ________________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) How did Burroughs first get his idea of a calculating machine?

2) How much was Burroughs' calculating machine in 1886? If one dollar at that time equals 50.25 dollars now, how much does the calculating machine worth in today's money? Show calculations

6) How was the calculating machine improved in 1893, how was it better than older machines?

7) What is different between today's calculators and Burroughs' machines? Which do you think would be bigger and harder to use?

8) What was the company was founded after his invention of the calculating machine?

Extra credits: Define the following words

bookkeepers -

Answer Key Burroughs

1. Burroughs first got his idea about a calculating machine when he worked at a bank and saw the tedious work of accountants and tellers doing calculations by hand

2. The machine was $475 and in today's money it would be 475 * 50.25 and would be $23868.75

3. The new device was equipped with a hydraulic regulator that makes the machine's operation smoother and error free.

4. The difference between today's calculator and the calculating machine is that the ones today are made up of mostly electronics, whereas the calculating machine was made up of mostly mechanical components.

5. Burroughs Adding Machine Company

E.C.

Bookkeepers: the profession whose job is to record the transactions of a business.

Earle Dickson

Born ?? – Died 1961

Invention
Band-aid adhesive bandage

Inventor Biography

Not much is known about this man who invented one of the most useful items, but we do know that at the time of his invention, he was working with Johnson & Johnson, the household supply company that still exists today.

Dickson married Josephine Frances Knight in 1917, and he realized that his new wife kept cutting her fingers while working around the kitchen. He also found that while he tried to tend to her wounds, the big bandage that is available at that time was too big and messy.

As an ingenious inventor, he decided to combine surgical tape and sterile gauze together. He would unroll the surgical tape and then fold the gauze into a narrow pad and stick the gauze to the tape. He also put a long and rough piece of cotton over the gauze so the tape wouldn't stick together. His wife could the unroll the tape, cut it, and use it when she cut herself again; and then afterward she would roll it back up and store it in a tight space. The creation saved a lot of space and it beats bringing out all the materials to treat a small wound and applying them individually.

Dickson mentioned his invention to one of his fellow employees at Johnson & Johnson and was encouraged to bring up his creation to his bosses in a meeting. They were not impressed initially but when Dickson showed that he would apply the band-aid to himself easily, the bosses were overwhelmed.

The new band-aids did not sell well at all originally, only $3,000 worth of it was sold in the first year. It may be because the product was 2 1/2 inches wide and 18 inches long. To improve the sales, the company gave free band-aids to the Boy Scout troops, and they certainly spread the news! By 1924 the company was making different sizes of band-aids, and then by 1939, they all came in the box sterilized. The band-aids we use today are improved from the ones in 1958, which were made of sheer vinyl.

Well, remember to thank Mr. Dickson whenever you need a band-aid!

Name: ______________________________ Date: ________________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) At what company did Dickson worked? Is that company still in business?

2) What size was the first bandage? Please tell me the length, width, and area.

3) What is the benefit of Band-Aid?

4) What are the materials that make up a band-aid today?

5) Why did Dickson invent the band-aid? Do you think it is a useful invention? Please explain.

Extra credits: Define the following words
Surgical tape-

gauze-

Answer Key Dickson

1. Dickson worked at Johnson & Johnson. It is still in business today
2. The first band-aid was 2.5 in wide and 18 in long. The area is 45 square in..
3. The benefits for bandage includes ease of use, and the small space it take up.
4. It is made up of sheer vinyl and sterile gauze
5. Dickson invented the band-aid so that his wife could use it to treat her wound easier.

E.C.

Surgical tape: tape that is made especially to use on the human body.

Gauze: a piece of fabric that is used to cover wounds for protection.

Gordon Gould
Born Jul 17 1920

Invention
Light Amplification by Stimulated Emission of Radiation (LASER)
Laser amplifiers

Inventor Biography

Gordon Gould was born in New York City in 1920, eventually became a great fan of Thomas Edison. His "mechanically-minded" mother discovered his interests in science and encouraged him with an excellent college education at Union College and Yale University, where he received his M.S. degree in physic in 1943. Afterward, Gould and a group of elite scientists worked on the Manhattan Project for the U.S. government to develop the nuclear weapons. He then resumed his work for his PhD degree at Columbia University where he studied optics, microwave, and spectroscopy.

In 1957, Gould had a "flash of idea", the LASER, to amplify the energy of light particles, light photons. He based his research on "maser", which amplifies microwave photon, even though it is 1000 times less powerful than the laser. Over a period of 2 days he had built a device that he predicted could heat up an object to have the temperature of the sun in a millionth of a second! However, fearing he needed a wonderfully working prototype, he filed his patent after 2 years, where other scientists had also developed their own laser devices. It took twenty years, but Gould finally did get his patent and was recognized as the inventor of laser.

During those times, Gould worked hard on other devices to stabilize and control the laser beams and provided much needed support in development of the applications of laser in the industrial, commercial, and medical settings. Manufacturers of many products had used laser for welding and cutting; and medical personnel has been using laser for surgery and scanning.

Gould later became a professor at the Polytechnic Institute of New York and established there a new laboratory devoted to the study of laser and optics. He also founded a company to develop optical communication technology in the 1980's that did research and development to further our study of lights and communications. Many modern scientific equipments are using his technology for accurate and dependable operations.

Name: ______________________________________ Date: ___________________

Teacher: _____________________________________

Inventor of the Week Questionnaire

1) What does LASER stand for?

2) What did Gould studies while he was attending Columbia University?

3) What was the Manhattan Project?

4) What do the manufacturers use laser for? What do medical personnel use laser for?

5) Is laser still being used today? What is it used for?

Extra credits: Define the following words

Welding -

optics -

Answer Key Gould

1. LASER stands for Light Amplification by Stimulated Emission of Radiation

2. Gould studied three subjects while he was at Columbia University: optics, microwave, and spectroscopy

3. The Manhattan Project was a project conducted by the United States during the World War II to invent a nuclear weapon

4. Manufacturers use laser for welding and cutting materials. Medical personnel use laser for surgery and scanning

5. Laser is still being used today in optical communication and other scientific equipments

E.C.

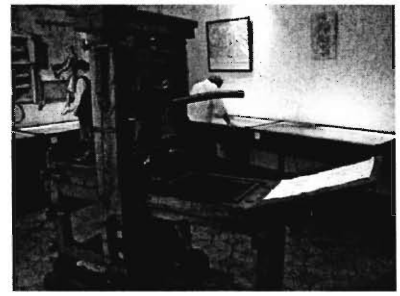
Welding – to join two pieces of metals using heat that melt and fuse the metals

Optics – science that relates to light and vision.

Johann Gutenberg

Born 1397 – Died Feb 3, 1468

Achievement
Movable-type Printing Press, the Gutenberg Bible, faster book production



Inventor Biography

Gutenberg was the son of a Merchant in Mainz, Germany before the Renaissance period in Europe. Not much is known about Johann Gutenberg's early years except he was in the patrician class of the society and thus enabling him to become a goldsmith and a metal worker. It is also known that he had open a shop for metal works and taught his apprentices methods for gem polishing, looking-glass making, and printing.

Before Gutenberg's invention of a movable-type printing press, book making was a very slow process and almost only for documents of the church, especially the bible. Books were first made by monks and scribes spending numerous hours copying and decorating books after books by hand. Then the invention of block-printing came along and made book-making easier and faster. Block-printing involving cutting a piece of hard wood with raised area of pictures and the texts needed to be print, then the block is inked and pressed onto paper. It was a very slow process and very inefficient. Gutenberg knew about this process form his readings and he decided to do something about it.

Several years before 1450, Gutenberg started experimenting with the idea of movable-type printing press, which is to make blocks of letters of the alphabet that can be arranged onto a grid into a set of words and sentences that can be inked and pressed onto pieces of paper, making pages of text. Then after the pages are printed, the types could be rearranged into other words and sentences onto another grid and print other pages. With this process, the printer no longer had to cut the block for each page; he can just make a lot of blocks of letters and arrange them to be different pages of text. When Gutenberg first made the types from hard wood, he found that they don't last long and are not had enough, so he started to use his skill as a goldsmith and made the types from metal

After Gutenberg discovered this new process, he put it to use by making bible in Latin for the church. So between 1450 and 1455, possibly 200 copies of such bibles were made, and they are called the Gutenberg Bibles. They are the most rare printed materials in the world today that a single page may cost up to $100,000!

Even though there may be evidence of Marco Polo bring the idea of movable-type printing technique to Gutenberg from Asia, Gutenberg was considered the inventor of the technique that revolutionized the book printing industry of Europe, enabling the occurrence of the Renaissance.

Name: ______________________________________ Date: ___________________

Teacher: _____________________________________

Inventor of the Week Questionnaire

1) What was Gutenberg's occupation? What did he teach his students?

2) What was Gutenberg's most important invention? How did it affect people?

3) What is a movable-type printing press?

4) Fill in the blank: Gutenberg was born before the ____________________ Period.

5) Where did historians think the idea of a movable-type printing press came from? It may be brought to Gutenberg by whom?

Extra credits: Define the following words

Latin -

Types -

Apprentice -

Answer Key Gutenberg

1. Gutenberg worked as a goldsmith and a metal worker. He taught his students methods of gem polishing, looking glass making, and printing.

2. Gutenberg invented the movable-type printing press that could print books much faster and much less expensive from before. It made knowledge easier to spread and started the Renaissance Period.

3. A movable-type printing press is a printing press that uses blocks engraved with letters to print books. The blocks can be rearranged into different phrases so they can be used again and again.

4. Renaissance

5. Historians think that Marco Polo may have brought the idea of movable-type printing press to Gutenberg from Asia.

E.C.

Latin – a language used in the early time, it forms the basis of English, Spanish, etc

Types – blocks with letters engraved used in printing

Apprentice – student learning under a master workman of crafts.

Robert Koffler Jarvik

Born May 11, 1946

Invention

Inventor of the world's first permanently-implantable artificial heart
Modifications to the artificial heart
Surgical stapler

Inventor Biography

Born in Michigan in 1946, invented the surgical stapler while still in his teens. Then in 1964 when Jarvik was attending the University of Utah, his father became ill with heart disease. He witnessed the hopelessness of patients needing a donor's heart but ultimately failing to survive before a new heart can be provided. In an effort to help those patients live as long as possible with the heart they have, medical scientists and biomedical engineers started to develop electrical devices that would allow the patients to live longer.

Jarvik became interested in the field of medicine and decided to go to the University of Utah's medical school in order to pursuit his ideas to make a superior artificial heart. He graduated with a medical doctor (MD) degree in 1976. But by that time, artificial heart designs had been in development for over 20 years through contributions by animal and human subjects. In 1969 a design by the Texas Heart Institute kept a human patient with an artificial heart for more than 60 hours, scientists and engineers began to have ideas of a permanent implantable heart.

In 1982, Jarvik finished his first model of the artificial heart Jarvik-7; it is the first of its kind that was made of polyester, plastic, and aluminum. It has an internal power system and a system of air hoses that control the blood flow through the device, mimicking circulation in the human body. Animal testing was conducted and soon it was implanted into the first human patient who lived for 112 days after the operation and died of organ failure, however, the heart was still working when the patient passed away.

After the operation on the initial patient, the result of the performance of the heart was considered a success and other Jarviks were implanted into many patients, and one held the record to live the longest after the operation, 18 months. And by the end of 1980's, 70 Jarvik artificial hearts were used to sustain patients' lives waiting for a real heart transplant. And improvements on the original model were constantly made so patients can receive the best of the technology.

Jarvik jumpstarted the development of artificial hearts that are getting more advanced and reliable today.

Name: ______________________________________ Date: ___________________

Teacher: _____________________________________

Inventor of the Week Questionnaire

1) What event brought about Jarvik's wish to invent an artificial heart?

2) What was Jarvik's first artificial heart made of?

3) Fill in the blank: An artificial heart is used to control blood flow to mimic ____________ throughout the body.

4) What kind of engineers help to develop the artificial heart, biomedical and 2 others?

5) Do you think other organs can be made out of machines and transplanted into the body? Please explain.

Extra credits: Define the following words

Artificial –

Circulation –

Answer Key Jarvik

1. Jarvik decided to invent an artificial heart when his father passed away because of heart failure and could not find a donor.

2. Jarvik's first artificial heart was made of polyester, plastic, and aluminum.

3. circulation

4. Biomedical engineers, mechanical engineers, and material engineers

5. There are some artificial organs used for human transplants already, such as artificial heart and artificial limps. But not many had been invented

E.C.

Artificial – man-made.

Circulation – moving of blood through blood vessels from the heart's pumping motion

Charles Franklin Kettering

Born Aug 29 1876 - Died Nov 25 1958

A teacher, farmer, engineer, mechanic, and social philosopher

Achievement
Engine Starting Device; Engine Starting, Lighting and Ignition System, first electric cash register

Charles Franklin Kettering invented the first electrical ignition system and the self-starter for automobile engines and the first practical engine-driven generator along with many other things related to automobile.

Inventor Biography

Born in Loudenville, Ohio, Kettering graduated from Ohio State University in 1904 as an electrical engineer. After graduation, Kettering joined the National Cash Register Company. At that company, he was among many scientists and engineers that developed the first electric cash register, among other inventions.

In 1909 he left the National Cash Register Company and, with businessman Edward A. Deeds, set up the Dayton Engineering Laboratories Company or Delco, where he invented his most significant engine devices, including the electrical engine starting device and portable electrical generator. Kettering's engine-driven generator, named the 'Delco,' provided electricity on millions of farms. Also, he and his company was said to revolutionize the automotive world into the electricity age.

In 1916 Kettering sold his company to General Motors. At G.M. he set up and directed a central research laboratory and stayed for 31 years, until his retirement in 1947. The lab developed the lightweight diesel engine that made the diesel locomotive possible, the refrigerant Freon, four-wheel brakes, safety glass, automatic transmission, and many other items for the automobile industry

Kettering was the holder of some 140 patents. Along with General Motor President Alfred Sloan, he established the Sloan-Kettering Institute for Cancer Research.

Did you know that Kettering's home in Dayton, Ohio was the first home in America to be air conditioned?

Name: ______________________________ Date: _______________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) To what machines did Kettering's inventions improved?

2) Please look up "automatic transmission" and describe it here.

3) What kind of engineer is Kettering?

4) Fill in the blank. Freon is a ________________.

5) What did Kettering and Alfred Sloan establish?

Extra credits: Define the following words
revolutionize-

generator-

safety glass-

automotive-

Answer Key Kettering

1. He made improvements to cash registers, farm equipments, and engines

2. Automatic transmission is a device that automatically changes the gears in machines that provide different gear ratio for different speed and torque requirements

3. He is a mechanical engineering

4. refrigerant

5. Sloan-Kettering Institute for Cancer Research

E.C.

Revolutionize: To bring out a radical change

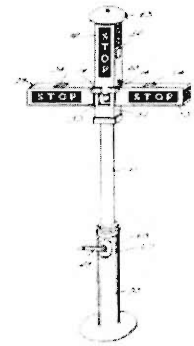
Generator: a machine that convert fuels into energy

Safety glass: a protective device for eyes in a laboratory, a construction site, or a factory setting

Automotive: car-related

Garrett Augustus Morgan

Born Mar 4, 1877 – Died Aug 27, 1963



Achievement

First patented traffic signal, gas mask, zig-zag attachment on sewing machine, human-hair straightener (hair gel)

Inventor Biography

Morgan was born in Paris, Kentucky, and was the son of former slaves (and the 7th of their 11 children). His formal education ended during elementary school.

As a teenager in 1895, Morgan moved north to Cincinnati, Ohio, looking for opportunity. His incredible ability to repair machinery led to many job offers from factories. In 1907, he started his own sewing equipment and clothing repair shop. His business expanded in 1909 using equipment that Morgan made (and invented) himself. And in the process of making sewing machine more efficient, he invented a liquid that can straighten human hair!

In 1912, Morgan invented the "safety hood" which consists of a hood covering the head of a person, and with a tube hanging from the inside of the hood to near the ground. A sponge is attached at the end of the tube and the apparatus acts as an air filter. Morgan developed it as a safety device for firefighter to enter a scene of disaster and work more efficiently. And in 1916, an explosion in the tunnel under Lake Erie, where Morgan lived nearby, became the testing ground for the safety hood. Several workers were trapped in the tunnel and luckily someone remembered Morgan's invention and summoned him to the scene with his "safety hood"; eventually Morgan and his brother saved several people and became two everyday heroes. A lot of orders for the "safety hood", also known as the gas mask, came to the company but unfortunately a lot were canceled when the customers learned that Mr. Morgan was a black American. But after the World War I broke out, the gas mask became a necessity that saved many American soldiers.

Realizing the dangers of speeding automobiles and horse carriages sharing the same roads, Morgan patented a traffic signal in 1923 - this was the first traffic signal patented, but not the first invented. His traffic signal was a T-shaped pole with arms (but with no lights) that has three signs, one or more of which popped out at a time: a red "stop," a green "go," and another red "stop in all directions." This last signal let pedestrians cross the street. It was controlled by an electric clock mechanism. This device became very popular, and was used all around the USA. Morgan sold his device to the General Electric Corporation for $40,000 (a huge sum at that time) and became the predecessor to the traffic light we use today.

Name: ______________________________________ Date: ___________________

Teacher: _____________________________________

Inventor of the Week Questionnaire

1) What are some of Morgan's inventions, are they still being used today?

2) How was Morgan's safety hood used? What is it used for and who uses it?

3) Why and when did safety hoods became a necessity? Please explain.

4) How much did Morgan sold this traffic signal invention for? And who did he sell it to?

5) Morgan invented a liquid to straighten human hair? What would you call it?

Extra credits: Define the following words
Summon-

Morgan was born in Paris, Kentucky; in what country is the other famous "Paris" city located?

Answer Key Morgan

1. Gas mask, Hair gel, zig-zag attachment of sewing machine. They are all still being used today in more advanced form.

2. The safety hood is worn over the head, with a tube with a sponge at the end to filter air. Air goes trough the tube and reach the person so he can breathe. It was used mainly by firefighters in disaster areas.

3. The safety hood became a necessity after World War I broke out. Soldiers used the hood as a measure against the newly invented gas weapons.

4. Morgan sold the traffic signal to General Electric Corporation for $40,000.

5. Morgan invented the hair gel.

E.C.

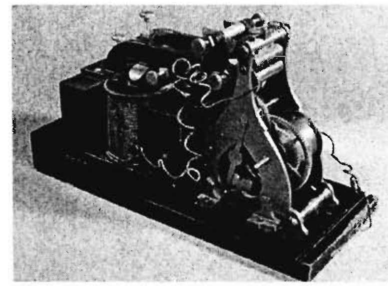
Summon – to call upon, to request to appear

The other Paris is located in France

Samuel Finley Breese Morse

Born Apr 27 1791 - Died Apr 2 1872

Invention
Pumps
Morse code
One wire telegraphy



Inventor Biography

Morse was a well-rounded, yet ambitious man in his time. He was born on April 27, 1791 in Charlestown, Mass. He developed his interest in painting and electricity when he was a student at Yale College. Then after he graduated in 1810, he traveled to study painting in England and became a famous portrait artist. Morse returned to the U.S. in 1825 and became influential in the art world and also tried his hands on inventions, he and his brother had gotten three patents for pumps. In 1832, Morse became interested in telegraphy, a method of sending and receiving information through currents of electricity over wires. When the first telegraph was built in 1774, it had 26 wires for each letter of the alphabet, and Morse decided to simplify it and reduce it to having only one wire.

In the next 6 years Morse and two other scientists developed a prototype of his one-wire telegraph and a new type of coding for the messages. It was a dot-and-dash code system, with a code made up of dots and dashes for each letter of the alphabet and numbers. Unlike earlier model, no messy printing is required when receiving a telegraph; trained operators could easily decipher the code sent over to them by learning the code, which is granted the name, Morse Code.

Seeing his success and the potentials of this new type of telegraph, the Congress provided Morse a grant to "wire the United States" in 1842. Two years later, on May 11, 1844, after many tests and trails, Morse sent his first telegraph message from the chamber of the Supreme Court in Washington, D.C.. to the Mount Clair train depot in Baltimore through an electrical wire. It was a successful attempt, and private companies started to use this new technology to "wire" different cities together. First, it was Washington to Boston and Buffalo, then later on, telegraph wires were connected all through America alongside the many railroad tracks. In 10 years, there were over 23,000 miles of telegraph wire in operating connecting people in far away places.

The first successful attempt to "wire" two continents was done in 1866, when a telegraph wire connecting Newfoundland and Ireland went into operation. Even though Morse was not directed involved in this project, his contributions earlier made this connection between two peoples possible.

Name: ______________________________ Date: _______________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) Describe the Morse Code. What is it used for? How is it used?

2) Fill in the blanks: _____________ is a method to transmit messages through _________ of electricity.

3) True of False: The first attempt of the Morse code telegraph was made between Worcester to Auburn.

4) Why is Morse's telegraphy system so special?

5) What did Morse do before he became an inventor?

Extra credits: Define the following words

Well-rounded -

portrait artist -

decipher -

Answer Key Morse

1. Morse Code is made up of dots and dashes for each letter of the alphabet and numbers, primarily used for transmitting messages

2. telegraphy and currents

3. false

4. Morse's telegraphy system consist of only one wire, whereas the systems before have multiple wires for each letter

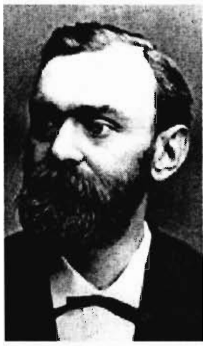
5. Morse was a student, a portrait artist, and an inventor

E.C.

Well-rounded: A person that is learned and talented and interested for boarder knowledge

Portrait artist: Normally a painter whose job is to paint people's picture of themselves

Decipher: to decode a message



Alfred Nobel
Born Oct 21 1833 - Died Dec 10 1896

Invention/Contribution
Dynamite
The Nobel Prize

Inventor Biography

Alfred Nobel, a true Renaissance man, was born in Stockholm, Sweden in 1833 and moved to St. Petersburg, Russia with his family when he was nine. He was educated by the best university professors and eventually became fluent in five languages: Swedish, English, French, German, and Russian. Knowledge of these languages enabled Nobel to read many of the great scientific text, poetry, and literature at that time.

From 1850-1852, Nobel was sent by his father to the United States and Paris to study science, and it was then that Nobel was first introduced to nitroglycerin, a liquid component that is very unstable and explosive. Nobel was fascinated, partly due to his father's experiments with explosives in his factory, and partly due to his highly scientific nature. Realizing the potentials of such liquid, Nobel decided to work to stabilize nitroglycerin in his father's factory during the Crimean War in 1853-1856, where they were also providing the Russian Navy with explosives.

After the war has ended, Nobel, his father, and his brother opened a laboratory in Stockholm in 1859 to continue working on the liquid. Great progress had been made but 5 years later his brother Emil, along with several workers in the lab, were killed in an explosion in the lab. This made Nobel to realize the deadly power of the liquid, and made him more focus and driven in the research. Meanwhile, the city of Stockholm prohibited experiments with explosive in the city limits but Alfred was determined to find a better way tending to explosives.

Two years after the accident, Alfred discovered that if one mixes nitroglycerin and a powdery substance called kieselguhr, one can produce a hardened form of explosive that can be molded into any shape; it is much more stable and easier to use. He named the mixture dynamite and received a patent in 1867. He set up several factories around the world to produce dynamite for mining operation, civic construction, and also for military use. Dynamite had made many mining and construction projects safer and cheaper, but it also made modern warfare more deadly.

Realizing the possibility of the horrors that can be unleashed with dynamite, Nobel set up a fund with part of his fortune in his will that will be awarded to people who advanced the fields of chemistry, physics, engineering, medicine, literature, and peace. The Nobel Prize was his greatest contribution to the humankind.

Name: ______________________________ Date: ________________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) Which one of Nobel's contributions do you think is more important? Dynamite or the Nobel Prize? Discuss your reasons.

2) What languages did Nobel speak? What is the benefit of knowing so many languages?

3) Define nitroglycerin

4) Why did Nobel set up the Nobel Prize Award?

5) Fill in the blanks: Dynamite is a dangerous substance made of ____________ and ____________ as the stabilizer.

Extra credits: Define the following words

Civic construction -

Stabilize -

decipher -

Answer Key Nobel

1. Dynamite: improved civil engineering and military engineering
   Nobel Prize: a way to reward and encourage scientific discovery

2. Swedish, English, French, German, and Russian. Knowledge of these languages enabled Nobel to read many of the great scientific text, poetry, and literature at that time.

3. an unstable liquid that is very explosive

4. Nobel set up his award because he felt guilt because dynamite may be used in the wrong hands and he wanted to repay the world and the scientists that try to advance science to understand it and to protect it

5. nitroglycerin and <u>kieselguhr</u>

<u>E.C.</u>

Civic Construction: construction of buildings and such for people

Stabilize: to stop movement or changes

Decipher: to decode a message

Madame C. J. Walker (Sarah Breedlove)

Born Dec 23, 1867 – Died May 25, 1919

Achievement

Many beauty and hair care products

Inventor Biography

One of the first female American to become a millionaire, Madame Walker was born in Delta, Louisiana, on the Burney family plantation; her name was originally Sarah Breedlove. Walker's parents were ex-slaves who had both died by the time she was 7. Sarah was married at age fourteen to Moses McWilliams. Widowed at age 20, she moved to St. Louis, Missouri, and supported her daughter, Lelia, by washing laundry for 18 years.

In 1905, she moved to Denver, Colorado, and married Charles Joseph (C.J.) Walker, a newspaper sales agent; they were divorced around 1910, but she kept his name. Madame Walker started her cosmetics business in 1905. Her first product was a scalp treatment method that used shampooing, massaging, application of an ointment of petroleum and sulfur and a hot comb to heal scalp disease.

Sarah later invented a system for straightening hair. She added Madame to her name and began selling her new "Walker System" door-to-door. Walker soon added a hair-growing ointment and other cosmetic products to her line of cosmetics. The products were very successful and she soon had many saleswomen, called "Walker Agents," who sold her products door to door. In 1910, she moved her company from Denver, Colorado, to Pittsburgh, Pennsylvania.

Her most famous customer was the dancer Josephine Baker, who performed in Paris, France. Walker eventually became a millionaire from her business, which was at its peak from 1911 through 1917; she employed thousands of people. Walker eventually moved to New York and became active in influencing the arts and philanthropy; she helped many causes, started scholarships, helped the NAACP, the Tuskegee Institute, and Bethune-Cookman College. She also helped spur the Harlem Renaissance. The Madame CJ Walker Manufacturing Company is no longer in business, replaced by newer and more advanced cosmetics companies.

Name: ______________________________ Date: ________________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) What did Madame Walker invented?

2) What was the procedure that Madame Walker invented for scalp treatment?

3) What is the Walker-System? How was it sold to the public?

4) What did Madame Walker use for money for after she became a millionaire?

5) What did Madame Walker contribute to people?

Extra credits: Define the following words

Walker Agents-

Cosmetics-

Petroleum -

Answer Key Walker

1. Madame Walker invented many beauty and hair products.

2. Her first product was a scalp treatment method that used shampooing, massaging, application of an ointment of petroleum and sulfur and a hot comb to heal scalp disease.

3. The Walker-System was a system used for straightening hair, it was sold by the Walker-Agents going door-to-door

4. Madame Walker used some of her money to start scholarships, helped the NAACP, the Tuskegee Institute, and Bethune-Cookman College. She also helped spur the Harlem Renaissance

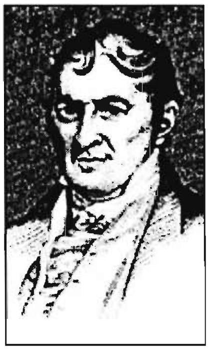
5. She contributed a lot to the cosmetics business and also to improve the life of people with her donations to charities.

E.C.

Walker Agents – young women employed by Madame Walker to sell her products

Cosmetics – products designed to beautify the body by direct application onto the body

Petroleum – a type of fossil fuel, thick liquid that is the basis of plastic and gasoline.



Eli Whitney

Born Dec 8 1765 - Died Jan 8 1825

Invention

Cotton gin
Nail-making machine
Products with interchangeable parts

Inventor Biography

Eli Whitney was born in Westboro, Massachusetts in 1765. He had shown interest and talent for machinery since a child. As a child, he showed an instinct and talent for machinery. He found work as a blacksmith in his youth, and invented a nail-making machine. Whitney attended and graduated Yale University with an engineering degree, not quite useful at that time, and could not found a job as an engineer. So he accepted a job in the South as a teacher.

When his teaching job fell through in 1793, he invited by widow Kathleen Greene to her plantation as a helper. During that time, Whitney discovered that it took human hands very long to extract cotton from the seed of the plant and decided to make a machine to make the work go faster and improve the production rate.

Legends tells the tale of Whitney spending only 10 days observing and making the first machine, the cotton gin. It worked well to have the lint of cotton taken out of the seed but jammed very easily. With suggestions from Mrs. Greene and a friend, Whitney constructed a second machine that was a total success; it worked to collect all the fibers from the seeds and never jammed. After his demonstration of the machine with the local farmers, everyone was fascinated, but then his workshop was broken into and his cotton gin broken apart and studied. Copies of the machine appeared, and even though Whitney held a patent of the design of the original machine, he could not win any lawsuits against the copycats. Disgusted by the reality, Whitney relocated to the North and started his own manufacturing plant in New Haven, Connecticut.

At that time, a product was usually made by one skilled person along, so it takes a long time to make a complex product. Therefore, Whitney realized that if he could get unskilled laborers to make complex products at the same rate as skilled laborers, he would make a lot of fortune. He figured out a way to achieve this through interchangeable parts. He decided to make rifles with his company, and he designed the product so that different parts could be made with different machines efficiently and the workers only had to operate the machine and put all the parts together into a rifle.

It was a very simple concept, the engineer only needed to design the product and machines that can make parts of the product repeatedly. This concept is called mass production and it is what strength the American industry.

Name: ______________________________ Date: _______________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) Why did Eli Whitney moved to the South to be a school teacher? Do you think an engineering degree now is useful?

5) What happened to Eli Whitney in the South that caused him to move back to New Haven?

6) What were the three important inventions of Eli Whitney?

4) Fill in the blank: A machine that work fast has a high ____________________.

6) How did Eli Whitney's concept of interchangeable parts improved the American Industry

Extra credits: Define the following words

copycat-

extract-

plantation-

Answer Key Whitney

1. Whitney could not found a job even after he earned an engineering degree, so he moved to the south for a new career

2. He created the cotton gin and was supposed to make a lot of money, but some people broke into his workshop and stole his ideas

3. Cotton gin, interchangeable parts, and mass production

4. production rate

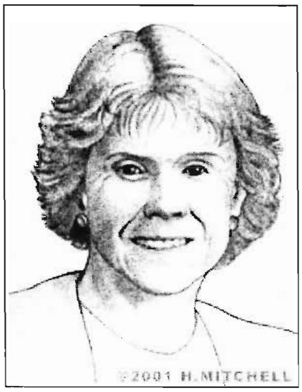
5. The concept of interchangeable parts promoted higher production rate and pushed the U.S. into the industrial Age.

E.C.

Copycat: A person that mimic another

Extract: To take out, to remove

Plantation: a large estate on which crops are grown



Sheila Windall

Born July 13, 1938

Invention/Contribution

Airfoil for aircrafts
Aircraft turbulence research
Helicopter research
U.S. Air Force Secretary

Inventor Biography

Born in Tacoma, Washington, Widnall was interested as a teenager in pursing an engineering education. In 1956, she became one of just 23 women in the incoming MIT freshman class, and acquired her PhD degree in 1964

Widnall's areas of expertise are in aircraft turbulence and spiraling airflows. Her work has made major contributions to the understanding and prediction of airplanes, helicopters, high-speed train, and also watercrafts. Widnall is also known for designing MIT's advanced wind tunnel facility that enables students to conduct aviation-related experiments. Sheila was the first woman to be named a professor at the school and later headed the entire faculty in 1979.

From 1978 to 1993, she was involved with the U.S. Air Force in their many different committees or served as advisor. Then in 1993, she was appointed by President Clinton as the Secretary of the U.S. Air Force, and the first woman who headed a whole branch of the United States military.

During her time with the Air Force, Widnall was responsible for 400,000 active duty forces and 185,000 men and women in the Air Force Reserve and Air National Guard. She also took up responsibility to spread up and use a $62 billion budget on everything involved with the Air Force, for example: maintenance, research, development, and personnel support.

Professor Windall retired from the Air Force in 1997 and resumed teaching at MIT, over the years, she had acquired many honors and awards that complimented her distinguish engineering career.

Name: ______________________________ Date: ________________

Teacher: ______________________________

Inventor of the Week Questionnaire

1) What were the two expertise of Windall?

2) What machines did Windall improve on with her knowledge? Why do you think it is the case?

3) How did Windall improve the U.S. Air Forces?

4) Please define “aviation”.

5) What was the reason of using a wind tunnel at MIT?

Extra credits: Define the following words

distinguish –

wind tunnel –

Answer Key Windall

1. Aircraft turbulence and spiraling airflows

2. The airplanes, helicopters, high-speed train, and also watercrafts. The reason is that in fast moving objects, the air around the objects play a major role in its motion.

3. Windall improved the Air Forces by setting up a fund that provide better support, research, maintenance for the machines and the personnel

4. Aviation is the design, development, production, and operation of aircrafts

5. The reason for using a win tunnel at MIT was to conduct aviation-related experiments

E.C.

Distinguish – very unique and distinct

Wind tunnel – device used to test airflow around objects that would travel in high speed

The Wright Brothers

Orville Wright
Born Aug 19, 1871
Died Jan 30, 1948

Wilbur Wright
Born Apr 16, 1867
Died May 30, 1912

Invention

Flying-Machine/Airplane

Inventors Biography

Wilbur was born in Millville, Indiana; Orville was born in Dayton, Ohio, where the family settled. They are from a religious family and both had gotten high school education but never graduated. Their passion had been in machines, especially flying machines. In 1893, the brothers opened a bicycle repair, design, and manufacturing shop in Dayton to fund their interest in making the first functional, powered flying machine in the world.

The Brothers based their research and designs on earlier works by Otto Lilienthal, Sir George Cayley, Octave Chunate. These scientists had worked on the concepts of airplane and gilder before and were quite successful, even though many information they described was wrong and the Wright brothers had to figure everything out again. In 1899, the brothers built the first full-scale, functional prototype and experimented with it. The machine was made by adding a pair of wings to a biplane kite, it was more of a guilder than a powered machine.

Before attempting a powered flight, they decided to master gliding and built three more biplane gliders, one for each year, which were improved versions of the ones used by the other scientists and with movable wing parts fore more stability and control.

The first powered model was finished in 1903 and the brothers took 4 flights in front of the public at Kitty Hawk in North Carolina on Dec 17, 1903. This newest machine has a curved propeller and an engine, and was named Wright Flyer I, or Kitty Hawk. The first flight was made by Orville and it lasted 12 seconds for 39 meters, and the last flight was made by Wilbur with 59 seconds and 279 meters. The last flight was also the only one that the inventor had some control.

For the next 6 years, the Wright brothers continued working on different designs for a more efficient airplane, and in 1909 the U.S. government bought the design and adopted it to use in the military. The money that the brothers got enabled them to open their Wright Company they used to continue their research and experiment.

Name: ______________________________________ Date: ___________________

Teacher: _____________________________________

Inventor of the Week Questionnaire

1) How old were the Wright brothers when they finished their first powered model of the airplane?

2) In what business were the Wright brothers involved in before their successful flight? And after the successful flight?

3) Fill in the blank: The first prototype in 1899 was more of a ______________ than a _____________ machine.

4) What were the speeds of the first and the last flight? Hint: Speed = distance (in meters) divided by time (in seconds). Show calculations

5) The Wright brothers were concerned about two concepts in their airplane so that they made a lot of models, what are the two concepts?

Extra credits: Define the following words
propeller-

functional-

Kitty Hawk-

Answer key Wrights

1. Orville was 32 and Wilbur was 36

2. The brothers operated a bicycle repair shop before their successful invention, and afterward, they were involved in the Wright Company for research and development of airplanes

3. guilder and power

4. 39m/12sec=3.25m/s and 279m/59sec=4.73 m/s

5. stability and control

E.C.

Propeller: a mechanism consists of a rotating shaft and radiating blades, use to move something

Functional: usable, an object that performs its expected functions

Kitty Hawk: the name of the first powered airplane and also the place it was demonstrated at

APPENDIX III Lesson Plan Evaluation/Teacher Survey

This appendix presents our originally developed lesson plan post-implementation evaluation form and also the teacher questionnaire. The lesson plan post-implementation evaluation form was developed entirely within our group with the help of our advisors and fellows. The form was also used as a mean to provide feedbacks from members of the project team that witnessed the lesson plan to provide inputs for alternations on the lesson plans.

The teacher questionnaire was developed the same way, but to ensure us unbiased answers from the teacher, we enlisted the help of Paula Quinn, the Assessment Consultant of the PIEE project. With her input, we were able to develop the final form of the teacher questionnaire that emphases accurate, short, and concise answers.

All completed the teacher questionnaire forms are presented below and only the lesson plan evaluation forms saved are presented. For those forms that contain hand-written answers, they were reproduced electronically below.

III.A Sample Lesson Plan Evaluation Form

<u>Evaluation:</u> Score the lesson on each of the below subjects. 1 = Lowest, 5 = Highest

Evaluator Name:____________________Lesson:____________________________

Creativity: Does the lesson encourage students to come up with original ideas?

1 2 3 4 5

Comments:____

____

Appropriate Content: Does the lesson challenge students to learn the subject matter without being too difficult?

1 2 3 4 5

Comments:____

____

Engineering: Does the lesson incorporate some aspects of the Engineering Design Process in addition to information on science or mathematics?

1 2 3 4 5

Comments:____

____

Interest: Is the lesson interesting enough that the class pays attention throughout the lesson?

1 2 3 4 5

Comments:____

____

Repeatability: Could the lesson be repeated easily by another teacher in another classroom using only the instructions given, and does the lesson use readily available materials?

1 2 3 4 5

Comments:____

____

III.A.1 Completed Evaluation Form 1

Evaluation: Score the lesson on each of the below subjects. 1 = Lowest, 5 = Highest

Evaluator Name: Melissa Costello Lesson: Balloon Racer

Creativity: Does the lesson encourage students to come up with original ideas?

5

Comments: Very open-ended for design constraints

Appropriate Content: Does the lesson challenge students to learn the subject matter without being too difficult?

4

Comments: Understanding of friction and wind resistance needed to make better racers

Engineering: Does the lesson incorporate some aspects of the Engineering Design Process in addition to information on science or mathematics?

5

Comments: Prototype purpose, aerodynamics, calculation of speed and acceleration

Interest: Is the lesson interesting enough that the class pays attention throughout the lesson?

5

Comments: They all actively participated and enjoyed the competition

Repeatability: Could the lesson be repeated easily by another teacher in another classroom using only the instructions given, and does the lesson use readily available materials?

5

Comments: Easy materials and easy construction

III.A.2 Completed Evaluation Form 2

Evaluation: Score the lesson on each of the below subjects. 1 = Lowest, 5 = Highest

Evaluator Name: Melissa Costello **Lesson: Plate Tectonics**

Creativity: Does the lesson encourage students to come up with original ideas?

1

Comments: The activities were more demonstrative.

Appropriate Content: Does the lesson challenge students to learn the subject matter without being too difficult?

4

Comments: The different plate movement types took some time for them to learn

Engineering: Does the lesson incorporate some aspects of the Engineering Design Process in addition to information on science or mathematics?

3

Comments: no engineering, but lots of science information

Interest: Is the lesson interesting enough that the class pays attention throughout the lesson?

4

Comments: The demonstrative activities kept their attention

Repeatability: Could the lesson be repeated easily by another teacher in another classroom using only the instructions given, and does the lesson use readily available materials?

5

Comments: Only Materials needed are textbooks

III.A.3 Completed Evaluation Form 3

Evaluation: Score the lesson on each of the below subjects. 1 = Lowest, 5 = Highest

Evaluator Name: William Wong Lesson: Plate Tectonics

Creativity: Does the lesson encourage students to come up with original ideas?

2

Comments: It was mainly a lecture, but the students did come up with some ideas as to why the plates much in such vastly different ways. And they also had some ideas about earthquakes and volcanoes are connected with plate tectonics while doing the experiment. Most interestingly is that some students came up with an idea of plates moving into another Pangaea millions years later after they've seen the graph with the velocity of the plates.

Appropriate Content: Does the lesson challenge students to learn the subject matter without being too difficult?

4

Comments: Most students did not know about earth's layers and plate movements. It was hard for them to initially grasp the ideas, but then as we went on and introduced volcanism and earthquakes, they are easier to accept such concepts. However, there is a student that would not be convinced that there is actually plate movement.

Engineering: Does the lesson incorporate some aspects of the Engineering Design Process in addition to information on science or mathematics?

2

Comments: The lesson plan did not have an engineering component, it was designed to introduce students to plate movements in relation to volcano, a lesson plan that followed which was engineering based.

Interest: Is the lesson interesting enough that the class pays attention throughout the lesson?

4

Comments: Frankly, the dynamic of the two classes are vastly different. The honors class seem bored by the idea of another "boring talk about science", but they warmed up to the idea to the exercise of "human plates". The other class, however, was very interested in the small details of the plate movements, and they generated much more ideas.

Repeatability: Could the lesson be repeated easily by another teacher in another classroom using only the instructions given, and does the lesson use readily available materials?

5

Comments: There is no special material needed from outside of the classroom, soft-splined books should be at hands and I believe most students are willing to participate in the "human plates" section. The instructions also seem quite easy to follow.

III.A.4 Completed Evaluation Form 4

Evaluation: Score the lesson on each of the below subjects. 1 = Lowest, 5 = Highest

Evaluator Name: Melissa Costello Lesson: Volcano

Creativity: Does the lesson encourage students to come up with original ideas?

5

Comments: Every group had creative solutions

Appropriate Content: Does the lesson challenge students to learn the subject matter without being too difficult?

4

Comments: Not very challenging material, but most learned it

Engineering: Does the lesson incorporate some aspects of the Engineering Design Process in addition to information on science or mathematics?

4

Comments: Teamwork was encouraged and they had to design their solution on paper before building it

Interest: Is the lesson interesting enough that the class pays attention throughout the lesson?

5

Comments: The kids enjoyed this activity and didn't want to stop

Repeatability: Could the lesson be repeated easily by another teacher in another classroom using only the instructions given, and does the lesson use readily available materials?

5

Comments: The volcano design is easy enough

III.B Sample Teacher Questionnaire

Please take a moment to fill out the form so we can have your thoughts on the PIEE program. Evaluate how the program was run as a whole, not individuals. For the scale questions, 1= awful/definitely not and 10 = great/definitely yes. There is room at the end for any additional comments you would like to make to further answer scale questions. Constructive criticism is highly valued, and your feedback will be used to improve the future of this program. Thank you for your time!

1) How well were your expectations of the college students' role in the classroom met?

   1 2 3 4 5 6 7 8 9 10

2) If any of your expectations were <u>not</u> met, or if there were any problems with our professional behavior in the classroom, please tell us what needs improvement.

3) (To whom this applies) How helpful was IQP student assistance in tutoring and/or the after school program?

   1 2 3 4 5 6 7 8 9 10

4) Did you see a potential heightened interest in engineering or science in general among your students?

   1 2 3 4 5 6 7 8 9 10

5) Did you see potential improvement in math skills among your students that could have been attributed in part to our lessons?

   1 2 3 4 5 6 7 8 9 10

6) After next year there will be no more college student assistance. At this point how comfortable would you feel teaching the engineering lessons without our help?

   1 2 3 4 5 6 7 8 9 10

7) What needs to be done next year to help raise your comfort level for delivering the engineering material by yourself and sharing the teaching method of these lessons with the other teachers?

8) Did you enjoy working with us and letting us teach our lessons in your classroom? (We definitely enjoyed working with the kids!)

1 2 3 4 5 6 7 8 9 10

9) If the program were open to more teachers, would you recommend it to others? Why or why not?

1 2 3 4 5 6 7 8 9 10

10) Please leave any additional comments that you feel will improve this program.

III.B.1 Completed Teacher Questionnaire 1

Please take a moment to fill out the form so we can have your thoughts on the PIEE program. Evaluate how the program was run as a whole, not individuals. For the scale questions, 1= awful/definitely not and 10 = great/definitely yes. There is room at the end for any additional comments you would like to make to further answer scale questions. Constructive criticism is highly valued, and your feedback will be used to improve the future of this program. Thank you for your time!

1) How well were your expectations of the college students' role in the classroom met?

   8

2) If any of your expectations were not met, or if there were any problems with our professional behavior in the classroom, please tell us what needs improvement.

   It would have been nice to have more tutoring time from the students.

3) (To whom this applies) How helpful was IQP student assistance in tutoring and/or the after school program?

   3

4) Did you see a potential heightened interest in engineering or science in general among your students?

   8

5) Did you see potential improvement in math skills among your students that could have been attributed in part to our lessons?

   5

6) After next year there will be no more college student assistance. At this point how comfortable would you feel teaching the engineering lessons without our help?

   8

7) What needs to be done next year to help raise your comfort level for delivering the engineering material by yourself and sharing the teaching method of these lessons with the other teachers?

   Additional training or materials.

8) Did you enjoy working with us and letting us teach our lessons in your classroom? (We definitely enjoyed working with the kids!)

10

9) If the program were open to more teachers, would you recommend it to others? Why or why not?

10

<u>Although this first year had some bumps I definitely feel there is great potential.</u>

10) Please leave any additional comments that you feel will improve this program.

III.B.2 Completed Teacher Questionnaire 2

Please take a moment to fill out the form so we can have your thoughts on the PIEE program. Evaluate how the program was run as a whole, not individuals. For the scale questions, 1= awful/definitely not and 10 = great/definitely yes. There is room at the end for any additional comments you would like to make to further answer scale questions. Constructive criticism is highly valued, and your feedback will be used to improve the future of this program. Thank you for your time!

1) How well were your expectations of the college students' role in the classroom met?

   6

2) If any of your expectations were not met, or if there were any problems with our professional behavior in the classroom, please tell us what needs improvement.

   Professional behavior means arriving on time when scheduled and interacting appropriately with students

3) (To whom this applies) How helpful was IQP student assistance in tutoring and/or the after school program?

   9

4) Did you see a potential heightened interest in engineering or science in general among your students?

   8

5) Did you see potential improvement in math skills among your students that could have been attributed in part to our lessons?

   Not applicable

6) After next year there will be no more college student assistance. At this point how comfortable would you feel teaching the engineering lessons without our help?

   9

7) What needs to be done next year to help raise your comfort level for delivering the engineering material by yourself and sharing the teaching method of these lessons with the other teachers?

   More content for the engineering components of the lessons

8) Did you enjoy working with us and letting us teach our lessons in your classroom? (We definitely enjoyed working with the kids!)

8

9) If the program were open to more teachers, would you recommend it to others? Why or why not?

3

This year I did not feel that there was enough support from the students. I did not receive the lessons that were planned over the summer.

10) Please leave any additional comments that you feel will improve this program.

III.B.3 Completed Teacher Questionnaire 3

Please take a moment to fill out the form so we can have your thoughts on the PIEE program. Evaluate how the program was run as a whole, not individuals. For the scale questions, 1= awful/definitely not and 10 = great/definitely yes. There is room at the end for any additional comments you would like to make to further answer scale questions. Constructive criticism is highly valued, and your feedback will be used to improve the future of this program. Thank you for your time!

1) How well were your expectations of the college students' role in the classroom met?

   4

2) If any of your expectations were not met, or if there were any problems with our professional behavior in the classroom, please tell us what needs improvement.

   Students need to be on time. Students need to get lesson plans to teacher at least a week in advance. Student need to be more committed

3) (To whom this applies) How helpful was IQP student assistance in tutoring and/or the after school program?

   Not Applicable

4) Did you see a potential heightened interest in engineering or science in general among your students?

   4

5) Did you see potential improvement in math skills among your students that could have been attributed in part to our lessons?

   2

6) After next year there will be no more college student assistance. At this point how comfortable would you feel teaching the engineering lessons without our help?

   5

7) What needs to be done next year to help raise your comfort level for delivering the engineering material by yourself and sharing the teaching method of these lessons with the other teachers?

   More preparation on engineering concepts on the student teachers behalf

8) Did you enjoy working with us and letting us teach our lessons in your classroom? (We definitely enjoyed working with the kids!)

5

9) If the program were open to more teachers, would you recommend it to others? Why or why not?

4

It all depends on how prepared the students as well as their motivation and commitment.

10) Please leave any additional comments that you feel will improve this program.

III.B.4 Completed Teacher Questionnaire 4

Please take a moment to fill out the form so we can have your thoughts on the PIEE program. Evaluate how the program was run as a whole, not individuals. For the scale questions, 1= awful/definitely not and 10 = great/definitely yes. There is room at the end for any additional comments you would like to make to further answer scale questions. Constructive criticism is highly valued, and your feedback will be used to improve the future of this program. Thank you for your time!

1) How well were your expectations of the college students' role in the classroom met?

   6

2) If any of your expectations were not met, or if there were any problems with our professional behavior in the classroom, please tell us what needs improvement.

   Make clear to the students what their role is in the classroom and accountability. Lines of communication when a problem arises that they need to follows.

3) (To whom this applies) How helpful was IQP student assistance in tutoring and/or the after school program?

   10

4) Did you see a potential heightened interest in engineering or science in general among your students?

   10

5) Did you see potential improvement in math skills among your students that could have been attributed in part to our lessons?

   7

   Did some tutoring in math

6) After next year there will be no more college student assistance. At this point how comfortable would you feel teaching the engineering lessons without our help?

   10

7) What needs to be done next year to help raise your comfort level for delivering the engineering material by yourself and sharing the teaching method of these lessons with the other teachers?

   Nothing, I feel very comfortable

8) Did you enjoy working with us and letting us teach our lessons in your classroom? (We definitely enjoyed working with the kids!)

7

IQP's didn't teach lessons in classroom, *assisted, Afterschool Program, IQP assigned did teach students in the 6th grade

9) If the program were open to more teachers, would you recommend it to others? Why or why not?

8

10) Please leave any additional comments that you feel will improve this program.

I feel the IQP's need to be held accountable for submitting engineering lessons in a timely manner. Requirements/hours IQP's expected to spend in classroom seem to have changed mid-stream. This needs to be clear to the IQP's, grad fellows, as well as teachers.

III.B.5 Completed Teacher Questionnaire 5

Please take a moment to fill out the form so we can have your thoughts on the PIEE program. Evaluate how the program was run as a whole, not individuals. For the scale questions, 1= awful/definitely not and 10 = great/definitely yes. There is room at the end for any additional comments you would like to make to further answer scale questions. Constructive criticism is highly valued, and your feedback will be used to improve the future of this program. Thank you for your time!

1) How well were your expectations of the college students' role in the classroom met?

   8

2) If any of your expectations were not met, or if there were any problems with our professional behavior in the classroom, please tell us what needs improvement.

   My IQP student never materialized for the after school program – Spring 2005, Midland Street

3) (To whom this applies) How helpful was IQP student assistance in tutoring and/or the after school program? Jim Rocci

   9

4) Did you see a potential heightened interest in engineering or science in general among your students?

   10

5) Did you see potential improvement in math skills among your students that could have been attributed in part to our lessons?

   7

6) After next year there will be no more college student assistance. At this point how comfortable would you feel teaching the engineering lessons without our help?

   9

7) What needs to be done next year to help raise your comfort level for delivering the engineering material by yourself and sharing the teaching method of these lessons with the other teachers?

Brief readings on topics/ Bibliography/ recent periodical articles – especially for themes/ topics not covered in our classroom text

8) Did you enjoy working with us and letting us teach our lessons in your classroom? (We definitely enjoyed working with the kids!)

9

9) If the program were open to more teachers, would you recommend it to others? Why or why not?

9

10) Please leave any additional comments that you feel will improve this program.